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GE Power Management

MLP

MICROPROCESSOR BASED DISTANCE PROTECTION

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1. DESCRIPTION

The MLP system is a digital multiprocessor which provides three phase trip distance protection and automatic reclosing as analysis and control functions. It is designed for the protection, control, and monitoring of lines and cables with voltage levels up to 132 kV and distances up to 150 km. Its application is adequate in systems where the directional overcurrent protection may not be sufficient and the trip time (1.5 cycles) is acceptable.

Each MLP system is linked to a distribution line and acts as a distance protection and independent reclosing system.

The MLP system includes a serial communications module that allows its use as an integrated component of a complete protection and control system of substations or higher levels (see diagram 1). Other system components are:

a) Remote controller PC compatible computer via modem.

b) Communications concentrator unit broadcasting device (FAC for fiber optics) and modem for connection to MLP and/or MOR, MTP y MCP systems linked to the substation distribution lines.

The information provided herein does not intend to cover all details of variations of the described equipment nor does it take into account the circumstances that be present in your installation, operating or maintenance activities.

Should you wish to receive additional information, or for any particular problem which cannot be solved by referring to the information contained herein, please write to:

GENERAL ELECTRIC POWER MANAGEMENT, S.A.

The MLP system includes the following operations

- Three directional distance protection zones for faults between phases and phase-ground faults.

- The measuring unit characteristic can be selected between negative sequence reactance and variable MHO for phase-ground fault detection inside zone 1, or extended zone 1 and zone 2. (All models)

- Measuring units with variable MHO characteristic, for ground-phase fault detection inside zone 3.

- Measuring units with variable MHO characteristic, for phase-phase fault detection inside zone 1 or extended zone 1, zone 2 and zone 3.

- Three protection schemes:

Scaled range.
Zone 1 extension.
Zone 2 acceleration. (MLP3000 only)

- The last two schemes cannot be selected simultaneously. The scaled range scheme will stay active even when any of the other two diagrams has been selected. The last scheme requires an existing communications channel between the protections on both sides of the line.

- Out of step blocking function.

- Line power function.

- 3 phase top in all zones.

- Event register which includes built-in calendar and clock, capable of storing up to 240 events. The data stored includes date, time, current and voltage values, status of any of the 12 distance measuring units that are activated, and type of event. Examples of events are: start of any measuring unit, trip and reclosing orders, opening or closing of the breaker, etc. In the event of power loss, the events will not be lost.

- Measuring and monitoring of the current and voltage of the three phases and the current of the zero sequence unit.

- On-line monitoring of the breaker status, distance protection and recloser:

- Hourly register of the maximum load current or power (selectable), capable of storing information accumulated over seven days.

- A phase direction indicator that indicates if the line current is in the trip direction or m the opposite direction.

- Serial communications module for local or remote data retrieval, breaker control and relay programming, as well as distance protection settings, recloser settings and system parameters. It also includes a keyboard and display for local communications. The different MLP models include one of the following standard interfaces:

  Plastic fiber optic interface
  Crystal fiber optics interface
  RS232C.

- Remote control of the breaker.

- Self-checks and monitoring of the internal circuitry and external inputs.

- Automatic recloser of up to three programmable recloses. (MLP2000 and MLP3000)

- Fuse failure detector in voltage measuring circuits.
- Remote open detector (without communications channel). (MLP3000)
- Fault selector
- Fault locator (MLP 3000).
- Oscillographic register that retrieves seven fault situations, which are stored for at least two hours in the event of a power loss. (MLP4000)

The oscillographic register retrieves data such as the waves of the three currents and voltages, status of the inputs and outputs, distance protection signals, reclosing signals and blocking signals. The register capacity is 30 cycles: two prefault cycles and 28 postfault cycles. The information generated by the fault selector (type of fault and it's location) and the type of trip performed will be stored. Data can be retrieved and saved in an ASCII file.

The MLP system protection and resetting operations are independent from control and communications operations so that a highly reliable protection operation can be ensured even in the case the rest of the components failed.

The MLP is stored in a unique assembling case 19". Dimensions are provided in figure 2.

It also includes an internal clock (without battery) with hundredths of a second precision. As it does not have a battery, it is necessary to set the time of relay when it is put into operation. In the event of a power loss, the clock will maintain date and time for two days.

2. APPLICATION

In its three versions (MLP1000, MLP2000, MLP3000 and MLP4000) the MLP is a distance relay whose application range is in sub-transmission and distribution lines, in power levels of up to 66 kV and exceptionally up to 132 kV in lines with 3 phase trip.

The MLP 1000 is the basic model of distance protection. It's main purpose is to replace directional overcurrent relays, in cases where the overcurrent relay on its own (the reach varies depending on the installed network voltage) has difficulties obtaining a good selection level with another network protections under any operation condition.

The MLP2000 model includes an additional programmable recloser of up to three reclosing attempts. This additional service lends an advantage over the MLP1000 as instead of using it only as a directional line relay it can also be used with relatively long lines where it is necessary to reinstall the service automatically.

The MLP3000 is the most sophisticated of the three models and includes a remote open detector, a fuse failure detector, and a fault locator. In additionally it contains an OSCILLOPERTURGRAFIC function and the possibility to be used with accelerated trip schemes in zone 2 (through carrier communications or other procedures to perform a logical trip). These advantages, make it very appropriate even in transportation networks in isolated systems and with voltages of up to 132 kV. It can be used in emergency situations with higher voltages, due to the fact that it is a relay with dedicated functions, but factors such as trip speed and other incorporated back-up functions might make other relay models such as the DLP, TLS and PLS more appropriate for these voltages.

The MLP4000 includes, in addition to the features of the MLP 1000, the oscilloperturgrafic function.

3. CHARACTERISTICS

3.1 GENERAL CHARACTERISTICS

- Accuracy, reliability and low consumption.
- Flush mounting.
- LED indicator for READY status.
- Built-in keyboard and display.
- Highly reliable solid state component.
- Microprocessor system.
- Self-checks (monitoring).

MODEL SELECTION

MLP	*	*	*	*	M0	*	0	*	00	*	DESCRIPTION
	1 **2** **3** **4**										MLP1000 Family MLP2000 Family MLP3000 Family MLP4000 Family
		0 **1**									Without test block (optional) With test block (standard)
			1 **5**								In=1A In=5A
				 1 **2** **3** **4**							**Communications** Keyboard and RS232 Keyboard and 1mm plastic F.O. Keyboard and 100/140 glass F.O Keyboard and 50/125 glass F.O.
						 0 **1** **2**					**Vaux inputs** 48 VDC 125 VDC 220 VDC
								G **H**			Vaux=48/125 VDC Vaux=110/250 VDC
										A	Revision Level

The MLP relays are structured in three different families which include each of the features listed below:

MLP 1000:

Three distance protection zones
Scaled distance protection scheme.
Zone 1 extension protection scheme
Out of step blocking
Fuse failure detector
Line Pick Up
Event register

Current or power log
Communications

MLP2000:

Features similar to those shown for MLP 1000 plus the reclosing operation.

MLP3000:

Features similar to those shown for MLP2000 plus following additional functions:

Zone 2 acceleration (with channel)
Fault locator
Oscillography register
Fault report

3.2. TECHNICAL SPECIFICATIONS

Rated Current: In = 1 A or 5 A
Rated Voltage: Vn = 110/√13 ± 20% VAC at 50 Hz
120/√13 ± 20% VAC at 60 Hz

Frequency: 50 Hz or 60 Hz (switchable)

Auxiliary Power: 48/125 ± 20% VDC
110/250 ± 20% VDC

Auxiliary Voltage Inputs: 48 ± 20% VDC
125 ± 20% VDC
220 ± 20% VDC

Thermal capacity:

Current Circuits:
Continuous: 4 x In
During 3 sec: 50 x In
During 1 sec: 100 x In

Voltage Circuits:
Continuous: 2 x Vn
During 1 min: 3.5 x Vn

Temperature Range:

Operation: -20°C to +55°C
Storage: -40°C to +65°C

Ambient Humidity: Up to 95% without condensation

Trip contact capacity:

Make and Carry: 3000 W resistive during 0.2 seconds with a maximum of 35 A and 380 VDC.

Break: 150 W resistive, with a maximum of 8 A or 380 VDC.

Carry Continuously: 8 A.

Make/Break delay: 10 ms/ 4 ms

Transmission start contact (REED relay):

Break: 20 W with 0.5 mA maximum or 500 VDC maximum
Make delay: 0.5 ms

Auxiliary contacts:

Operating Capacity: 1760 VA resistive with 8 A maximum or 380 VAC or 250 VDC maximum
Connection Time: 12 ms (approx.) Release Time: 10 ms (approx.)

Communications:

Plastic Fiber Optics 1 mm:

Typical emitted power -8 dBm
Receiver sensitivity -39 dBm
Numerical aperture N.A. = 0.5
Wave Length 660 nm (visible red)

Crystal Fiber Optics 100/140:

Typical emitted power -11.5 dBm
Receiver sensitivity -25.4 dBm
Numerical aperture N.A. = 0.3
Wave length 820 nm (near infrared)
Connector type SMA

Crystal Fiber Optics 50/125:

Typical emitted power -17.5 dBm
Receiver sensitivity -25.4 dBm
Numerical aperture N.A . = 0.2
Wave length 820 nm (near infrared)

Type Tests:

Insulation test:
2 kV 50/60 HZ during 1 min (IEC 255-5).

Impulse test:
5 kV peak 1.2/50 aes, 0.5 J (IEC 255-5).

1 MHz noise test:
2.5 kV common mode. 1 kV differential mode, Class III (IEC 255-22-1)

Electrostatic discharge:
Class III (IEC 255-22-2)

Radio Interference:
Class III (IEC 255-22-3).

Fast Transient:
Class III (IEC 255-22-4).

Accuracy:

Operation values:±5%
Operation time: ±5% or 30 ms (whichever is greater)

Number of zones:
Three zones (I, II, and III) and one dependent on zone I (extended zone I)

Operating characteristics:

Zone I, extended zone I. and zone II:

Ground faults: Reactance or variable mho (selected by user).

Fault between phases: Variable mho.

Characteristics angle for the reactance characteristic:

70° to 90° in 0.5° steps.

Reach setting:

Zone I:	(0.01 - 12)x5/InΩ
Extended zone I:	1 to 2 times the zone I reach
Zone II:	(0.01 - 50) x 5/In Ω
Zone III:	(0.01 - 50) x 5/In Ω

Homopolar sequence compensation factor:

1 to 7 in steps of 0.1

Positive sequence angle: 10° to 90° in 0.5° steps
Homopolar sequence angle: 10° to 90° in 0.5° steps

Operating time setting:

Zone I: 0 to 500 ms in 1 ms steps
Zone II: 100 ms to 3 s in 1 ms steps
Zone III: 120 ms to 10 s in 1 ms steps

Protection Schemes: Scaled distance
Zone I extension
Zone II acceleration (requires communications channel)

The scaled distance protection scheme is active even if one of the other two protection schemes is selected.

RECLOSER SETTING RANGES (MLP2000 and MLP 3000)

Number of recloses: 0, 1, 2, 3 (setting 0 disables the recloser)

Reclosing time:	From 0.2 to 99s in 0.01s steps
Closing time:	From 0.1 to 99 s in 0.01 s steps
Reset time:	From 0.1 to 99 s in 0.01 s steps
Delay time:	From 0.1 to 99s in 0.01 s steps

OSCILLOGRAPHIC REGISTER (MLP3000 and MLP4000)

Number of oscillograms: 7
Number of cycles per oscillo: 240

DIMENSIONS

1 four height standard 19" rack

3.3 SETTINGS RANGES AND VALUES

General settings:

001 IDENTIFICATION:

20 characters ASCII to identify each MLP unit. The identification can be modified only through serial communications with the relay. It cannot be modified from the keyboard

002 BREAKER NUMBER:

4 characters ASCII to identify the breaker associated with each MLP unit. As with the identification, the breaker number can be modified only via serial communications, not from the keyboard.

101 LINE DISTANCE:

The fine distance protected by the MLP system, can be set from 0.4 at 150 km, in steps of 0.01 or 0.4 at 90 miles, in steps of 0.01, depending on relay configuration.

102 CT RATIO:

Variable between I and 4000, ~n steps of 1.

103 PT RATIO:

Variable between I and 4000, in steps of 1.

104 RECORD TYPE:

Select between current log or power log. (see 4.15)

105 SYSTEM FREQUENCY:

Select between 50 Hz or 60 Hz depending on system to be protected.

106 ALLOW RECLOSER INHIBITION INPUT (IN_R): (MLP2000 and MLP3000)

Enable or disable.

107 ALLOW EXTENDED Z1 PULL BACK INPUT (RZ1X):

Enable or disable.

108 ALLOW CARRIER RECEIVER INPUT (RCVR): (MLP3000)

Enable or disable.

109 ALLOW RECLOSER CANCEL INPUT: (MLP2000 and MLP3000)

Enable or disable.

110 ALLOW RECLOSING INITIATE INPUT (R_I): (MLP2000 and MLP3000)

Enable or disable.

111 ALLOW LINE PICK UP INPUT (LPU):

Enable or disable.

112 ALLOW TRIP BLOCK INPUT (TRP_B):

Enable or disable.

113 ALLOW BREAKER STATUS INPUT (52B):

Enable or disable.

114 AMPS ACCUMULATED IN BREAKER OPENINGS:

Adjustable from 0 to 100.000 (kA2), in steps of 1. Each time the breaker is opened, (kA2) is incremented by the number passing through the three phases at the moment of opening. (See 4.16)

115 MAXIMUM ACCUMULABLE AMPS IN BREAKER OPENINGS

Adjustable from 0 to 100.000 (kA), in steps of 1. When the accumulated value exceeds maximum an alarm is triggered. (See 4.6)

Protection Settings:

201 OUT OF STEP BLOCKING (OSB) IN SERVICE

Enable/Disable fine pick out function

202 LINE PICK UP (LPU) IN SERVICE:

Enable/Disable fine pick up function.

203 REMOTE OPEN DETECTOR (ROD) IN SERVICE: (MLP3000)

Enable/Disable remote open detector function.

204 FUSE FAILURE (FF) IN SERVICE:

Enable/Disable fuse failure function.

205 ALLOW RECLOSES AFTER A TRIP IN ZONE 2: (MLP3000 and MLP2000)

Enable/Disable.

206 ALLOW RECLOSES AFTER A TRIP IN ZONE 3:(MLP3000 and MLP2000)

Enable/Disable

207 MHO OR REACTANCE CHARACTERISTIC:

Select the mho of reactance characteristic for the phase-ground distance measuring units in zone 1, extended zone 1 and zone 2.

208 PROTECTION SCHEME:

Select between the following protection schemes:

0 - Scaled distance.
1 - Zone 1 extension.
2 - Zone 2 acceleration. (MLP3000)

When selecting scheme 1 or scheme 2, scheme 0 is also selected.

209 PROTECTION IN SERVICE:

Enable or disable the MLP distance protection.

210 ALLOW TRIP CAUSED BY REMOTE OPEN DETECTOR:(MLP3000)

Enable or disable.

211 ALLOW TRIP CAUSED BY A LINE PICK UP:

Enable or disable.

212 GENERAL TRIP AUTHORIZATION:

Even though certain types of trips are allowed, if the general trip authorization is disabled all trips remain disabled.

213 ALLOW ZONE 3 TRIPS:

Enable or disable.

214 ALLOW ZONE 2 TRIPS

Enable or disable.

215 ALLOW ZONE I TRIPS:

Enable or disable.

216 LPU TIMER FUNCTION:

Even though the setting is variable between 0 and 150 ms, in 1 ms steps, for design reasons it is recommended to set it to 128 ms. (See 4.5)

217 OSB TIMER FUNCTION:

Variable between 40 and 200 ms, in 1 ms steps. (See 4.8)

218 ROD TIMER FUNCTION: (MLP3000)

Variable between 0 and 150 ms, in I ms steps. (See 4.6)

219 POSITIVE SEQUENCE LINE IMPEDANCE MODULE:

Variable between 0.01 and 12x5/In Ohms, in 0.001 Ohm steps.

220 POSITIVE SEQUENCE ANGLE OF MAXIMUM REACH:

Variable between 10° and 90°, in 0.50 steps.

221 ZERO SEQUENCE CURRENT COMPENSATION:

The zero sequence impedance module may be between 1 and 7 times the positive sequence impedance module, in 0.01 Ohm steps.

$$K_O = \frac{Z_{OL}}{Z_{IL}}$$

222 ZERO SEQUENCE ANGLE OF MAXIMUM REACH:

Variable between 40 and 90, in 0.5 steps.

223 ZONE 1 REACH:

Variable between 0.01 and 12x5/In Ohms, in 0.001 steps.

224 EXTENDED ZONE 1 REACH:

Variable between 1 and 2 times Zone 1 reach, in 0.01 Ohm steps.

225 ZONE 2 REACH:

Variable between 0.04 and 50x5/In Ohms. in 0.001 Ohms steps.

226 ZONE 3 REACH:

Variable between 0.01 and 50x5/In Ohms, in 0.001 Ohms steps (although not used, you must set this higher than Z 1).

227 REACTANCE CHARACTERISTIC ANGLE:

In case of selecting the minimum reactance for the phase-ground distance measuring unit in Zone 1, the characteristic angle may vary between 70° and 90°, in 0.5° steps.

228 ZONE 1 TRIP TIMER:

Variable between 0 and 500 ms in 1 ms steps.

229 ZONE 2 TRIP TIMER:

Variable between 100 and 3000 ms in 1 ms steps.

230 ZONE 3 TRIP TIMER:

Variable between 100 and 10000 ms in 1 ms steps

231 CURRENT SUPERVISION THRESHOLD (IØs):

Distance measuring units are not permitted to operate under this threshold adjustable between 0.15 and 3.00 times the rated voltage in 0.01 steps. This threshold is typically set to 0.15 (See 4.3. DMU overcurrent supervision)

232 LPU OVERCURRENT THRESHOLD (IØld):

Above this threshold adjustable between 0.15 and 3.00 times the rated current in 0.01 steps, the LPU operates when engaged; typically set to 3 00. (See 4.5)

Recloser settings:

301 NUMBER OF RECLOSING ATTEMPTS: (MLP2000 and MLP3000)

The number of reclosing attempts can be programmed up to a maximum of three. If the number of attempts is set to 0 the recloser disables itself.

302 RECLOSING WAIT CONDITIONS: (MLP2000 and MLP3000)

Wait until reclosing inhibit signal disappears once it has been initiated. (See 4.9)

303 TIME DELAY FOR THE FIRST RECLOSING ATTEMPT: (MLP2000 and MLP3000)

Variable between 0.20 s and 99.00 s, in 0.01 s steps. (See 4.9)

304 TIME DELAY FOR THE SECOND RECLOSING ATTEMPT: (MLP2000 and MLP3000)

Variable between 0.20 s and 99.00 s, in 0.01 s steps.

305 TIME DELAY FOR THIRD RECLOSING ATTEMPT: (MLP2000 and MLP3000)

Variable between 0.20 s and 99.00 s, in 0.01 s steps.

306 TIME DELAY FOR RECLOSING CONDITIONS: (MLP2000 and MLP3000)

Variable between 0.10 s and 99.00 s, in 0.01 s steps. (See 4.9)

307 DWELL TIME: (MLP2000 and MLP3000)

Variable between 0.10 s and 99.00 s, in 0.01 s steps. (See 4.9)

308 RESET TIME: (All models)

Variable between 0.10 s and 99.00 s, in 0.01 s steps. (See 4.9)

Event Masks:

003 EVENT MASKS:

Allow or disallow which events are registered for each of the following causes.

- Zone 1 trip.
-- Extended Zone 1 trip.
- Zone 2 trip.
- Extended Zone 2 trip.
- Accelerated Zone 2 trip.
- Zone 3 trip.
- ROD trip.
- LPU trip.
- Manual trip order.
- Manual trip closing order.
- Breaker open.
- Breaker close.
- Failure opening the breaker.
- No closing conditions.
- Failure closing the breaker.
- Permanent fault.
- Recloser manually blocked.
- Recloser manually unlocked.
- Fault cleared.
- Reclosing initiation.
- Disable ~2 B input.
- Disable external blocking trip.
- Disable line pick up input.
- Disable reclosing initiation input.
- Disable reclosing cancel input.
- Disable extended Zone 1 pull back input.
- Disable reclosing inhibition input
- Any measuring unit activation.
- Fuse failure.
- Carrier transmission
- Carrier reception.

- Cold boot.
- Warm boot.
- Settings changed.
- Relay synchronization.
- Clear event file.
- Default settings.
- Default calibration.
- Current detected while breaker open.
- Power supply failure.
- Power supply restored.
- Event file deteriorated.

3.4 INTERRELATIONS BETWEEN SETTINGS

When setting the MLP distance relay you must take into account that the relay will not only reject values which are outside of the permissible range, it will also reject setting that are not coherent with the other setting . Therefore, when setting the MLP it is also necessary to consider the relationship between the following setting:

General Settings:

106 ALLOW RECLOSER INHIBITION INPUT (IN_R): (MLP2000 AND MLP3000)

You may not disable this setting if the setting 302 RECLOSING WAIT CONDITIONS has been set to YES.

108 ALLOW CARRIER RECEIVER INPUT (RC\TR): (MLP1000)

You may not disable this setting if the setting 208 PROTECTIONS SCHEME has been set to zone II acceleration.

114 AMPS ACCUMULATED IN BREAKER OPENINGS

You may not set this setting to value greater that set for 115 MAXIMUM ACCUMULABLE AMPS IN BREAKER OPENINGS.

Protection Settings:

205 ALLOW RECLOSES AFTER A TRIP IN ZONE II: (MLP2000 AND MLP3000)

In the MLP 3000 model this setting permits recloses after a ROD trip.

218 ROD TIMER FUNCTION: (MLP3000)

You may not set this setting to value greater that set for 229 ZONE II TRIP TIMER.

223 ZONE I REACH

You may not set this setting to value greater that set for 226 ZONE III REACH.

225 ZONE II REACH

You may not set this setting to a value greater that set for 226 ZONE III REACH.

228 ZONE I TRIP TIMER

You may not set this setting to value greater that set for 230 ZONE III TRIP TIMER minus 20 ms.

229 ZONE II TRIP TIMER
You may not set this setting to value greater that set for 230 ZONE III TRIP TIMER minus 20 ms.

Recloser settings:

303 TIME DELAY FOR THE FIRST RECLOSING ATTEMPT
304 TIME DELAY FOR THE SECOND RECLOSING ATTEMPT
305 TIME DELAY FOR THE THIRD RECLOSING ATTEMPT (MLP2000 and MLP3000)

The reclosing time must not be set to a time less than the opening time of the installed breaker; by doing so reclosing procedures cannot be performed since the recloser, the recloser will be blocked at the end of a reclosing time and the breaker will be closed instead of open.

308 RESET TIME: (All models)

When the setting 208 PROTECTION SCHEME has been set too ZONE I EXTENSION, you may not set this timer to a value less than that set for 229 ZONE II TRIP TIMER.

4. PRINCIPLES OF OPERATION

4.1 INPUTS

The external connections of the MLP protection system can be seen in diagrams 3.1, 3.2, 3.3 and 3.4 (MLP1000), 3.5, 3.6,3.7, and 3.8 (MLP2000), 3.9, 3.10, 3.11, and 3.12 (MLP3000).

Digital Inputs

The protection system includes the following digital inputs:

CC-1: Breaker status (52/b)
CC-2: External trip block (to the protection system)
CC-3: Line pick up (to the protection system)
CC-4: Reclosing initiate (to the recloser /MLP2000 and MLP3000)

CC-5: Reclosing block (to the recloser /MLP2000 and MLP3000)
CC-6: Carrier reception (to the protection /MLP3000)
CC-7: Extended Zone I pull back (to the protection)
CC-8: Reclosing disable (to the recloser /MLP2000 and MLP3000)

Initiate reclosing and block reclosing signals may also reach the recloser from the protection system.

The extended zone 1 pull back signal may also reach the protection from the recloser.

If any input is damaged and the MLP reads that this input is changing more than 15 times per second, the MLP decides that this input has to be disabled, leaving it in a determined state. In this case an event is generated for disabling the input. The disabled inputs remain in the following states:

CC-1: Breaker.. Closed.
CC-2: External trip block............................ Inactive
CC-3: Line pick up.................................... Inactive
CC-4: Reclosing initiation........................... Inactive
CC-5: Reclosing block................................ Blocked
CC-6: Carrier reception............................... No reception
CC-7: Extended Zone 1 pull back unit........ Zone pulled back
CC-8: Reclosing inhibition........................... Inhibited

Analog current and voltage inputs

The voltage transformers of the protected line supply a secondary phase-ground voltage which is applied to the relay input and reduced by internal voltage transformers whose secondary voltages provide input voltage to the protection system.

The current transformers of the protected circuit supply a secondary current of up to 160 A which is applied to the relay input and reduced by the internal power transformers. The secondary currents of the relay's internal transformers are connected to input resistance which supply voltage that represents the current of the protection .

The relay input voltages as well as the voltages that represent the input current to the relay pass through lowpass filters (with a 250 Hz break frequency to eliminate high frequencies that can produce "aliasing" on the software filters of 50 Hz or 60 Hz before reaching a multiplexer and a variable amplification stage.

The amplified output reaches an analog/digital converter in which the power and voltage are instantly measured.

4.2 CURRENT AND VOLTAGE MEASURING

The internal microprocessor timer generates an interrupt every 1.25 ms (50 Hz) or every 1 ms (60 Hz) so there are 16 interrupts per network cycle. In each interrupt a multiplexer is used to obtain the instantaneous samples of the three phase currents and the three ground-phase voltages from the analog/digital converter . These samples are corrected according to the gains applied during the extension period.

The fundamental component phasors for the for the three currents and phase voltages are obtained (in rectangular coordinates) from the instantaneous samples and previous samples using a phasor identification algorithm based on the "minimum squares algorithm".

4.3 DISTANCE MEASURING UNITS (DMU)

The relay has 18 distance measuring units, however the zone 1 and zone 2 units are not activated simultaneously:

Zone 1: AG, BG, CG, AB, BC, CA.
Zone 2: AG, BG, CG, AB, BC, CA.
Zone 3: AG, BG, CG, AB, BC, CA.

The measuring units operating characteristics are:

Phase-ground faults:

Reactance or MHO variable (switchable) in zones land 2, MHO variable in Zone 3 that supervises. reactance operations, when selected.

Phase-phase faults:

MHO variable in the three zones.

The operation and polarization quantities used in the reactance units for ground-phase faults, in zones 1 and 2 are:

Fault	Quantity Operation	Polarization Qty.
ØG	I'Øx Zr - Vøn	IØ2 x Xr

The quantities used in the mho units for phase-ground faults, in zones l, 2 and 3 are:

Fault	Quantity Operation	Polarization Qty.
ØG	I'Øx Zr - Vøn	VØ1m

The quantities used in the mho units for faults between phases, in all zones are:

Fault	Quantity Operation	Polarization Qty.
ØØ	IØØx Zr	VØØ1m

Where: I'Øx Zr = (IØ - I0) x Zr/Θ1 + K0 x I0 x Zr/Θ0

Zr: Set impedance reach.
Xr: Relay reactive angle of maximum reach.

VØn:	Phase-ground voltage
VØ1m:	Positive sequence voltage with memory related to the 0 phase
IØ:	Phase current.
I0:	Zero sequence current
Θ1 :	Angle of the positive sequence line impedance
Θ0:	Angle of the zero sequence line impedance
K0:	Zero sequence compensation constant
IØ2:	Negative sequence current related to the 0 phase
IØØ:	Current difference between phases
VØØ:	Phase to phase voltage
VØØ1:	Positive sequence voltage related to a given pair of phases.

Operation and Polarization quantity comparisons.

The operating condition for the circular mho characteristics and minimum reactance plane characteristics is based on the difference between the operating quantity and the polarization quantity between +90° and -90°:

$$-90° < ANG (Mag\_Op) - ANG (Mag\_Pol) < +90°$$

The fault condition for the minimum reactance characteristic (minimum reactance tent function) is based on the difference of the arguments of the operating quantity and the polarization quantity between $+\alpha$ and $-\alpha$, with a< 90°: (setting n° 226)

$$-\alpha < ANG(Mag\_Op) - ANG(Mag\_Pol) < +\alpha$$

Overcurrent supervision of the DMU

The ground fault measuring units are supervised by IØs detectors.

The phase to phase fault measuring units phases are supervised by IØØs detectors.

This way, although the difference of the operation and polarization quantity arguments, for example, of the AG unit, is between +90° and -90°, if the phase A current A does not exceed the set current threshold, the AG distance measuring unit will not be activated.

IØs: Phase to ground overcurrent detectors: the threshold is adjustable (typically 15% of In).

IØØs: Phase to phase overcurrent detectors; the threshold is adjustable (typically 15% of In).

Operating Security.

The MLP contains an algorithm, based on the operating quantity, which verifies the system trip decision. The main objective of the additional function is to avoid the transients that are produced by resistive voltage transformers which tend to produce overreaches. This algorithm generally avoids overreaches for fault that are close to the limit of the first zone. The programmed delay for this algorithm, which is exclusively for faults close to the limit of the first zone, is 15 ms).

4.4 PROTECTION SCHEMES

The MLP includes three protection schemes:

0 - Scaled distance:
Three line distance protection Zones for faults between ground-phase and phases.
1 - Zone 1 extension.
2 - Zone 2 acceleration. (MLP3000)

The last two schemes cannot be selected simultaneously and the first one is active when selecting one of the other two.

The protection logic can be seen in the block diagram of figure 4. The trip decision logic can be seen in figures 5.1, 5.2, 5.3 and 5.4. The protection schemes for zone 1 extension and zone 2 acceleration can be seen in figures 6.1 and 6.2.

Scaled distance

To better understand the scaled distance scheme, we will discuss how the protection operates under five different situations:

1 - Fault inside the zone 1 reach.
2 - Fault inside the zone 2 reach

3 - Fault inside the zone 3 reach or overreach.
4 - Remote open detector.
5 - Line pick up.

Since it is a three phase trip protection, the type of fault detected (single phase, two phase, or three phase) is irrelevant at the time of the tap decision. therefore the type of fault is not mentioned.

When setting the different timers you must take into account the operating time of the measuring units (1 network cycle). So when setting the zone I timer to 0 ms (instantaneous trip) the relay takes 1 network cycle to detect a fault and 8 ms to close the trip contact.

1 - Fault inside the zone 1 reach

In the case of a fault inside the zone 1 reach, any of the 6 distance measurable units in zone 3 or overreach as well as the 6 distance measuring units in zone 1 will detect the fault

Once the protection trip is produced, the process is identical to that of the previous fault.

3 - Fault inside the zone 3 reach and outside the zone 2 reach

In the case of a fault inside the zone 3 reach, zone 1 distance measuring units will not detect the fault, ho•ever zone 3 distance measuring units will detect the fault. After activating the "DMUZ3 ACTIVE" signal the protection is activated and the zone 2 and zone 3 timers are started.

The zone 2 timer will be the first to finishing counting and will deactivate the zone 1 distance measuring units and activate those of zone 2. At this moment the zone 2 measuring units will continue without detecting the fault and will have to wait until the end of the zone 3 timer count to allow a protection trip in zone 3 provided that the block trip in zone 3 is not set, in which case the protection is returned to standby.

Once the protection trip is produced, the process is identical to those of the previous fault.

4 - Remote open detector

Activation of the remote open detector unit directly authorizes a protection trip. provided that the block trip by remote open detector is not set, in which case the protection is returned to standby.

Once the protection trip is produced, the process is identical to those of the previous fault.

5 - Line pick up

Activation of the line pick up unit directly authorizes a protection trip.

Once the protection trip is produced, the process is identical to those of the previous fault.

Zone 1 extension

The zone 1 extension scheme covers the part of the line not covered by the zone 1 reach (typically 20% of the line length).

channel.

The advantage of this scheme over the others is that it does not require a transmission

When this scheme is enabled, the zone 1 reach 110%-120% of the line length (extended zone 1 reach) therefore the whole line in zone 1 is protected, however, external faults of up to a 20% outside the line length, will cause a trip in extended zone. After a trip of this type, recloser will pull extended zone 1 back to zone 1, therefore after the reclosing, these types of faults will not trigger a trip in zone 1.

Acceleration in Zone 2 (MLP3000)

The zone 2 acceleration scheme covers the part of the line not covered by the zone I reach (typically 20% of the line length).

This scheme requires a transmitting and receiving channel. When using this scheme, the channel is activated by the detection of a fault in zone 1.

Let's suppose a fault at 95% of the line length, with the zone I reach set to 80% of the line length. In this case, relay A (see figure 6.2) will not detect a fault in zone 1 but as relay B will detect a fault in zone 1 it activates the transmission channel, therefore when relay A receives the signal through the channel it extends reach in zone 1 zone 2 and detects the fault in zone.

The transmission time is one network cycle to perform the MUZ 1, plus 0,5 ms to close the transmission contact, plus the propagation time (depending on the conductor and the length of line).

4.5 LINE PICK UP UNIT (LPU)

This function allows instantaneous breaker tripping caused by overcurrent during a line close fault when the relay has not been previously polarized (voltage transformers are connected to the breaker side of the line, with the extreme remote being open). A digital input is included which informs the protection that a close breaker order has been produced. The closing operations performed through the relay itself are also supervised by this function.

The logic of the line pick up tripping unit is included figure 4 and figure 7.

The level of the Iild overcurrent detectors will be a setting (typically 3 * In) and the time used for testing the overcurrent (typically 128 ms).

4.6 REMOTE OPEN DETECTOR UNIT (ROD) (MLP3000)

The remote open detector unit operates when the breaker on the remote side opens during an unbalanced internal fault. This characteristic allows the accelerated isolation of faults. In the absence of this unit, a sequential trip will be provoked.

In this Way it allows a rapid trip in the local extreme, for faults inside the line but outside zone 1 reach without using a communications carrier. For example, let's see how a fault is cleared in 95% of the line:

The local relay will detect the fault in zone 3 and start the zone 3 and zone 2 timers. Meanwhile the remote extreme detects the fault in zone 1 and orders a trip. When the remote breaker has been opened, it is detected by the local relay and once the ROD timing has terminated a remote open detector trip is performed.

We need to keep in mind that if the tripping time plus the time to open the remote breaker plus the ROD timing is greater then the zone 2 timing, the local relay will perform a zone 2 trip and not a ROD trip. For ROD timing keep in mind that ROD units as well as distance measuring units take 1 cycle to operate.

This unit does not work for three phase faults, since the information to detect that the remote extreme is open reaches the local extreme through a vectoral change of t]1C line current in any of the "healthy" phases.

Figures 8.1 and 8.2 illustrate the algorithm for remote open pole detection. This algorithm is based on the fact that the impedance of a "healthy" line whose extreme remote is open is purely capacitive.

4.7. DISTURBANCE DETECTION UNIT (DD) (MLP3000)

This function assists in the detection of a fuse failure and the starting of the oscillographic register. Its purpose is to detect faults before they are detected by the distance measuring units, based on the detection of the fault positive sequence current.

Figures 9.1 and 9.2 illustrate the algorithm for disturbance detection.

4.8 FUSE FAILURE UNIT (FF) (MLP3000)

The fuse failure detector of the voltage transformers is designed to operate when one or two phases of the alternating voltage is lost. This situation may be interpreted by the distance measuring units as a fault and provoke a trip in the absence of a fault. Therefore the detection of a fuse failure blocks any protection trip.

This unit can be disabled by it's corresponding setting.

In addition to this, a digital input allows the exterior blocking of the trips. This input is used when a MAGNETOTERMICO with auxiliary contact is used in place of fuses in the voltage circuits. This contact is wired to the mentioned input to avoid an unsuitable trip during MAGNETOTERMICO operation and the subsequent loss of the voltages.

Figures 10.1 and 10.2 illustrate the algorithm for fuse failure detection.

4.9 RECLOSER (MLP2000 and MLP3000)

The reclosing unit permits up to three reclosing attempts of the line breaker. The number of attempts is programmable between 0 and 3, with 0 indicating that the reclosing unit is disabled.

The recloser includes a counter that increments the count each time it reaches the closing time state.

The MLP recloser includes a set of digital inputs and outputs which permits it's use with an external protection independent of the MLP.

Logic:

The description of the MLP recloser logic can be seen in figures 11.1, 11.2 and 11.3.

The recloser inputs and outputs are:

Inputs:

- Breaker status (52/b)	-> CC-1
- Initiate reclosing (IR)	-> CC-4
- Reclosing blocked (BR)	-> CC-5
- Reclosing inhibition (INR)	-> CC-8
- Manual block (L/O_ M)	-> Via communications
- Manual unblock (RST_L/O_M)	-> Via communications

The IR and BR signals may arrive from the protection itself or from the exterior via the contact converters CC-4 and CC-5 respectively.

The 52/b and INR signals arrive via the contact converters CC-1 and CC-8 respectively.

The L/O_M and RST_L/O_M arrive through a command via the relay keyboard or the remote communications system.

Outputs:

- In progress (CC).
- Fault cleared (FD).
- Breaker closed (reclosing) (RCL).
- Recloser blocked (L/O).
- Extended Zone 1 pulled back (RZIX).

Of these signals only the reclosing or close signal include non-programmable contacts; the other four may be used as external signals by the communications system, (remote communications or relay display) or through programmable contacts, or may remain as internal signals.

Internal States:

The internal states that describe how the recloser functions, in accordance with the mentioned diagrams, and the variables that are activated in each one of them are:

Disable:

The recloser is disabled is this state, as if it did not exist. None of the outputs will be activated.

Standby:

The recloser remains in this state until reclosing initiation is performed. None of the outputs will be activated.

Reclosing time (N):

These are the programmed times (N) for each of the reclosing times . Waits for the programmed reclosing time for the fault to clear before reclosing. CC is activated.

Delay time:

If at the moment of reclose the INR signal (inhibit reclose) is active and a delay is programmed, the recloser waits during the programmed time for the disappearance of the inr signal.

Closing time:

This is the programmed vigilance time for a successful reclose. If the breaker does not close the recloser will block. I f the breaker closes, the timer is reset to wait for the next reclose. Waits the programmed time for the breaker to close. CC and extended zone I pull back are active.

Reset time:

The programmed time that passes from the time a successful reclose until returning to the stand-by state. This timer is also used to exit a blocked state and move into the stand-by state, and finally for the vigilance of a successful close after a manual order.

L/O (Lock-out):

Corresponds to open line status or to an unsuccessful cycle for any of the following causes: a permanent fault, a failure closing the breaker, a reclosing attempt with the inhibition input active, a failure opening the breaker, or having the recloser blocked by the protections or the C-5 contact converters. The L/O and extended Zone I pullback outputs will be active. This state is exited if, while the breaker is closed. a start reclose does not occur during the security time.

Manual L/O.

State similar to the previous state, but the only way to enter into or exit from it is by performing a block operation. The L/O and extended Zone I pullback signals will be active.

Once in this state, even after a system power failure, you remain in this state.

Reclosing cycle initiation

For the recloser to be in standby, the breaker must be closed and a manual reclosing block must not be active.

Once the initiate reclosing cycle signal is activated (caused by the protection or externally), the recloser leaves the standby state reclosing time corresponding to the first programmed reclosing starts.

When the reclosing time ends, the reclosing counter is incremented, a close breaker order is issued and the closing time begins.

If the closing time ends, and the closing of the breaker is not detected the Lock-out estate is activated (recloser blocked).

On the contrary, if the closing of the breaker is detected before the closing time ends, the reset time will begin.

If the reset time ends and a new initiate reclosing cycle signal is not issued, a clearing fault is issued and the recloser returns to standby.

On the contrary, if the initiate reclosing cycle signal is issued during the reset time, the closing time for the next programmed reclosing will begin.

If during a reclosing cycle a reclosing block signal appears (by the protection or externally) the reclosing process is aborted and the recloser passes to the Lock-out state.

4. 10. DIRECTION INDICATOR

The MLP has a phase direction indicating unit that provides information of whether the direction of the current circulating through the line is in the trip direction or the opposite direction.

The measurement is obtained by measuring the lag between the voltage and the phase current

The direction indicator is activated when the phase difference between V0 and I0, is less than 90°

The direction indicator remains deactivated when the phase difference between VØ and IØ, is greater than 90°.

The measurement updates the actual measurement unit status in 4/5 ms depending on the frequency (50 or 60 Hz).

When putting the relay into service, this function allows you to check that the voltages and currents are properly connected.

4.11 MLP STATUS

You can request the MLP status which will provide general information about the status of the protection, relay model and version, actual values (modules) of the phase voltages, phase and zero sequence currents (VA, VB, VC, IA, IB, IC, I0) and the date and time.

The protection status can be requested through the remote communications channel or through the MMI, in which case the protection will return all of the values and the date and tine label.

The protection general status information consists of:

* Model and version of the MLP unit.
* Date and time.
* General status of the MLP:
    Trip signal:
        by ROD.
        by LPU.
        in Zone 3.
        in Zone 2.
        in Zone 1.

    Protection enabled or disabled.
        Recloser status Breaker status.
        Phase A direction indicator
        Phase B direction indicator.
        Phase C direction indicator.

* Voltage and current module

I0.
IA.
IB.
IC.
VA.
VB.
VC.

* Alarms:
  A critical error exists.
  15V power in the danger zone.
  Breaker needs maintenance.
  Current passing with the breaker open.
  No clock:: needs synchronism.
  DEFAULT SETTINGS.
  DEFAULT CALIBRATION.

* Relay inputs
  Recloser inhibition.
  Extended Zone 1 pullback.
  Reclosing block.
  Reclosing initiate.
  Line pick up.
  External trip block.
  Channel reception.

* Selectable relay outputs.

* Measuring units signals:
  Z 1 extended to Z I X.
  Zone 2 activation.
  LPU unit.
  FF unit.
  ROD unit.
  Anv zone 3 distance measuring unit.
  DD unit.
  Any zone 1 distance measuring unit.

4.12 EVENT REGISTER

The MLP includes an event register that stores all actions performed within the relay, whether by the relay itself or by external operation.

Each event consists of:

* Cause that generated the event.

* Date-time: day, month, hour, minute, second and hundreds of a second.

* MLP general status:
Hardware critical error exists.
Breaker status, open or closed.
Protection enabled or disabled.
Recloser blocked.
Recloser in service.
Recloser in standby.

* Voltages and currents passing through the three phases and the neutral at that moment, expressed as secondary values (modules).

* Status of the 12 distance measuring units (Z 1/Z2 and Z3).

Up to 240 events are stored; new events, above this number, overwrite the least recent events. The events can be requested by dates.

Events can only be deleted via serial communication. never through the relay keyboard.

Events are stored in the EEPROM so that they will not be lost in the event of a power supply failure

The types of events registered are:
- Zone 1 trip.
- Extended zone 1 trip.
- Zone 2 trip.
- Accelerated zone 2 trip.
- Zone 3 trip.
- ROD top.
- LPU trip.
- Open order
- Close order
- Opening of the breaker.
-- Closing of the breaker.

- Recloser blocked due to opening failure.
- Recloser blocked due to closing conditions fault.
- Recloser blocked due to by closing failure.
- Recloser block due to permanent fault.
- Recloser manually blocked.
- Recloser manually unblocked.

- Fault successfully cleared.
- Reclosing initiate.

- Breaker status input (57B) disabled.
- External trip block input disabled.
- Line pick up (LPU) input disabled.
- Initiate reclosing input disabled.
- Block reclosing input disabled.
- Z1X pull back input disabled.
- Reclosing inhibition input disabled.

- Any distance measuring unit operation.
- Fuse failure detection.
- Channel transmission.
- Channel reception.
- Cold boot.
- Warm boot
-- Settings changes.
-- Relay synchronism.
-- Delete events.
- Protection with default settings.
- Protection with default calibration.
- Current detected while breaker open.
-- ±15V power supply failure.
- Power supply restored.
- Event file deteriorated.

Due to the fact that some events are not relevant in certain cases, which events must be registered and which events must not, can be programmed via an event mask. The event masks can be set in the relay settings module.

Through the MLink program, the event log may be stored m a file and can be retrieved afterwards as an input data file for user programs.

4.13 OSCILLOGRAPHIC REGISTER.

The oscillographic register retrieves the seven most recent fault situations.

In case of a power loss, data saved in the oscillography recorder remain stored for at least two hours.

The start of the oscillograph will always be. for trip motives, initiated by the protection.

Each trip record retrieves, in the oscillograph, the following data during 30 cycles, 2 cycles prefault and 28 postfault. In addition it contains a fault report and the relay settings at the moment of fault.
Analog waves:

* Secondary current waves of phases: A, B. C.

* Secondary voltage waves of phases: A, B, C.

Digital signals:

- Reclosing disabled.
- Extended zone I pull back.
- Transmission reception.
- Reclosing block.
- Reclosing initiate.
- Line pick up.
- External trip block.
- Breaker status 52/b.

Recloser signals:

- Permanent fault.
- Failure closing the breaker..
- No closing conditions fault.
- Failure opening the breaker.
- Repetitive tripe.
- Recloser blocked.
- Reclosing cycle in process.
- Fault cleared.

Digital outputs:

- Transmission start.
- Extended zone 1 pull back.
- Closing of the breaker.
- Reclosing block.
- Reclosing initiate.
- Breaker failure initiate.

Measuring units:

- Z1 or Z2 measuring units activated.
- ROD trip.
- LPU trip.
- Fuse Failure.
- Zone 3 trip.
- Zone 2 trip.
- Zone I trip.

Zone 1 or zone 2 distance measuring units:

DMUZIAG, DMUZlBG, DMUZ1CG, DMUZ1AB, DMUZlBC, DMUZlCA.

Zone 3 distance measuring units:

DMUZ3AG, DMUZ3BG, DMUZ3CG, DMUZ3AB, DMUZ3BC, DMUZ3CA.

Fault report:

In the case of a trip the values mentioned below are saved as a fault report:

- Prefault values IA. IB, IC, and I0.
- Prefault values VA, VB and VC.
- Prefault values IA, IB and VC.
- Time label: date and time.
- Fault distance in km or Miles. (MLP3000 only)
- Fault type: AG, BG, CG, ABG, BCG, CAG, AB, BC, CA, 3PH.
- Type of trip (Z1, Z2, Z3, ROD, LPU)

Using the Mlink program, the events can be saved in an ASCII file, and afterwards they can be edited and the waves and flags can be displayed using the graphics processor MLPDATA.

4.14 FAULT LOCATOR (MLP3000).

This function provides, in each oscillographic register fault report, the location in the line where the fault has been produced and also what type of fault it is.

Phase selectors are used to determine the type of fault. These selectors are independent from the measuring units.

Once the measuring units have detected a fault in any of the zones protected by the relay and the protection has tripped, the phase selectors determine the type of fault based on the presence and angular relations of the sequence current.

Figure 12 shows the phase selectors algorithm:

This algorithm requires only the current phasors of the three phases. From these it obtains the zero sequence currents, positive and negative referenced to phase A (the algorithm may be applied in the same way for the sequence currents referenced to another phase).

This algorithm requires the line data and the fault currents and voltages.

4.15 CURRENTS OR VOLTAGE LOG.

The MLP program includes an hourly register of currents:

Each minute the MLP measures the current passing through phase A. The highest value from all of the measurements collected over one hour is saved, providing it does not surpass the value of 1.5 * In or any Zone III unit has activated (DMUZ3).

The hourly register saves the data registered for a week in a circular stack that when completed, automatically substitutes the oldest data by the newest. Data is saved in volatile RAM

If the MLP is not set to the right time, the hourly register stores current values every hour but based on values starting from the date and hour of the last registered event or in the case it does not exist, from the default date and time (01101/88, 00:00:00).

Through a setting it is possible to change the current log to a voltage log with these characteristics:

Each minute the active and reactive power is calculated:

$$P = 3 * (Vx * Ix + Vy * Iy) = 3 * |V| |I| \cos(90-\alpha)$$
$$Q = 3 * (Vx * Iy - Vy * Ix) = 3 * |V| |I| \sin(90-\alpha)$$

where:

P: Active power
Q: Reactive power
Vx, Vy: Real or imaginary components of the voltage corresponding to phase A.
Ix, Iy: Real or imaginary components of the current corresponding to phase A.

4.16 BREAKER SUPERVISION.

The breakers require maintenance depending on how often they are opened and with what current during certain periods of time. The MLP supervises the opening of it's associated breaker for maintenance purposes.

Each time the MLP detects a breaker opening it registers the maximum current of the phases. If the maximum current does not exceed the rated current, the rated current is used as the value. The MLP program calculates the square of the current and adds it to the values obtained In previous openings.

The MLP allows a limit to be set for this sum and when this limit is reached, it indicates that the breaker requires maintenance. It also allows you to set the value of the sum when associating a breaker that has been previously opened to the MLP.

4.17 SELF CHECKS AND ERROR ROUTINES.

The MLP performs the following self checks during startup as well during the idle time when protection and communications functions are not being performed:

–Analog digital converter.
–Power supply (15 V)
–Oscillographic (RAM) memory
–Working (RAM) memory
–(EEPROM) no volatile memory portion that includes the event register.
–EEPROM portion that includes the system configuration (settings and calibration)

If a critical error is detected during the startup tests the following actions are taken:

- the alarm is activated
- the outputs are disabled
- the protection and the recloser are taken off-line
- communications are enabled
- the protection is placed in an infinite program loop that cannot be exited until power is disconnected and w hen connected again the failure that caused the critical error disappears.

To indicate locally that the relay is in this program loop, the "READY" LED on the front panel of the relay is switched off and an error message is displayed on the monitor.

If a critical error is detected during the time when communications and protection operations are idle, the system is reset. If the critical error is detected during the reset initiation, the protection will enter into the infinite program loop described above.

Description of failures:

Critical errors:

–Analog/digital converter error.
–Non-recoverable power supply loss (15V)
–Working (RAM) memory error.
–Error in the part of the (EEPROM) no volatile memory that contains the system configuration, settings and calibration (see EEPROM errors).

Non critical errors:

–Oscillographic (RAM) memory error.
–Error in the part of the (EEPROM) memory that contains the event log.

Testing the A/D converters consists of measuring a reference voltage taken from +5 VDC. The failure for this test is considered critical.

The MLP uses two WATCHDOGS as a program monitoring system.

The breaker status is checked constantly and if the breaker is open with current passing, an alarm indication is triggered and the event is registered.

EEPROM errors.

The EEPROM can have two types of critical errors:

1 - A malfunction of the chip: in this case the protection enters the infinite loop of the boot program described above and the HW ERROR signal is activated.

2 - The settings or the calibration have deteriorated: in this case protection attempts to retrieve the settings or calibration or set the defaults.

The settings as well as the calibration are duplicated, and after so the deteriorate, both copies must be lost.

- If the settings deteriorate:

The protection substitutes the deteriorated settings with the default settings. When using the default settings, the protection and the trips are disabled. This will activate the DEFAULT SETTINGS signal, the alarm contact, and the out of service LED on the front panel of the relay. These alarms remain active until the user reenters the correct settings.

The following list indicates the default settings for the relay:

001	IDENTIFICATION:	MLP GENERAL ELECTRIC
002	BREAKER NUMBER:	1234
101	LINE DISTANCE:	100 km
102	CT RATIO:	1
103	PT RATIO:	1
104	RECORD TYPE:	C
105	SYSTEM FREQUENCY:	50 Hz
106	ALLOW RECLOSER INHIBITION INPUT (IIN_R)	YES
107	ALLOW EXTENDED Z1 PULL BACK INPUT (RZ1X):	YES
108	ALLOW CARRIER RECEIVER INPUT (RCVR):	YES
109	ALLOW RECLOSER CANCEL INPUT:	YES
110	ALLOW RECLOSING INITIATE INPUT (R_I):	YES
111	ALLOW LINE PICK UP INPUT (LPU):	YES
112	ALLOW TRIP BLOCK INPUT (TRP_B):	YES
113	ALLOW BREAKER STATUS INPUTS (52B):	YES
114	AMPS ACCUMULATED AMPS IN BREAKER OPENINGS:	0 kA^2
115	MAXIMUM ACCUMULABLE AMPS IN BREAKER OPENINGS:	8,000 kA^2

Protection Settings:

201	OUT OF STEP BLOCKING (OSB) IN SERVICE:	NO
202	LINE PICK UP (LPU) IN SERVICE:	NO
203	REMOTE OPEN DETECTOR (ROD) IN SERVICE	NO
204	FUSE FAILURE (FF) IN SERVICE	NO
20:	ALLOW RECLOSES AFTER A TRIP IN ZONE II	NO
206	ALLOW RECLOSES AFTER A TRIP IN ZONE III:	NO
207	MHO OR REACTANCE CHARACTERISTIC:	Mho
208	PROTECTION SCHEME:	Scaled Distance
209	PROTECTION IN SERVICE	NO
210	ALLOW TRIP CAUSED BY REMOTE OPEN DETECTOR	NO
211	ALLOW TRIP CAUSED BY A LINE PICK UP	NO
212	GENERAL TRIP AUTHORIZATION	NO
213	ALLOW ZONE III TRIPS	NO
214	ALLOW ZONE II TRIPS	NO
215	ALLOW ZONE I TRIPS	NO
216	LPU TIMER FUNCTION	128 ms
217	FF TIMER FUNCTION	60 ms
218	ROD TIMER FUNCTION	0 ms
219	POSITIVE SEQUENCE LINE IMPEDANCE MODULE	6Ω
220	POSITIVE SEQUENCE ANGLE OF MAXIMUM REACH	85º
221	ZERO SEQUENCE CURRENT COMPENSATION	3
222	ZERO SEQUENCE ANGLE MAXIMUM REACH	75º
223	ZONE I REACH	4.8Ω
224	EXTENDED ZONE I REACH	1.4
225	ZONE II REACH	9Ω
226	ZONE III REACH	12Ω
227	CHARACTERISTIC ANGLE	90º
228	ZONE I TRIP TIMER	0 ms
229	ZONE II TRIP TIMER	100 ms
230	ZONE III TRIP TIMER	200 ms
231	CURRENT SUPERVISOR THRESHOLD (iØs):	15 times In
232	LPU OVERCURRENT THRESHOLD (IØs):	3 times In

Recloser setting:

301	NUMBER OF RECLOSING ATTEMPTS:	Disable (0)
302	RECLOSING WAIT CONDITIONS:	NO
303	TIME DELAY FOR THE FIRST RECLOSING ATTEMPT:	0.2 s
304	TIME DELAY FOR THE SECOND RECLOSING ATTEMPT:	0.2 s
305	TIME DELAY FOR THIRD RECLOSING ATTEMPT:	0.2 s
306	TIME DELAY FOR RECLOSING CONDITIONS:	0.1 s
307	DWELL TIME:	0.1 s
308	RESET TIME:	0.1 s

Event masks:

003	EVENT MASK:	All allowed

- If the calibration deteriorates:

The protection substitutes the deteriorated calibration for the default calibration and the DEFAULT CALIBRATION BY signal is activated.

The calibration loss implies the need to recalibrate the relay in the factory. Since it is not always possible to immediately disconnect the relay and send it back to the factory so that it can be recalibrated, using the default calibration settings is acceptable as long as the default calibration setting is maintained below 5% error. However, it is not advisable to postpone the recalibration longer than absolutely necessary.

Cold/warm boot

Any system reset causes a cold boot. During this boot the self checks are performed. If no critical errors are detected a warm boot is performed.

During a warm boot the system variables and parameters are initiated and the corresponding LED on the front panel of the relay is lighted.

Cold boots as well as warm boots are saved as events.

4.18 OUTPUTS

The external connections of the MLP may be seen in figures 3.1 to 3.12.

Non-seleccionable outputs:

The relay includes the following non-seleccionable output contacts:

Two trip contacts.
Two closing contacts (RCL).
Alarm equipment.
Transmission initiate (XMTR).

Seleccionable outputs:

The relay includes seleccionable contacts; each contact may be assigned to one of the logical quantities in List - 2.

List-2:
- Reclosing initiate. (MLP2000 and MLP3000)
- Reclosing block. (MLP2000 and MLP3000)
- Fuse failure.
- LPU trip.
- Breaker failure initiate.
- Zone 2 activation.
- Zone I timer end.
- Zone 2 timer end.
- Zone 3 timer end.
- Reclosing cycle in progress (recloser). (MLP2000 and MLP3000)
- Recloser block (Lock-out). (MLP2000 and MLP3000)
- Extended Zone I pulled back.
- ROD measuring unit. (MLP3000)
- OSB detected.
- Any measuring unit:
  DMUZ 1 AG, DMUZ I BG, DMUZ I CG, DMUZ IAB, DMUZ I BC, DMUZ 1 CA, DMUZ3AG, DMUZ3BG, DMUZ3CG, DMUZ3AB, DMUZ3BC. DMUZ3CA.

-- Any ground measuring unit:
  DMUZ 1AG, DMUZ 1 BG, DMUZ 1 CG, DMUZ3AG, DMUZ3BG, DMUZ3CG.

-- Any Z1 ground measuring unit:
  DMUZ1AG, DMUZ1BG, DMUZ1CG

-- Any Z3 ground measuring unit:
  DMUZ3AG, DMUZ3BG, DMUZ3CG.

-- Any phase measuring unit:
  DMUZ1AB, DMUZlBC, DMUZ1CA, DMUZ3AB, DMUZ3AB, DMUZ3BC, DMUZ3CA.

-- Any zone 1 phase measuring unit:
  DMUZ 1AB, DMUZ 1 BC, DMUZ 1 CA.

- Any Z3 phase measuring unit:
  DMUZ3AB, DMUZ3BC, DMUZ3CA.

The standard configuration is:

Contact - 1: Fuse failure.
Contact - 2: Breaker failure initiate.
Contact - 3: Zonc 2 timer end.
Contact - 4: Zone 3 timer end.
Contact - 5: Extended Zone 1 pull back.
Contact - 6: In progress. (MLP2000 and MLP3000)
Contact - 7: Block (Lock-out). (MLP2000 and MLP3000)

Configurable output selection is performed in the factory when ordered.

4.19 OPERATIONS

The MLP program allows the following operations to be performed:

- Breaker opening.
- Breaker close.

- Recloser block. (MLP2000 and MLP3000).
- Recloser unblock (MLP2000 and MLP3000).

- Relay synchronism

The synchronism operation can only be performed via serial communications, not through the relay keyboard.

4.20. OUT OF STEP BLOCKING UNIT

The out of step blocking units is designed to identify a three phases power oscillation fault situation. This prevents the distance protection system from tripping unnecessarily.

There is a setting which allows you to disable this setting as well as a timer to determine the speed at which the impedance, as seen by the relay, enters into the tripping zone. This speed allows us to identify a phase power oscillation fault situation.

Figure 17 illustrates the state diagram for this functions as well as the X/J plane characteristic

To better understand this, we will explain the operation with an example.

In a fault situation, the impedance crosses the OSB zone (in tomato form) and stars the oscillation detection timer (TL3). When this timer terminates, the M3 measuring unit (circle) is checked. Because of the fault, which developed rapidly, this unit will be activated. In this case the relay will not be blocked by a power oscillation.

Needless to say, if the impedance evolves slowly, when the aforementioned timer terminates, the M3 measuring unit will not vet have been activated, showing that the power oscillation had occurred. In this way the relay will block the trip. Once leaving the OSB zone, the relay will wait a fixed time of 50 ms before returning to the initial or stand-by state.

5 COMMUNICATIONS

5.1 REMOTE COMMUNICATIONS

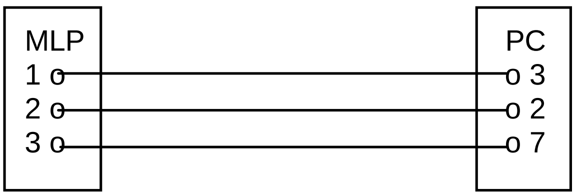
The user can communicate with the MLP in two modes:

- Local: Communications are accomplished through the keyboard and monitor situated on the front panel of the relay.

- Remote: Communications are accomplished through the serial port located on the rear panel of the relay.

The MLP is provided with a half duplex serial communications module which permits it's utilization as part of a completely integrated substation protection and control system.

You can connect and remotely control up to 255 MLP systems with a CPR communications concentrator unit, which through the use of a modem can be connected to a PC compatible computer. The MLP is connected via a 20 mA current loop, fiber optics, or an RS232 cable (see figure 1).



The MLP uses serial communications only for interfacing with external units in such a way that you can only set and request data in this mode. Needless to say, if for any reason communications are cut, the MLP continues protecting the fine and stores data in it's memory for transmission once communications have been reestablished.

The protection functions remain active during communications. While changing the settings in local mode, the MLP continues protecting the system with the previous settings until the user has finished making the changes. In this instant, an almost instantaneous change of the settings is performed.

5.2 SELF CHECKS AND ERROR ROUTINES

When the MLP detects a critical error in one of it's components, whether during initialization or in use, it will immediately enter into a reinitialization cycle attempting to solve the problem. The error message "HW ERROR" will appear on the screen.

Causes of critical errors are:

- A/Ds error
- Loss of 15 VDC
- ROM error
- RAM error
- E2PROM settings and configuration error
- System keyboard-monitor memory error

To avoid inadvertently leaving the trips disabled when the relay is put into service, the MLP will display a "TRIP INACTIVE” message on the screen.

In parallel with this monitoring (software), the MLP applies a "WATCHDOG" in the form of an intrinsic (hardware) monitoring system to assure total reliability of the system.

In the event of a non-critical functional indication in the MLP status, the following warnings are displayed:

- Current passing with breaker open.
- Protection has been initialized but has not received a synchronize command, indicating "WITHOUT CLOCK".
- The breaker require maintenance for exceeding the limit of accumulated amperes.
- Power supply failure.
- ERROR indication to advise of an oscillografic RAM failure and failures in the E2PROM event zone.

5.3 RELAY DATA

The following sections will explain the complementary information, supplied by the relay. The rest of the information such as: view settings and their modifications, operations, settings configuration, etc. is sufficiently explained in the corresponding sections of this manual.

5.3.1 EVENT REGISTER

The MLP contains an internal event register which logs all actions produced by the relay.

Each event is composed of, in addition to the previous information, the following data:

- Indication of the activation of measurement unit AG in zone I
- Indication of the activation of measurement unit BG in zone I
- Indication of the activation of measurement unit CG in zone I

- Indication of the activation of measurement unit AB in zone I
- Indication of the activation of measurement unit BC in zone 1
- Indication of the activation of measurement unit CA in zone 1

- Indication of the activation of measurement unit AG in zone 3
- Indication of the activation of measurement unit BG in zone 3
- -- Indication of the activation of measurement unit CG in zone 3

- Indication of the activation of measurement unit AB in zone 3
- Indication of the activation of measurement unit BC in zone 3
- Indication of the activation of measurement unit CA in zone 3

- Indication of a critical error
- Indication of a non-critical error

- Breaker status
- Protection status
- Recloser status

- The current of each phase and the zero sequence
- The voltage of each phase

The register is maintained as a circular stack with a limit of 240 events. Once the limit is exceeded the latest events will be stored in the fields of the first events registered. This means that event number 241 will be stored in the field of event 1 overwriting it's previous contents.

In some cases you may not wish to record certain events which have no importance. Through the use of a mask, you can program only those events which you wish to register.

Using the Mlink program, an event log can be saved to a file and later used as an input data file for application programs executed by the user.

5.3 2 CURRENTS AND VOLTAGE LOGS

The MLP provides an hourly log of the maximum load current or power which permits the user to view the load of the protected line or the active or reactive power.

The hourly register is capable of saving data accumulated over one week. The data is maintained in a circular stack, with the oldest information being replaced by the newest. The data are stored in volatile RAM, therefore if there is a power outage, the data will be lost.

If the date and time of the MLP are not set, the register will save the hourly current values beginning with the date and time of the last registered event. In the event that no previous events exist. the date and time will start at the default setting of (01/01/88, 00:00:00).

Using the Mlink program, the current log can be saved to a file and later used as an input data file for application programs executed by the user.

5.3.3 MLP STATUS

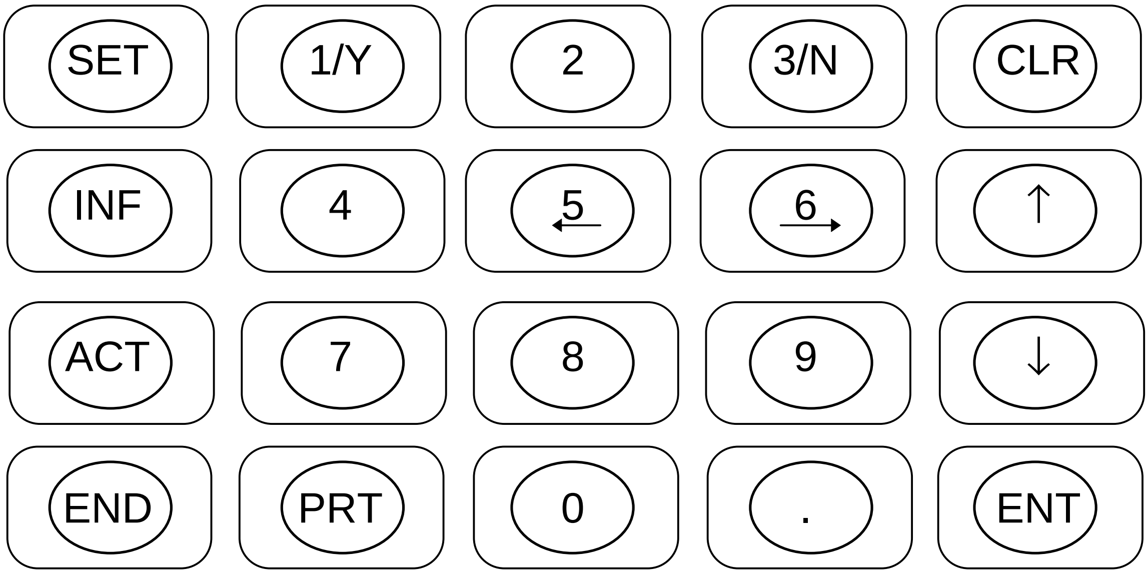
Requesting the status from the MLP provides you with general information regarding the breaker status, the recloser and it's possible blocks, and the communications status. Additionally, a series of indicators that warn of errors or special conditions are displayed.

Having detailed the composition of the MLP status request, we would like to emphasize that all of the values displayed are instantaneous, and will be displayed as such (every 120 ms) on the screen or from the Mlink program.

5.4 LOCAL COMMUNICATIONS

5.4.1 KEYBOARD AND DISPLAY

The MLP has a 20 key keyboard and a 32 character liquid crystal display divided into 2 lines of 16 characters each. These two items permit the user direct access to the MLP's functions. The layout of the keyboard is displayed in the following illustration:



The local mode communications system is comprised of a series of tree structured menus and warning screens

The warning screens contain information related to the last fault cleared and relay power errors and initialization. When you apply power to the relay for the first time a standby screen is displayed:

MLP
GENERAL ELECTRIC

The screen changes rapidly displaying the last fault stored by the protection:

TRP AG Z1 27
13APR 13:07 0050

This message, with TRP (when relay tripping is disabled) not blinking, indicates the relay has been initialized. This message only appears in this case, maintaining itself in the standby mode. Pressing the CLR key will return you to the standby screen:

MLP
GENERAL. ELECTRIC

In the standby mode you can access the menu tree which allows access to the remote communication or receive other warning messages such as:

HW ERROR

or

TRIP INACTIVE

indicating previously listed errors.

If a fault occurs, a message such as the following will appear:

TRP AG Z1 27
13APR 13:07:0050

where.

TRP or BLQ when the trip has been disable is blinking, 'AG' indicates the type of fault 'Z 1' indicates the type of trip '27' indicates the distance in kilometers or miles '13APR 13:07:0050' indicates the date and time the fault occurred.

As before, you can return to the standby screen by pressing the CLR key.

To leave the standby mode and enter into the menu system, press the INF, ACT, SET, or ENT key, or type the system configuration password (**7169**). This provides access to the following groups:

Information (INF): provides data related to the relay status, current or power logs, and event logs.

Operations (ACT): open and close the breaker, block and unblock the recloser.

Settings (SET): View and modify the settings.

Single key operations (ENT):

Configuration (7169): set the external communications parameters as well as enable other functions.

General rules covering the use of the user keyboard and monitor interface:

If you are inside of one group you cannot select another without out of group.

To move around within a group use the ENT, CLR, ↑, and ↓, keys (see figure 14). Their use is as follows:

ENT: Accepts the option that is currently displayed on the monitor. This is equivalent to descending one level in the menu tree.

CLR: Abandons the option that is currently displayed on the screen. This is equivalent to ascending one level in the menu tree.

↑/↓ Changes the option. This is equivalent to lateral movement within the circular menu. When the desired option appears on the screen, use the ENT key to select it.

The use of these keys and others, minus generic keys, (together with concepts such as circular. logical keys, etc...) will be explained in detail when describing each group.

5.4.2 INFORMATION GROUP

This group provides information related to the MLP. To access this option, press the INF key when the MLP is in standby. When entering the information menu, the first group of information elements will be displayed:

EVENT LOGS

By pressing the ↑/↓ keys, the following groups will appear on the screen:

EVENT LOGS
CURRENT LOGS
POWER LOGS
MLP STATUS

pressing ↑ displays:

CURRENT LOGS

pressing ↑ displays again:

POWER LOGS

pressing ↑ displays:

MLP STATUS

and pressing ↑ displays the first menu (in a circular mode):

EVENT LOGS

To descend within the menu tree and enter into the information group press the ENT key. To ascend within the menu tree or return to the previous menu press the CLR key. In the current position, pressing the CLR key will display:

The significance of the asterisk will be explained later in the section INTERACTION OF THE KEYBOARD WITH REMOTE COMMUNICATIONS. For now, it is sufficient to know that its presence indicates that the system is not in the standby mode

5.4.3 EVENT LOGS

Starting from the screen:

EVENT
LOGS

Pressing the ENT key will display a dynamic screen (with an incrementing level bar) indicating that the events accumulated within RAM are being retrieved:

RETRIEVING LOGS

RETRIEVING LOGS

RETRIEVING LOGS

until it retrieves the 52 (maximum) most recent events. When utilizing the keyboard on the front panel, you are limited to viewing the last 52 events to see all of 240 events you need to remote communication.

After this appears on the monitor, the most recent event will be displayed with its corresponding date and time (day-month hour:minute:second-hundreds), for example:

E_TRIP Z1X
01DEC 07:50:2590

The ↑ key advances the display through older events, while the ↓ key advances the display through newer events. The events are organized in a circular way. If you press the ↓ key when viewing the oldest event, the next event in line will be the most recent. If you press the ↑ key when viewing the most recent event, the next event in line will be the oldest.

When you desire more information related to the event(s) displayed on the monitor, pressing ENT u ill display other types of events, if they had been produced at that time, together with the information related to each event.

Pressing the CLR key will retreat until returning to the event screen, from which you can select another event using the ↑/↓ keys. Pressing CLR from this screen will return you to the information menu. Upon leaving the information screen, all event data will be lost. To view the data again you will have to reload them.

5.4.4 CURRENT OR VOLTAGE LOGS

As in the previous case, this type of log is available in an analog mode. If you request logs that are not available, the following message will be displayed on the monitor:

DATA
NOT AVAILABLE

When the logs are available, the procedure is the same as with the events, with the following being displayed on the monitor

RETRIEVING LOGS

RETRIEVING LOGS

RETRIEVING LOGS

until retrieving 168 logs, which is the maximum capacity of the relay logs. Once all of the logs have been loaded into memory, the most recent log will be displayed on the monitor. For example:

3.43 A
01DEC 07:50:2590

In the case of currents (as in this case), there is only one screen displayed for the log. In the case of powers, the following will be displayed:

40.90W
01DEC 07:50:2590

This screen displays the active voltage. To display the reactive voltage pressing the ENT key will display the rest of the information, which in this case is the reactive voltage screen. The following will be displayed:

41.89VAR
01DEC 07:50:2590

Pressing CLR will return you to the screen:

40.90W
01DEC 07:50:2590

To view other logs, the ↑ key advances the display through older events, while the ↓ key advances the display through newer events. The events are organized in a circular way. If you press the ↑ key when viewing the oldest event, the next event in line will be the most recent If you press the ↓ key when viewing the most recent event, the next event in line will be the oldest.

5.4.5. STATUS

Starting from the screen

MLP STATUS

Pressing ENT will display the name of the first status element

MODEL

To view the values associated with this item, pressing ENT will display, in the example of MODEL

MODEL MLP V1.0
MLP3152M010G00A

indicating the model and version of the relay

To access another element press CLR. Only the element name will appear, and by pressing the ↑/↓ keys you can select the desired data. Pressing ENT will display the values associated with that element.

5.4.6 OPERATIONS GROUP

This group permits the user to manipulate the breaker (OPEN or CLOSE) from the keyboard, as well as BLOCK and UNBLOCK the recloser. To access this group press the ACT key when the MLP is in the standby mode. The first operation for this group will be displayed on the screen:

OPEN BREAKER

indicating that opening the breaker is the first option. Pressing the ↑/↓ keys will display the rest of the operations on the screen. Once you have located the desired operation. pressing the ENT key will select it.

To avoid undesired operations, the keyboard program requires confirmation for each operation. To confirm the operation, press the 1/Y key. Pressing the 3/N key will abort the operation. Pressing the CLR key at this screen is equivalent to pressing the 3/N key. If you confirm the operation, the result of the operation will be displayed on the screen. Using either the ENT or the CLR keys will acknowledge the message and return you to the operations menu.

For example, the process of opening a breaker is carried out in the following way:

OPEN BREAKER

press ENT:

CONFIRM Y/N

press 1/Y:

OPERATION IN PROCESS

if the operation is successful. the MLP will display:

OPERATION SUCCESSFUL

If the breaker was not opened, and in general if any operation is not successful, the following message will be displayed on the monitor:

OPERATION
NOT SUCCESSFUL

Pressing ENT or CLR will return you to the initial menu:

OPEN
BREAKER

5.4.7 VIEW SETTINGS

The settings group allow you to view an modify the MLP's settings. To access these options, pressing SET when the MLP is in the standby mode will display:

VIEW
SETTINGS

pressing the ↑/↓ keys will advance you to the following option:

MODIFY
SETTINGS

which will be covered in the next section

To access these options, pressing ENT while VIEW SETTINGS is displayed on the monitor will display:

GENERAL
SETTINGS

Pressing the ↑/↓ keys will display the following groups:

GENERAL SETTINGS
PROTECTION SETTINGS
RECLOSER SETTINGS
EVENT MASKS

The way of viewing any one of the groups (such as modify settings) is the same. Using as example the general settings, pressing ENT will display:

IDENTIF:.............MLP
GENERAL ELECTRIC

This setting has various characteristics. It is alphanumeric, therefore you may view it on the monitor, but you may not modify it; it is 20 characters in length therefore the first 4 characters are displayed on the first line of the monitor.

Pressing the ↑ key will display the next setting:

```
BREAKER NUM
    1234
```

which is the other alphanumeric setting, but it preserves the settings general presentation format. The first line displays setting name and the second line it's value and unit.

To view any of the settings, using the ↑/↓ keys will display the different settings in a circular list. To return to the previous menu, press the CLR key.

5.4.8 MODIFY SETTINGS

The MLP permits you to change blocks of settings or only those in which you are interested. During a settings change the MLP ensures that the entered settings are within the limits. that they have loaded correctly in memory, that a series of values is initialized, etc... Due to this, the line which the relay protects will be momentarily unprotected. This lasts 5 milliseconds (ONE FOURTH OF THE NETWORK CYCLE). To avoid losing the settings in the event of a power loss, they are duplicated in non-volatile EEPROM memory.

Returning, to the system keyboard, starting from the screen:

```
  GENERAL
  SETTINGS
```

pressing ENT displays:

```
LINE LENGTH (KM)
   73.93      -----
```

This screen is composed of the setting name on the first line. The left side of the second line contains the setting that the protection currently has, while on the right side hyphens are initially displayed indicating that you may enter a new setting which differs from that of the protection

This format will be the same for every type of setting. The format characteristics depending on the type of setting are:

- If it is an alphanumeric setting you may not change it therefore it will not appear (this is why 'INDENTIF' did not appear).

- For logical settings, whether binary or coded, it is not necessary to press the ENT key to enter them. They are sufficiently defined by the 1/Y - 3/N keys or by the code keys.

– Keys not configured for the setting are not acknowledged

– For numeric settings, once you have entered their value you must press the ENT key to check their range.

An example of this process is:

You wish to change this setting to 333, therefore typing 333 displays:

LINE LENGTH (KM) 73.93 3------	3	LINE LENGTH (KM) 73.93 33-----	3	LINE LENGTH (KM) 73.93 333---

You press ENT to accept the input data and the following is displayed:

```
VALUE OUT
OF RANGE
```

The system detected that the setting that you entered is outside of the allowable range or one or more settings aren't "coherent" with others. Pressing any key will return you to the initial menu for changing this setting.

If the newly desired setting is 22, after pressing ENT the setting is accepted and the following is momentarily displayed:

```
LINE LENGTH (KM)
73.93 22.00
```

You can update this setting in the relay or modify one or more settings for a definitive change at a later time. As an example, change another setting using the ↑/↓ keys until the logical setting is displayed:

```
LOG TYPE
CURRs -----
```

Pressing 1/Y changes to:

```
LOG TYPE
CURRs POWER
```

This way you can change 1, 2, or however many settings you wish. Once you have decided that the GENERAL SETTINGS group is set as you wish, proceed to change the settings in the relay. To do this you must press the END key which will display:

```
MODIFY SETTINGS?
Y/N
```

Responding NO will return you to the CHANGE SETTINGS screen with all of the settings intact. If you respond YES the settings are transmitted to the protected unit with the following message being displayed on the monitor:

SETTINGS
CHANGED

Pressing ENT or CLR will return you to the menu displayed previous to the END operation.

If you press CLR to exit, the following will appear:

QUIT?
Y/N

pressing 1/Y to quit, and 3/N to continue without deleting any of the processed changes.

5.4.9 SETTINGS NOT ACCESSIBLE FROM THE KEYBOARD

Some settings have been excluded from the keyboard due to various incompatibilities with the keyboard-monitor system. They are:

Date and time: may be viewed but not modified. To avoid the loss of substation relay synchronism, the date and time may only be changed through remote communications.

Breaker identification and number: may be viewed but not modified. Given the fact that the MLP has only a numeric keyboard, modification of these settings must be done through remote communications.

Event: this option is only accessible through the remote controller, due to the memory in the keyboard-monitor controller.

Oscillograms: the information which is needed to construct an oscillogram is too large to be displayed on the monitor.

5.4.10 SINGLE KEY OPERATIONS

The MLP allows a simplified operation mode through the use of the ENT key. This mode allows access to diverse relay information without the necessity to remove the transparent plastic cover.

The key used in this operational mode is the ENT key. To access the simplified mode the relay must be in standby:

```
        MLP
GENERAL ELECTRIC
```

Pressing the ENT key displays

```
Ia:     0.88 A
Va:    21.11 V
```

showing the current and the voltage, which are refreshed approximately each second. Consecutively pressing ENT will display the values for:

Ib and Vb
Ic and Vc
I0

PROTECTION STATUS (WHETHER IT IS IN SERVICE OR NOT)
RECLOSER STATUS
PROTECTION SCHEME SELECT

LOCKED OR UNLOCKED RECLOSER
RECLOSE NUMBER
RESET RECLOSE NUMBER

BREAKER STATUS

FAULT TYPE, TRIP TYPE, FAULT LENGTH AND DATE-TIME OF THE LAST FAULT.

5.4.11 CONFIGURATION UNIT

The MLP contains a configuration unit which can be accessed exclusively through the keyboard it is used to select how the MLP will interact with the exterior.

The configuration unit is entered from the standby screen by entering a four digit numerical code. If the code is correct you will enter into the configuration unit. If the code is not correct, you will be returned to the standby screen. The code is only for the MLP relay. It is not meant as a password, but a simple measure of security to avoid accidental manipulation of the configuration. The code is **7169**, which was selected because it is the corresponding ASCII code for the initials 'GE'. To enter the configuration from the standby screen, follow this example:

MLP
GENERAL ELECTRIC → 7 → * → 1 → ** → 6 → *** → 9 → ****

and the configuration menu will be displayed, where all of the settings will be shown in an integrated manner, except for the password which can only be viewed when changing it:

SETTINGS CONF.
2400 INBMASK

The value and significance of the settings on the second line are.

2400 => baud rate
1 => stop bits
N => operations from the keyboard enabled
B => settings change from the keyboard enabled
M => remote operations enabled
A => remote settings change enabled
S => language set to Spanish
K => length values displayed in kilometer
I => unit number

A detailed explanation for each of the settings is as follows:

Speed:

The baud rate which the MLP uses to communicate serially with the remote controller. The possible values for this setting are between 300 and 19,200 baud optic fiber and 9,600 baud to RS232.

Stop bits:

The number of bits added to each byte transmitted across the serial line. It is treated as a logical binary setting with the logical keys 1/Y for 1. and 3/N for 2.

The MLP always transmits 8 bits without panty, with the number of stop bits and speed programmed in this unit.

Keyboard authorizations:

The MLP allows you to block the keyboard for certain critical functions. These functions are:

Operations:
Opening and closing the breaker, blocking and unblocking the recloser. This setting is considered logical with 'N' meaning enabled using the 1/Y key, and 'n' meaning prohibited using the 3/N key.

Settings changes:
This setting is considered logical with ‘B' meaning enabled using the 1/Y key, and ‘b' meaning prohibited using the 3/N key.

Each one of these authorizations can be set independently with their prohibition inhibiting the entrance into the related functions.

Remote authorizations:
The MLP allows you to prohibit remote access to certain critical functions. These functions are

Operations:
This setting is analogous to the keyboard setting, with ‘M’ meaning enabled using the l/Y key, and 'm' meaning prohibited using the 3/N key.

Settings changes:
This setting is analogous to the keyboard setting, with 'A' meaning enabled using the l/Y key, and 'a' meaning prohibited using the 3/N key.

If a command corresponding to a prohibited function is recorded from the remote controller, the error message "ACCESS DENIED" will be returned. Given the fact that these authorizations can only be set from the keyboard, this provides you a method of filtering commands which can be executed from the remote controller.

Language:
The MLP can display it's messages in two languages: Spanish and English. To program the language use the logical keys, with 'E' meaning English using the 1/Y key, and 'S' meaning Spanish using the 3/N key.

Units of measurement:
Units of measurement can be displayed in kilometers or miles on the MLP. To set the desired measurement unit use the logical keys, with 'K' meaning kilometers using the 1/Y key, and 'I' meaning miles using the 3/N key.

Unit number:
Each MLP is identified by a unit number which serves to the messages directed to it through the remote communications line. This number may be between 1 and 255, both extremes included.

Password:
To avoid unauthorized personnel from communicating remotely with the relay through the use of Mlink which allows settings changes and execution of operations, the relay provides a password. The password may only be viewed through the relay monitor and is composed of a number between 1 and 99999

Updating the configuration unit is performed in the same way as any other settings group, pressing the END key ,and confirming the command. The configuration change takes effect immediately. The configuration is stored in the permanent EEPROM memory.

5.4.12. INTERACTION OF THE KEYBOARD WITH REMOTE COMMUNICATIONS

In the MLP, the keyboard has priority over remote communications. When the keyboard is active, all messages specifically directed to the unit from a remote controller are responded to with the error message "RELAY BUSY".

The keyboard becomes active when pressing either the SET, INF, or ACT keys. It is also activated by pressing the ENT key for simplified operations, or one of the numeric keys for entry into the configuration unit. If, when pressing one of these keys, remote communications are active. the following message will be displayed on the monitor:

```
BREAKING REMOTE
  PLEASE WAIT
```

which remains displayed for the amount of time necessary to break the remote communications session. To ensure transmission integrity, the MLP is designed so that remote communications cannot be interrupted if a message is being transmitted.

For this reason, the previous message may remain displayed for a noticeable amount of time if the transmission rate is low (300 -600 baud) and will be practically invisible at high transmission rates (above 2400 baud).

When the user establishes serial communications \with the relay, a blinking R" will appear on the left of the first line on the relay display. This is to notify a local user that any keypad action will disconnect the remote communications session.

If the unit number or transmission rate parameters are modified, the communications will be affected as soon as the changes are confirmed. The same occurs for remote communication authorizations.

Once the remote communications have been broken, the MLP will operate as normal. The keyboard will remain active until the operator deactivates it by pressing the END or CLR keys while the MLP is in standby. The asterisk displayed on this screen indicates that the keyboard is active and remote communications are inhibited. Upon deactivating the keyboard the asterisk will disappear:

Keyboard active		Keyboard inactive
(*) MLP GENERAL ELECTRIC	CLT END	MLP GENERAL ELECTRIC

In any screen in which values are not changed for a period of 5 minutes and 20 seconds, and no keys have been pressed, or approximately 30 minutes in refresh operations such as the status request or single key operations, the MLP returns to the standby mode and deactivates the keyboard.

6. ACCEPTANCE TESTS

6.1 FUNCTIONAL TESTS

Slowly apply 2200 volts RMS for the initial test and 1600 volts for following periodic tests, between all short-circuited terminals (except the "A1" terminal connected to ground) and the ease for 1 second.

6.2 ACCEPTANCE TESTS

Necessary equipment:

* 3 Multiamp units, or in their place 3 voltage sources, 3 current sources
* A continuous voltage source
* A stopwatch
* A multimeter
* A latching relay which simulates a breaker

Jumpers and switches placed over the extensors are used to simulate closing exterior contacts. Combinations of resistance and voltmeters are used to observe the active signals across the auxiliary relays in the following form:

Relay deenergized: Contact open
Relay energized: Contact closed

Connect the relay in accordance with the scheme in figure 16.

6.2.1 INITIAL CONFIGURATION

Apply power to the relay and, using the keyboard, enter the password '0186' with asterisks appearing on the display.

Once the password has been entered, the following will be momentarily displayed on the monitor

SYSTEM
CONFIGURATION

rapidly changing to:

MLP
GENERAL ELECTRIC

At this point the default settings configuration is:

- 2400 baud and 1 stop bit for remote communications

- distance units set to km
- language set to Spanish
- password set to 0
- all configurable functions enabled

Testing the keyboard and monitor:

Press the following keys to check the monitor readings:

KEY	**READING**
<SET>	VIEW SETTINGS
<up arrow>	MODIFY SETTINGS
<down arrow>	VIEW SETTINGS
<CLR>	MLP GENERAL ELECTRIC
<INF>	EVENT LOGS
<down arrow>	MLP STATUS
<ENT>	MODEL
<ENT>	Check the model
<CLR> <CLR> <CLR>	MLP GENERAL ELECTRIC
<ACT>	OPEN BREAKER
<CLR> <END>	MLP GENERAL ELECTRIC (without *)
<ENT>	Ia: 0.00 A, Va: 0.00 V
<CLR> or <END>	MLP GENERAL ELECTRIC (without *)
<7169>	SETTINGS CONFIG: 2400 lNBMASK l
<CLR>	MLP GENERAL ELECTRIC

Adjust the relay to the following settings:

Note: Some settings only apply to model MLP2000 and MLP3000.

000 - General Settings:

001 - IDENTIFICATION:	
002 - BREAKER NUMBER:	
101 - LINE LENGTH:	100
102 - ASSOCIATED ED CT RATIO:	1
103 - ASSOCIATED PT RATIO:	1
104 - RECORD TYPE:	CURRs
105 - SYSTEM FREQUENCY:	60
106 - RECLOSER INHIBITION INPUT (R_INH):	YES
107 - EXTENDED ZONE 1 PULL BACK INPUT (RZ1X):	YES
108 - CARRIER RECEIVER INPUT (RCVR):	YES
109 - RECLOSING CANCEL INPUT (R_C):	YES
110 - RECLOSING INITIATE INPUT (R_I):	YES

111 - LINE PICK UP INPUT (LPU):	YES
112 - TRIP BLOCK INPUT (TRIP_B):	YES
113 - BREAKER STATUS INPUT (52B):	YES
114 - ACCUMULATED AMPS:	0
115 - LIMIT ACCU. AMPS:	8000

200 - Protection Settings:

201- OSB IN SERVICE	NO
202 - LPU IN SERVICE:	NO
203 - ROD IN SERVICE:	NO
204 - FF IN SERVICE:	NO
205 - Z3 TRIP RECLOSING:	NO
206 - Z2 TRIP RECLOSING:	YES
207 - MHO/REACT:	MHO
208 - PROTEC. SCHEME:	0=D.E
209 - PROT. IN SERVICE:	NO
210 - TRIPS CAUSED BY ROD (ROD (TRIP):	YES
211 - TRIPS CAUSED BY LPU (LPU TRIP):	YES
212 - GENERAL TRIP:	YES
213 - Z3 TRIP:	YES
214 - Z2 TRIP:	YES
215 - Z1 TRIP:	YES
216 - LPU TIMER:	128
217 - OSB TIMER:	60
218 - ROD TIMER:	0
219 - POSITIVE SEQUENCE IMPEDANCE (ZL1 IMPED):	6.0
220 - POSITIVE SEQUENCE ANGLE (ZL1 ANGLE):	85°
221 - ZERO SEQUENCE CURRENT COMPENSATION (K0):	3.0
222 - ZERO SEQUENCE ANGLE(ZL0 ANGLE):	75°
223 - Z 1 REACH:	4.80
224 - Z1X REACH:	1.40
225 - Z2 REACH:	9.00
226 - Z3 REACH:	12.0
227 - REACT CHARAC ANG:	90°
228 -Z1 TIMER:	0
229 - Z2 TIMER:	100
230 - Z3 TIMER:	400
231 - IS THRESH DETEC (IØs):	0.15
232 - IL THRESH DETEC (IØld):	3.00

300-Recloser Settings:

301 - NUM RCL ATTEMPTS:	1
302 - RECLOSING HOLD:	NO
303 - DELAY ATTEMPT 1:	1
304 - DELAY ATTEMPT 2:	1
305 - DELAY ATTEMPT 3:	1
306 - HOLD TIME:	0.1
307 - DWELL TIME:	0.1
308 - RESET TIME:	0.5

003-Event Mask:

Allow all events.

Note: Some settings only apply to model MLP2000 and MLP3000.

6.2.2 INPUT CONTACT

Once the input contacts have been activated one-by-one, you ill enter into the "RELAY STATUS" menu to check that the relay actually reads the corresponding input activation.

CC 1: Breaker status:

Check that once the input has been activated, the SC7 and SC5 outputs, the recloser blocked, and the ZIX pull back are activated. Once the input deactivates, the SC7 and SC5 outputs should deactivate.

CC2: Trip Block:

With the input inactive momentarily apply the voltages and currents indicated by the AG00 fault(see fault list) and check that the relay trips correctly. With the input active follow the same procedure and check that this time the relay does not trip.

CC3: Energizing the line:

With the LPU IN SERVICE function and the input deactivated, apply 16 A in each of the three phase and check that once the input is activated, the relay is tripped by the LPU.

CC4: Initiate reclosing:

With the breaker closed (CC1 without power) and with the external Initiate reclosing active (CC4 with power applied), perform the open breaker operation and check that it opens and immediately closes. (MLP2000 and MLP3000)

CC5 Reclosing block:

With the breaker closed (CC1 \without power) check in the relay status that the recloser is in standby and upon activating the external reclosing block (CC5 with power applied) that the recloser passes to the blocked state. Next, momentarily apply the currents and voltages indicated by the AG50 fault and check that the relay trips but does not reclose with CC5 without power apply the voltage and currents indicated by the AG50 fault and check that the relay trips and recloses. (MLP2000 and MLP3000).

CC6: Channel reception:

With the breaker closed (CC1 without power) and without channel reception (CC6 without power), momentarily apply the currents and voltages indicated by the AG80 fault checking that the relay trips and recloses and that the last events generated were TRIP IN Z2, BREAKER OPENED, BREAKER CLOSED, and FAULT CLEARED. Next, with the breaker closed (CC1 without power) and with channel reception (CC6 with power applied), momentarily apply the currents and voltages indicated by the AG80 fault checking that the relay trips and recloses and that the last events generated were TRIP IN ACCELERATED Z2, BREAKER OPENED, BREAKER CLOSED, and FAULT CLEARED (the event(s) MEAS_UNIT ACT and/or OPEN BRK CURR. may appear at the same time as one of the previous events or be inserted among them). If you have a stop watch, you can observe that an accelerated Z2 trip must be faster than a Z2 trip. (MLP3000)

CC7: Z1X pull back:

With the breaker closed (CC 1 without power), the zone 1 extension scheme selected (PROTEC. SCHEME = 0 = EX. Z1) and CC7 without power, momentarily apply the currents and voltages indicated by the AG99 fault, checking that the relay trips in Z I and recloses. Check that the last events generated were TRIP IN Z1X, BREAKER OPENED, BREAKER CLOSED, and FAULT CLEARED. With power applied to CC7 repeat the same operation and check that the relay trips in zone 2 and recloses, and that the last events generated were TRIP IN Z2, BREAKER OPENED, BREAKER CLOSED, and FAULT CLEARED (the event(s) MEAS_UNIT ACT and/or OPEN BRK CURR. may appear at the same time as one of the previous events or be inserted among them).

CC8: Reclosing inhibition:

Assure you have returned the protection scheme to scaled distance. With the breaker closed (CC 1 without power) and CC8 without power, momentarily apply the currents and voltages indicated by the AG50 fault, checking that the relay trips and recloses. Check that the last events generated were TRIP IN Z I, BREAKER OPENED, BREAKER CLOSED, and FAULT CLEARED. With the breaker closed (CC 1 without power) and power applied to CC8, momentarily apply the currents and voltages indicated by the AG50 fault, checking that the relay trips but does not reclosing and that the last events generated were TRIP IN Z 1, BREAKER OPENED, and NO CLOSE COND (the event(s) MEAS_UNIT ACT and/or OPEN BRK CURR. may appear at the same time as one of the previous events or be inserted among them). (MLP2000 and MLP3000)

6.2.3. RELAY MEASUREMENT

Apply current to the relay through the rear terminals B7-B12, bridging the terminals B8-B9 and B10-B1 land applying voltage to the terminals A2-A3, A4-A5, and A6-A7; enter into the single key menu and check that the relay correctly measures the currents and voltages applied.

The voltage and current values that must be checked are:

I (Amp)	Acceptable Range
0.10 (*In)	0.09 - 0.11 (*In)
0.50 (*In)	0.47 - 0.52 (*In)
1.00 (*In)	0.95 - 1.05 (*In)
2.00 (*In)	1.90 - 2.10 (*In)
5 00 (*In)	4.75 - 5.25 (*In)
10.00 (*In)	9.50- 10.50 (*In)

V (Vol)	Acceptable Range
0.70	0.66 - 0.73
3.50	3.32 - 3.67
7.00	6.65 - 7.35
14.00	13.30- 14.70
35.00	33.2: - 36.75
70.00	66.50 - 73.50

6.2.4 SINGLE PHASE MEASUREMENT UNIT'S REACH FOR THE MHO CHARACTERISTIC

* The magnitudes used in the mho units for ground faults are:

Fault	Quantity Operation	Polarization Qty.
ØG	I'Øx Zr - Vøn	VØ1m

Where: I'Øx Zr = (IØ - I0) x Zr/Θ1 + K0 x I0 x Zr/Θ0
= IØ x Zr/Θ1 + I0 x (K0 x Zr/Θ0 - Zr/Θ1)

Zr: Adjusted impedance reach.
VØn: Ground phase voltage
VØ1m: Positive sequence voltage with memory reference to the phase
IØ: Phase current.
I0: Zero sequence current
Θ1 : Positive sequence line impedance angle
Θ0: Zero sequence line impedance angle
K0: Zero sequence compensation constant

* Set the following protection settings:

201 - OSB IN SERVICE	NO
202 - LPU IN SERVICE	NO
203 - ROD IN SERVICE:	NO
204 - FF IN SERVICE:	NO
205 - MHO/REACT:	MHO
206 - PROTEC. SCHEME:	0=D E
207 - PROT. IN SERVICE:	YES
212 - GENERAL TRIP:	YES
213 - Z3 TRIP:	YES
214 - Z2 TRIP:	YES
215 - ZI TRIP:	YES
219 - POSITIVE SEQUENCE IMPEDANCE (ZL1 IMPED):	6.0
220 - POSITIVE SEQUENCE ANGLE (ZL1 ANGLE):	85°
221 - ZERO SEQUENCE CURRENT COMPENSATION (K0):	3.0
222 - ZERO SEQUENCE ANGLE(ZL0 ANGLE):	75º
223 - Z1 REACH:	4.80
224 - Z1X REACH:	1.40
225 - Z2 REACH:	9.00
226 - Z3 REACH:	12.0
228 - Z1 TIMER:	0
229 - Z2 TIMER:	100
230 -- Z3 TIMER:	120

6.2.4.1. Z1 (AG, BG, CG) PHASE TO GROUND MEASUREMENT UNIT REACH

Change the settings:

213 - Z3 TRIP:	NO
214 - Z2 TRIP:	NO
215 - Z1 TRIP:	YES
226 - Z2 REACH:	2.00

1. Apply the following voltages to the relay through the rear terminals A2-A3, A4-A5, A6-A7

VA (A2-A3) = 67 | 0° VB (A4-A5) = 67 | 120° VC (A6-A7) = 67 | 240°

2. Adjust the fault current argument in accordance with table MHOZ1ØG-5IN or table MHOZ1ØG- 1 IN, according to the rated current: (it is left to the user's discretion to select the characteristic point(s) to check).

3. Set the fault current (IA, IB, or IC according to the phase in fault) to 8.7 A for IN = 5 and 2 A for IN = 1 and the rest of the currents to zero.

4. Reduce the voltage of the phase in fault gradually and check that the relay trips when the voltage is within the limits listed in tables MHOZ1ØG-5IN or MHOZ1ØG-1IN.

5. Reduce the fault current to zero.

6. Repeat the tests for faults in phases BG and CG.

α = degrees that V leads I

α	**MHOZ1ØG-5IN**	In=5A	**MHOZ1ØG-1IN**	In=1A
	Voltage	Acceptable Range	Voltage	Acceptable Range
+39.0	53.12	50.31 - :5.60	12 21	11.44 - 12.65
+49.0	60.06	56.87 - 62.86	13.81	12.93 - 14.30
+59.0	65.16	61.71 - 68.20	14.98	14.03 - 15.51
+69.0	68.29	64.67 - 71.48	15.70	14.71 - 16.26
+79.0	69.35	65.67 - 72.~8	15.94	14.94 - 16.51
+89.0	68.29	64.67 - 71.48	15.70	14.71 - 16.26
+99.0	65.16	61.71 -68.20	14.98	14.03- 15.51
+109.0	60.06	56.87-62.86	13.81	12.93- 14.30
+119.0	53.12	:0.31 -55.60	12.21	11.44- 12.65

6.2.4.2. Z2 (AG, BG, CG) PHASE TO GROUND MEASUREMENT UNIT REACH

Change the settings:

212 - Z3 TRIP:	NO
213 - Z2 TRIP:	YES
214 - Z 1 TRIP:	YES
224 - Z2 REACH:	9.00

1. Apply the following voltages to the relay through the rear terminals A2-A3, A4-A5, A6-A7. THE ANGLES ARE LAGGING!

VA (A2-A3) = 67 | 0°   VB (A4-A5) = 67 | 120°   VC (A6-A7) = 67 | 240°

2. Adjust the fault current argument in accordance with table MHOZ2ØG-5IN or table MHOZ2ØG-1IN, according to the rated current: (it is left to the user's discretion to select the characteristic point(s) to check).

3. Set the fault current (IA, IB, or IC according to the phase in fault) to 4.6 A for IN = 5 and 2 A for IN = 1 and the rest of the currents to zero.

4. Reduce the voltage of the phase in fault gradually and check that the relay trips when the voltage is within the limits listed in tables MHOZ2ØG-5IN or MHOZ2ØG-1IN.

5. Reduce the fault current to zero.

6. Repeat the tests for faults in phases BG and CG.

α= degrees that V leads I

α	**MHOZ1ØG-5IN** In=5A		**MHOZ1ØG-1IN** In=1A	
	Voltage	Acceptable Range	Voltage	Acceptable Range
+39.0	52.66	49.87 - 55.12	22.90	21.59 - 23.87
+49.0	59.54	56.38 - 62.31	25.89	24.41 - 26.98
+59.0	64.60	61.18 - 67.61	28.09	26.49 - 29.28
+69.0	67.70	64.11 - 70.86	29.44	27.76 - 30.68
+79.0	68.75	65.10 - 71.95	29.89	28.19 - 31.15
+89.0	67.70	64.11 - 70.86	29.44	27.76 - 30.68
+99.0	64.60	61.18 - 67.61	28.09	26.49 - 29.28
+109.0	59.54	56.38 - 61.31	25.89	24.41 - 26.98
+119.0	52.66	49.87 - 55.12	22.90	21.59 - 23.87

6.2.4.3 Z3 (AG. BG CG) PHASE TO GROUND MEASUREMENT UNIT REACH

Change the settings:

213 - Z3 TRIP: YES
214 - Z2 TRIP: NO
215 - Z1 TRIP YES

1. Apply the following voltages to the relay through the rear terminals A2-A3, A4-A5, A6-A7. THE ANGLES ARE LAGGING!

VA (A2-A3) = 67| 0° VB (A4-A5) = 67| 120° VC (A6-A7) = 67| 240°

2. Adjust the fault current argument in accordance with table MHOZ3ØG-5IN or table MHOZ3ØG-1IN, according to the rated current: (it is left to the user's discretion to select the characteristic point(s) to check).

3. Set the fault current (IA, IB, or IC according to the phase in fault) to 3.5 A for IN = 5 and 2 A for IN = 1 and the rest of the currents to zero.

4. Reduce the voltage of the phase in fault gradually and check that the relay trips when the voltage is within the limits listed in tables MHOZ3ØG-5IN or MHOZ3ØG-1IN.

5. Reduce the fault current to zero.

6. Repeat the tests for faults in phases BG and CG.

α= degrees that V leads I

α	**MHOZ3ØG-5IN** Voltage	In=5A Acceptable Range	**MHOZ3ØG-1IN** Voltage	In=1A Acceptable Range
+39.0	53.43	50.60 - 55.92	30.53	28.84 - 31.88
+49.0	60.40	57.20 - 63.22	34.51	32.61 - 36.04
+59.0	65.54	62.06 - 68.60	37.45	35.38 - 39.11
+69.0	68.68	65.04 - 71.89	39.25	37.08 - 40.98
+79.0	69.74	66.05 - 73.00	39.85	37.65 - 41.62
+89.0	68.68	65.04 - 71.89	39.25	37.08 - 40.98
+99.0	65.54	62.06 - 68.60	37.45	35.38 - 39.11
+109.0	60.40	57.20 - 63.22	34.51	32.61 - 36.04
+119.0	53.43	50.60 - 55.92	30.53	28.84 - 31.88

6.2.5 SINGLE PHASE MEASUREMENT UNIT'S REACH FOR THE MINIMUM REACTANCE CHARACTERISTIC

* The operation magnitudes and polarization used in the reactance units for ground faults in zones 1 and 2 are:

Fault	Operation Magnitude	Polarization Magnitude.
ØG	I'Øx Zr - Vøn	I2 x Xr

Where: I'Øx Zr = (IØ - I0) x Zr/Θ1 + K0 x I0 x Zr/Θ0
= IØ x Zr/Θ1 + I0 x (K0 x Zr/Θ0 - Zr/Θ1)

Zr: Adjusted impedance reach.
Xr: Relay reactive impedance.
VØn: Ground phase voltage
IØ: Phase current.
I0: Zero sequence current
Θ1 : Positive sequence line impedance angle
Θ0: Zero sequence line impedance angle
K0: Zero sequence compensation constant
IØ2: Negative sequence voltage in reference to the Ø phase.

* Set the following protection settings:

201 - OSB IN SERVICE	NO
202 - LPU IN SERVICE	NO
203 - ROD IN SERVICE:	NO
204 - FF IN SERVICE:	NO
205 - MHO/REACT:	REACT
206 - PROTEC. SCHEME:	0=D E
207 - PROT. IN SERVICE:	YES
212 - GENERAL TRIP:	YES
213 - Z3 TRIP:	NO
214 - Z2 TRIP:	YES
215 - ZI TRIP:	YES
219 - POSITIVE SEQUENCE IMPEDANCE (ZL1 IMPED):	6.0
220 - POSITIVE SEQUENCE ANGLE (ZL1 ANGLE):	85°
221 - ZERO SEQUENCE CURRENT COMPENSATION (K0):	3.0

222 - ZERO SEQUENCE ANGLE(ZL0 ANGLE):	75º
223 - Z1 REACH:	4.80
224 - Z1X REACH:	1.40
225 - Z2 REACH:	9.00
226 - Z3 REACH:	20.0
228 - Z1 TIMER:	0
229 - Z2 TIMER:	100
230 -- Z3 TIMER:	120

6.2.5.1 REACH OF PHASE TO GROUND MEASUREMENT UNIT Z 1 (AG BG, CG)

Change the settings:

213 - Z3TRIP:	NO
214 - Z2 TRIP:	NO
215 - Z 1 TRIP:	YES
225 - Z2 REACH:	YES

1. Apply the following voltages to the relay through the rear terminals A2-A3, A4-A5, A6-A7. THE ANGLES ARE LAGGING!

VA (A2-A3) = 67⌊ 0°   VB (A4-A5) = 67⌊ 120°   VC (A6-A7) = 67⌊ 240°

2. Adjust the fault current argument in accordance with table REACTZ1ØG-5IN or table REACTZ1ØG-1IN, according to the rated current: (it is left to the user's discretion to select the characteristic point(s) to check).

3. Set the fault current (IA, IB, or IC according to the phase in fault) to 5 A for IN = 5 and 2 A for IN = 1 and the rest of the currents to zero.

4. Reduce the voltage of the phase in fault gradually and check that the relay trips when the voltage is within the limits listed in tables REACTZ1ØG-5IN or REACTZ1ØG-1IN.

5. Reduce the fault current to zero.

6. Repeat the tests for faults in phases BG and CG.

α= degrees that V leads I

α	**REACTZ1ØG-5IN** In=5A		**REACTZ1ØG-1IN** In=1A	
	Voltage	Acceptable Range	Voltage	Acceptable Range
+49.0	51.83	49.24 - 54.42	20.73	19.70 - 21.77
+59.0	45.64	43.35 - 47.92	18.25	17.34 - 19.17
+69.0	41.90	39.81 - 44.00	16.76	15.92 - 17.60
+79.0	39.85	37.86 - 41.84	15.94	15.14 - 16.74
+89.0	39.12	37.17 - 41.08	15.65	14.87 - 16.43
+99.0	39.61	37.63 - 41.59	15.84	15.05 - 16.63
+109.0	41.37	39.30 - 43.44	16.55	15.72 - 17.38

6.2.5.2. REACH OF PHASE TO GROUND MEASUREMENT UNIT Z2 (AG, BG, CG)

Change the settings:

213 - Z3 TRIP:	NO
214 - Z2 TRIP:	YES
215 - Z1 TRIP:	NO
225 - Z2 REACH:	9.00

1. Apply the following voltages to the relay through the rear terminals A2-A3, A4-A5, A6-A7. THE ANGLES ARE LAGGING!

VA (A2-A3) = 67| 0°   VB (A4-A5) = 67| 120°   VC (A6-A7) = 67| 240°

2. Adjust the fault current argument in accordance with table REACTZ2ØG-5IN or table REACTZ2ØG-1IN, according to the rated current: (it is left to the user's discretion to select the characteristic point(s) to check).

3. Set the fault current (IA, IB, or IC according to the phase in fault) to 3 A for IN = 5 and 2 A for IN = 1 and the rest of the currents to zero.

4. Reduce the voltage of the phase in fault gradually and check that the relay trips when the voltage is within the limits listed in tables REACTZ2ØG-5IN or REACTZ2ØG-1IN.

5. Reduce the fault current to zero.

6. Repeat the tests for faults in phases BG and CG.

α= degrees that V leads I

α	REACTZ2ØG-5IN	In=5A	REACTZ2ØG-1IN	In=1A
	Voltage	Acceptable Range	Voltage	Acceptable Range
+49.0	58.33	55.42 - 61.25	38.89	36.95 - 40.83
+59.0	51.36	48.79 - 53.92	34.24	32.53 - 35.95
+69.0	47.16	44.80 - 49.52	31.44	29.87 - 33.01
+79.0	44.85	42.61 - 47.09	29.90	28.40 - 31.39
+89.0	44.03	41.83 - 46.23	29.36	27.89 - 30.82
+99.0	44.57	42.35 - 46.80	29.72	28.23 - 31.20
+109.0	46.56	44.23 - 48.89	31.04	29.49 - 32.59

6.2.6 TWO PHASE MEASUREMENT UNIT'S REACH FOR THE MHO CHARACTERISTIC

* The operation quantities used in the MHO units for phase-phase faults are:

Fault	Operation Quantity	Polarization Quantity.
ØØ	(IØ - IØ’)x Zr -(VØ - VØ’)	(VØ1m - VØ1m)

Where:

Zr: Adjusted impedance reach.
VØn: Ground phase voltage
VØ1m: Negative sequence voltage with memory referenced to the Ø phase.
IØ: Phase current.
Θ1 : Positive sequence line impedance angle

* Set the following protection settings:

201 - OSB IN SERVICE	NO
202 - LPU IN SERVICE	NO
203 - ROD IN SERVICE:	NO
204 - FF IN SERVICE:	NO
207 - MHO/REACT:	MHO
208 - PROTEC. SCHEME	0 = D.E.
209 - PROT. IN SERVICE	YES
212 - GENERAL TRIP:	YES
213 - Z3 TRIP:	YES
214 - Z2 TRIP:	YES
215 - Zl TRIP:	YES
219 - POSITIVE SEQUENCE IMPEDANCE (ZL1 IMPED):	6.0
220 - POSITIVE SEQUENCE ANGLE (ZL1 ANGLE):	85°
221 - ZERO SEQUENCE CURRENT COMPENSATION (K0):	3.0
222 - ZERO SEQUENCE ANGLE(ZL0 ANGLE):	75º
223 - Z1 REACH:	4.80
224 - Z1X REACH:	1.40
225 - Z2 REACH:	9.00
226 - Z3 REACH:	12.0
228 - Z1 TIMER:	0

229 - Z2 TIMER:	100
230 -- Z3 TIMER:	120

6.2.6.1 REACH OF PHASE TO PHASE MEASUREMENT UNIT Z 1 (AG BG, CG)

Change the settings:

213 - Z3TRIP:	NO
214 - Z2 TRIP:	NO
215 - Z 1 TRIP:	YES
225 - Z2 REACH:	2.00

1. Apply the following voltages to the relay through the rear terminals A2-A3, A4-A5, A6-A7. THE ANGLES ARE LAGGING!

VA (A2-A3) = 67| 0°   VB (A4-A5) = 67| 120°   VC (A6-A7) = 67| 240°

2. Adjust the fault current argument in accordance with table MHOZIØØG-5IN or table MHOZ1ØØG-1IN, according to the rated current: (it is left to the user's discretion to select the characteristic point(s) to check). ***Note***: The angle between the two fault currents must be 180º

3. Set the fault current (IA, IB, or IC according to the phase in fault) to 10 A for IN = 5 and 2 A for IN = 1 and the rest of the currents to zero.

4. Simultaneously reduce the voltage of both phases gradually and check that the relay trips when the voltage is within the limits listed in tables MHOZ1ØØ-5IN or MHOZ1ØØ-1IN.

5. Reduce the fault currents to zero.

6. Repeat the tests for faults between phases BG and CG.

α= degrees that V leads I

α	**MHOZ1ØØ-5IN**	In=5A	**MHOZ1ØØ-1IN**	In=1A
	Voltage	Acceptable Range	Voltage	Acceptable Range
+25.0	48.00	45.46-50.25	9.60	8.98- 9.93
+35.0	52.08	49.33 - 54.52	10.42	9.74 - 10.77
+45.0	54.58	51.70-57.14	10.92	10.21 - 11.29
+55.0	55.43	52.49 - 58.02	11.09	10.37 - 11.46
+65.0	54.58	51.70-~7.14	10.92	10.21 - 11.29
+75.0	52.08	49.33 - 54.52	10.42	9.74 - 10.77
+85.0	48.00	45.46 - 50.25	9.60	8.98 - 9.93

6.2.6.2 REACH OF PHASE TO PHASE MEASUREMENT UNIT Z 1 (AG BG, CG)

Change the settings:

213 - Z3TRIP:	NO
214 - Z2 TRIP:	YES
215 - Z 1 TRIP:	NO
225 - Z2 REACH:	9.00

1. Apply the following voltages to the relay through the rear terminals A2-A3, A4-A5, A6-A7. THE ANGLES ARE LAGGING!

VA (A2-A3) = 67 | 0° VB (A4-A5) = 67 | 120° VC (A6-A7) = 67 | 240°

2. Adjust the fault current argument in accordance with table MHOZ2ØØG-5IN or table MHOZ2ØØG-1IN, according to the rated current: (it is left to the user's discretion to select the characteristic point(s) to check). ***Note***: The angle between the two fault currents must be 180º

3. Set the fault current (IA, IB, or IC according to the phase in fault) to 6.7 A for IN = 5 and 2 A for IN = 1 and the rest of the currents to zero.

4. Simultaneously reduce the voltage of both phases gradually and check that the relay trips when the voltage is within the limits listed in tables MHOZ1ØØ-5IN or MHOZ1ØØ-1IN.

5. Reduce the fault currents to zero.

6. Repeat the tests for faults between phases BG and CG.

α= degrees that V leads I

α	**MHOZ2ØØ-5IN**	In=5A	**MHOZ2ØØ-1IN**	In=1A
	Voltage	Acceptable Range	Voltage	Acceptable Range
+25.0	60.30	57.15-63.16	18.00	16.96- 18.75
+35.0	65.43	62.01 - 68.53	19.53	18.40 - 20.34
+45.0	68.57	64.98 - 71.82	20.47	19.29 - 21.32
+55.0	69.63	65.99 - 72.93	20.78	19.58 - 21.65
+65.0	68.57	64.98 - 71.82	20.47	19.29 - 21.32
+75.0	65.43	62.01 - 68.53	19.53	18.40 - 20.34
+85.0	60.30	57.15-63.16	18.00	16.96- 18.75

6.2.6.3 REACH OF PHASE TO PHASE MEASUREMENT UNIT Z3 (AG,BG,CG)

Change the settings:

213 - Z3TRIP:	YES
214 - Z2 TRIP:	NO
215 - Z 1 TRIP:	NO

1. Apply the following voltages to the relay through the rear terminals A2-A3, A4-A5, A6-A7. THE ANGLES ARE LAGGING!

VA (A2-A3) = 67│ 0°   VB (A4-A5) = 67│ 120°   VC (A6-A7) = 67│ 240°

2. Adjust the fault current argument in accordance with table MHOZ3ØØG-5IN or table MHOZ3ØØG-1IN, according to the rated current: (it is left to the user's discretion to select the characteristic point(s) to check). ***Note***: The angle between the two fault currents must be 180º

3. Set the fault current (IA, IB, or IC according to the phase in fault) to 5 A for IN = 5 and 2 A for IN = 1 and the rest of the currents to zero.

4. Simultaneously reduce the voltage of both phases gradually and check that the relay trips when the voltage is within the limits listed in tables MHOZ3ØØ-5IN or MHOZ3ØØ-1IN.

5. Reduce the fault currents to zero.

6. Repeat the tests for faults between phases BG and CG.

α= degrees that V leads I

α	**MHOZ3ØØ-5IN**	In=5A	**MHOZ3ØØ-1IN**	In=1A
	Voltage	Acceptable Range	Voltage	Acceptable Range
+25.0	60.00	56.86 - 62.85	24.00	22.66 - 25.05
+35.0	65.10	61.70 - 68.19	26.04	24.59 - 27.18
+45.0	68.23	64.66 - 71.47	27.29	25.77 - 28.48
+55.0	69.28	65.66 - 72.57	27.71	26.17 - 28.92
+65.0	68.23	64.66 - 71.47	27.29	25.77 - 28.48
+75.0	65.10	61.70 - 68.19	26.04	24.59 - 27.18
+85.0	60.00	56.86 - 62.85	24.00	22.66 - 25.05

6 2 7 NON-CONFIGURABLE OUTPUT CONTACTS

With the relay disconnected from the power source, remove the protection CPU and reassemble the relay. Apply power to the relay and check that the alarm output contact (C3-C4) is closed.

With the relay disconnected from the power source, insert the protection CPU in it's place and reassemble the relay. Apply power to the relay and check that the alarm output contact (C3-C4) is open.

- Set the following protection and recloser settings:

207 - MHO/REACT:	MHO
208 - PROTEC. SCHEME	0 = D.E.
209 - PROT. IN SERVICE	YES
212 - GENERAL TRIP:	YES
213 - Z3 TRIP:	YES
214 - Z2 TRIP:	YES
215 - Zl TRIP:	YES
219 - POSITIVE SEQUENCE IMPEDANCE (ZL1 IMPED):	5.0
220 - POSITIVE SEQUENCE ANGLE (ZL1 ANGLE):	87°
221 - ZERO SEQUENCE CURRENT COMPENSATION (K0):	3.1
222 - ZERO SEQUENCE ANGLE(ZL0 ANGLE):	73º
223 - Z1 REACH:	3.00
225 - Z2 REACH:	4.00
226 - Z3 REACH:	15.0
228 - Z1 TIMER:	0
229 - Z2 TIMER:	100
301 - NUM RCL ATTEMPTS	1
303 - DELAY ATTEMPT 1:	5s

Apply the voltages and currents indicated by the AG70 fault (see fault list) for a period of less than ls and check that first the trip contacts (C5-C6, C7-C8) are closed followed by the close or reclosing contacts (C9-C 10. C 11 -C 12).

6.2.8 PHASE SELECTORS, FAULT LOCATOR (MLP3000), AND THE ZONE. TIMERS.

Set the following protection settings:

207 - MHO/REACT:	MHO
208 - PROTEC. SCHEME	0 = D.E.
209 - PROT. IN SERVICE	YES
213 - Z3 TRIP:	YES
214 - Z2 TRIP:	YES
215 - Zl TRIP:	YES
219 - POSITIVE SEQUENCE IMPEDANCE (ZL1 IMPED):	5.0
220 - POSITIVE SEQUENCE ANGLE (ZL1 ANGLE):	87°
221 - ZERO SEQUENCE CURRENT COMPENSATION (K0):	3.1
222 - ZERO SEQUENCE ANGLE(ZL0 ANGLE):	73º
223 - Z1 REACH:	3.00
225 - Z2 REACH:	4.00
226 - Z3 REACH:	15.0
228 - Z1 TIMER:	0
229 - Z2 TIMER:	100
230 - Z3 TIMER	200

6.2.8.1. AG FAULTS

Apply the voltages and currents indicated by the faults AG00, AG25, AG50. AG75. and AG99 and check that:

–The relay signals an AG fault in all of them.
–The relay finds the fault distance in all of them with an error of less than 5%. For example: for the AG50 fault' the relay must locate the fault between 45 and 55 km.
–In the faults AG00, AG25, and AG50, the relay trips in zone 1, in the AG75 fault the relay trips in zone 2, and in the AG99 fault the relay trips in zone 3.
–The trip time in zone 1 is less than 50ms.
–The trip time in zone 2 is greater than 100 ms and less than 150 ms.
–The trip time in zone 3 is greater than 200 ms and less than 250 ms.

6.2.8.2. BC FAULTS

Apply the voltages and currents indicated by the faults BC0, BC25,BC50, BC75, and BC99 and check that:

- the relay signals an BC fault in all of them.
- the relay finds the fault distance in all of them with an error of less than 5%. For example: for the BC50 fault, the relay must locate the fault between 45 and 55 km.
- in the faults BC0, BC25 and BC50, the relay trips in zone 1, in the BC75 fault the relay trips in zone 2, and in the BC99 fault the relay taps in zone 3.
- the trip time in zone 1 is less than 50 ms.
- the trip time in zone 2 is greater than 100 ms and less than 150 ms.
- the trip time in zone 3 is greater than 200 ms and less than 250 ms ms.

6 2.8.3. BCG FAULTS

Apply the voltages and currents indicated by the faults BCG0, BCG25, BCG50, BCG75, and BCG99 and check that:

- the relay signals an BCG fault in all of them
- the relay finds the fault distance in all of them with an error of less than ~v/O. for example for the BCG50 fault, the relay must locate the fault between 45 and 55 km.
- in the faults BCGO, BCG25, and BCG50, the relay trips in zone 1, in the BCG75 fault the relay taps in zone 2, and in the BCG99 fault the relay trips in zone 3.
- the trip time in zone I is less than 50 ms.
- the trip time in zone 2 is greater than 100 ms and less than 150 ms.
- the trip time in zone 3 is greater than 200 ms and less than 250 ms.

6.2.8.4. 3PH FAULTS

Apply the voltages and currents indicated by the faults 3PH0, 3PH25, 3PH50, 3PH75, and 3PH99 and check that:

- the relay signals an 3PH fault in all of them.
- the relay finds the fault distance in all of them with an error of less than 5%. For example: for the 3PH50 fault, the relay must locate the fault between 45 and 55 km.
- in the faults 3PHO, 3PH25, and 3PH50, the relay trips in zone 1, in the 3PH75 fault the relay trips in zone 2, and in the 3PH99 fault the relay trips in zone 3.
- the trip time in zone 1 is less than 50ms.
- the trip time in zone 2 is greater than 100 ms and less than 150 ms.
- the trip time in zone 3 is greater than 2()0 ms and less than 250 ms.

6.2.9 ZONE 1 EXTENSION SCHEME

Set the following protection setting:

209 - PROT. IN SERVICE	1= Z1X
223 - Z1 REACH:	4.50
224 - Z1X REACH:	1.20
225 - Z2 REACH:	6.00
226 - Z3 REACH:	15.0

With the breaker closed (CC1 without power), the Z1X without pull back (CC7 without power), momentarily apply the currents and voltages indicated by the AG99 fault, checking that the relay trips in zone 1 and recloses. Check that the last events generated were TRIP IN Z 1X. BREAKER OPENED, BREAKER CLOSED, and FAULT CLEARED.

With Z1X pulled back (power applied to CC7) repeat the same operation and check that the relay trips in zone 2, and that the last events generated were TRIP IN Z2, BREAKER OPENED, (the event(s)MEAS_UNIT ACT and/or OPEN BRK CURR. may appear at the same time as one of the previous events or be inserted among them).

6.2.10 ZONE 2 ACCELERATION SCHEME (MLP3000)

Set the following protection setting:

208 - PROTEC. SCHEME:	2=ACZ2

With the breaker closed (CC1 without power) and without channel reception (CC6 without power), momentarily apply the currents and voltages indicated by the AG:0 fault checking that the transmission start output is activated (the D11-D12 contact closes).

With the breaker closed (CC1 without power) and without channel reception (CC6 without power), momentarily apply the currents and voltages indicated by the AG80 fault checking that the relay trips and recloses and that the last events generated were TRIP IN

Z2, BREAKER OPENED, BREAKER CLOSED, and FAULT CLEARED. Next, with the breaker closed (CC1 without power) and with channel reception (CC6 with power applied), momentarily apply the currents and voltages indicated by the AG80 fault checking that the relay trips and recloses and that the last events generated were TRIP IN ACCELERATED Z2, BREAKER OPENED, BREAKER CLOSED, and FAULT CLEARED (the event(s) MEAS_UNIT ACT and/or OPEN BRK CURR. may appear at the same time as one of the previous events or be inserted among them).

If you have a stop watch, you can observe that an accelerated Z2 trip must be faster than a Z2 trip.

6.2.11. LPU FUNCTION

Set the following protection setting:

202 - LPU IN SERVICE	YES

Apply the voltages and currents corresponding to a balanced system, but instead of applying the rated voltage, apply more than 3 times the rated voltage of the relay. Ensure that tripping by LPU is permitted and that the MLP sees the breaker open (for this use the latching relay which simulates the breaker in position 0).

To check the LPU function there are 2 tests:

In the first test the CC-3 input contact (LPU input) is activated and check that the LPU trips the relay. This is checked by observing the trip contacts and the trip message on the monitor.

In the second test, instead of activating the LPU input, perform the close breaker operation and check for the same conditions as in the first test.

6.2.12. ROD FUNCTION (MLP3000)

-Set the following protection settings:

203 - ROD IN SERVICE	YES
207 - MHO/REACT:	MHO
208 - PROTEC. SCHEME	0 = D.E.
209 - PROT. IN SERVICE	YES
210- TRIPS CAUSED BY ROD (ROD(TRIP):	YES
213 - Z3 TRIP:	YES
214 - Z2 TRIP:	YES
215 - ZI TRIP:	YES
218 - ROD TIMER	0
219 - POSITIVE SEQUENCE IMPEDANCE (ZL1 IMPED):	5.0
220 - POSITIVE SEQUENCE ANGLE (ZL1 ANGLE):	87°
221 - ZERO SEQUENCE CURRENT COMPENSATION (K0):	3.1
222 - ZERO SEQUENCE ANGLE(ZL0 ANGLE):	73º
223 - Z1 REACH:	3.00
225 - Z2 REACH:	4.00

226 - Z3 REACH:	15.0
229 - Z2 TIMER:	140
230 - Z3 TIMER:	200

Apply the three voltages and the phase A current as indicated by the AG99 fault (see fault list). With a delay of less than 400 ms apply the currents for phases B and C modifying their phases in such a way that the phase B and C currents are leading their respective voltages by 90°. Ensure that the relay performs a ROD trip by checking the indication on the monitor or the corresponding event in the event log.

6.2.13 DD FUNCTION (MLP3000)

Check In the Relay Status menu that the DD is inactive and observe how it activates when applying any fault.

6.2.14 FF FUNCTION (MLP3000)

-Set the following protection setting:

204 - FF IN SERVICE:	YES

Apply the voltages and currents corresponding to a balanced system with the voltages to the rated voltage (67V) and ensure. View the FF status in the Relay status menu and check that when the voltage falls in any of the three phases the FF activates and recuperates when the voltage returns.

6.2.15 TRIP BLOCKS (Settings and Input)

Set the following protection settings:

208 - PROTEC. SCHEME	0 = D.E.
209 - PROT. IN SERVICE	YES
213 - Z3 TRIP:	YES
214 - Z2 TRIP:	YES
215 - ZI TRIP:	YES
219 - POSITIVE SEQUENCE IMPEDANCE (ZL1 IMPED):	5.0
220 - POSITIVE SEQUENCE ANGLE (ZL1 ANGLE):	87°
221 - ZERO SEQUENCE CURRENT COMPENSATION (K0):	3.1
222 - ZERO SEQUENCE ANGLE(ZL0 ANGLE):	73º
223 - Z1 REACH:	3.00
225 - Z2 REACH:	4.00
226 - Z3 REACH:	15.0
227 - Z1 TIMER	0
229 - Z2 TIMER:	140
230 - Z3 TIMER:	200

PROHIBIT A TRIP IN ZONE 1, apply a fault in Zone 1 (i.e. AG50) and check that the relay trips in Zone 2.

PROHIBIT A TRIP IN ZONE 2, apply a fault in Zone 2 (i.e. AG75) and check that the relay trips in Zone 3.

PROHIBIT A TRIP IN ZONE 3, apply a fault in Zone 3 (i.e. AG99) and check that the relay does not trip.

PROHIBIT A GENERAL TRIP, apply a fault in Zone I (i.e. AG50) and check that the relay does not trip.

Activate the trip block input (CC-2), apply a fault in Zone I (i.e. AG50) and check that the relay does not trip.

6. 2.16 DIRECTION INDICATORS

Apply the voltages and currents of a balanced system with 0ø of lag between the voltages and currents.

In the Relay Status menu check that the voltage for phase A in the trip address. Increment the difference between the voltage and current of phase A until the phase A current is not in the trip address. Check that the lag between IA and VA is 90ø ñ 5ø. Perform the same tests for phases B and C.

6.2. 17 OPERATIONS

Set the latching relay which simulates a breaker to position 0 indicating that the breaker is closed Put the recloser in service

Perform the block recloser operation and check in the relay status that the recloser has been blocked.

Perform the open breaker operation and check in the relay status that the breaker is open.

Perform the close breaker operation and check in the relay status that the breaker is closed.

Perform the synchronize operation and check in the relay status that the relay and the PC that are being used have the same time.

6.2.18 BREAKER SUPERVISION

Set the following general settings:

102 - ASSOCIATED CT RATIO:	1000
114 - ACCUMULATED AMPS:	1000
115 - LIMIT ACCU. AMPS:	1200

Apply the voltages and currents of a balanced system with the rated values (67 V and 1/5 A). Successively perform the open breaker and close breaker operations and check that the value accumulated by the breaker in 1 or in 25 kA^2 according to the current applied. Check that at the moment the accumulated value exceeds the limit value the relay activates the BREAKER MAINTENANCE signal.

6.2.19 RECLOSER (MLP2000 and MLP3000)

1. Put the recloser in service setting the NUMBER OF INTENTS to 1 and open the breaker. Check (in the single key menu or the Relay status menu) that the RECLOSER is CLOSED. Check that the recloser passes to the STANDBY state upon closing the breaker.

2. Activate the RECLOSING INHIBIT input, .apply the AG00 fault, and check (in the single key menu) how the RECLOSER passes from the STANDBY state to the IN PROGRESS state, and finally remains BLOCKED. Check that this has generated, in this order, the following events: TRIP IN Z1, BREAKER OPENED. and NO CLOSING CONDITIONS.

3. With the breaker closed and the recloser in standby, disconnect the trip output and the latching relay. Apply the AG00 fault that the same occurs as in the previous case, except the events generated should be TRIP IN Z 1 and OPEN FAILURE.

4. Proceed in the same way as the previous case, but instead of disconnecting the trip output, disconnect the close output and check that the recloser passes through the same states as in the previous two cases and generates the events: TRIP IN Z 1, BREAKER OPENED, and CLOSE FAILURE

5. With the system correctly connected and the recloser in standby, apply the AG00 fault for one second and check that the recloser passes from STANDBY to IN PROGRESS and returns to STANDBY. The following events should be generated: TRIP IN Z l, BREAKER OPENED BREAKER CLOSED and FAULT CLEARED.

6.2.20 CONFIGURABLE OUTPUTS

(For relays with standard outputs)

SC- 1 Output: FUSE FAILURE: Proceed in the same way as in section 6.2.14 and check that the corresponding output is activated.

SC-2 Output: INITIATION OF BREAKER FAILURE: Set the relay in the same configuration as in section 6.2.8, apply any fault and check that the corresponding output is activated

SC-3 Output: END OF Z2 TIMER: Set the relay in the same configuration as in section 6.2.8, apply the voltages and currents of the AG75 fault and check that the corresponding output is activated.

SC-4 Output: END OF Z3 TIMER: Set the relay in the same configuration as in section 6.2.8, apply the voltages and currents of the AG99 fault and check that the corresponding output is activated.

SC-5: EXTENDED ZONE 1 PULL BACK: Block the recloser, either manually (block recloser operation) or by deactivating the breaker status input and check that the corresponding output is activated. For model MLP1000 and MLP4000 in which there is no recloser, the way for activating SC-5 out put is activating CC-7 contact converter input.

SC-6: CYCLE IN PROGRESS (RECLOSER): Set the number of reclosing attempts to l, apply the voltages and currents of the AG00 fault for I second, and check that after activating the trip output and until the close output is deactivated, the corresponding output is activated (MLP2000 and MLP3000).

SC-7: BLOCKED (RECLOSER): Block the recloser, either manually (block recloser operation) or by deactivating the breaker status input and check that the corresponding output is activated (MLP2000 and MLP3000).

SC-8: START OF TRANSMISSION: Select the Accelerated Zone 2 scheme, apply the voltages and currents of the AG50 fault and check that the corresponding output is activated.

6.2.21 EVENT REGISTER

Ensure that the event mask is set to allow all events. Perform the following operations in this order: delete events, synchronize the relay, open the breaker, and close the breaker. Perform an events inquiry and check that these events are listed in chronological ordered, that the date and time are correct

CLEAR EVENTS
SYNCHRONIZE
OPEN ORDER
BREAKER OPENED
CLOSE ORDER

BREAKER CLOSED

6.2.22 OUT OF STEP BLOCKING

The following is an elementary test of OSB function. considering that an exhaustive test would require complex equipment.

201 - OUT OF STEP BLOCKING (OSB) IN SERVICE:	NO
202 - LINE PICK UP (LPU) IN SERVICE:	NO
203 - REMOTE OPEN DETECTOR (ROD) IN SERVICE:	NO
204 - FUSE FAILURE (FF) IN SERVICE:	NO
207 - MHO OR REACTANCE CHARACTERISTIC:	Mho
208 - PROTECTION SCHEME:	0=D.E
209 - PROTECTION IN SERVICE:	YES
212 - GENERAL TRIP AUTHORIZATION:	YES
213 - ALLOW ZONE 3 TRIPS:	YES
214 - ALLOW ZONE 2 TRIPS:	YES
215 - ALLOW ZONE 1 TRIPS:	YES
217 - FF TIMER FUNCTION:	100 ms
219 - POSITIVE SEQUENCE LINE IMPEDANCE MODULE:	6Ω
220 - POSITIVE SEQUENCE ANGLE OF MAXIMUM REACH:	85°
221 - ZERO SEQUENCE CURRENT COMPENSATION:	3
222 - ZERO SEQUENCE ANGLE OF MAXIMUM REACH:	75°
223 - ZONE 1 REACH:	4.8Ω
224 - EXTENDED ZONE I REACH:	1.4
225 - ZONE 2 REACH:	9Ω
226 - ZONE 3 REACH:	12Ω
228 - ZONE 1 TRIP TIMER:	0 ms
229 - ZONE 2 TRIP TIMER.	100ms
230 - ZONE 3 TRIP TIMER:	120 ms

Apply the following voltages and currents:

VA=63|0º ||VB=63 |120° || VC=63 | 240°

IA = 10 |20º || IB=10 |140° || IC=10|260º

Slowly reduce the voltage in the phase until the relay taps. Set the setting 201 OUT OF STEP BLOCKING (OSB) IN SERVICE to YES. Slowly reduce the voltage in the three phases and check that the relay does not trip.

7. PERIODIC TESTS AND MAINTENANCE

7.1 DESCRIPTION

It is recommended to develop a periodic testing program to check all MLP functions involved in the scheme used. It is left to the users discretion which of the ACCEPTANCE TESTS should be applied depending on the installation.

NOTE: The tests results performed with sine wave generator equipment must be interpreted cautiously, due to the fact that this equipment does not reflect the true behavior of the electrical system, which can be achieved in a simulator.

The equipment needed for these tests is the same as for the acceptance tests with the addition of XTM test combs

7.2 TESTS PERFORMED WITH THE XTM COMBS.

Description:

The XTM test combs are designed for tests on the equipment installed. There are two types of test combs: the XTM28L1 (left) and the XTM28R1 (right); each one allows access to 14 points on the relay side, and 14 on the system side. The points corresponding to the system side are located on the exterior of the comb. The test combs are coded so they cannot be accidentally exchanged.

The test combs are equipped with a sliding handle to allow wiring to the terminals. The terminals are screw type on flat contact boards. The handles include a overhanging PLANE which permits guiding the wires connected to the terminals.

Of the external relay connections, the ones wired through a test block allowing access by the test combs are:

- AC inputs.
- AC voltage inputs.
- Standby voltage inputs.
- Trip contacts.

(see external connection diagrams in figures 3.1 to 3.12)

7.3 THE TEST BLOCK DENOMINATION.

The test block and connection combs are located on the left side of the test block. Their terminals are labeled from 1 to 28, with numbers 1 to 14 labeled on the left side and numbers 15 to 28 labeled on the right side. These points are designated in the external connection diagram (figure 3) and in the tests schemes such as TPI to TP28.

The left test comb (XTM28L1) terminals are labeled from 1R to 14R and 1S to 14S identifying the relay and system sides respectively, with the system side in red. In the same way, the right test comb (XTM28R1) terminals are labeled from 15R to 28R and 15S to 28S

7 4 CONNECTION OF THE TEST COMBS.

The connections designated in diagrams such as TP must be performed on the relay side of the test combs. When you wish to use quantities related to the system in the test, for example standby voltage, you must bridge the relay side with the corresponding system side to the point that you wish to test. Special precautions must be taken when working with substation batteries

The connections to the test combs must be performed before inserting them into the relay.

7.5. INSERTING THE TEST COMBS.

To insert the test combs the connection combs must first be extracted. In this way, the circuits wired through the test block are disconnected. Short-circuit bars on the system side of the test block are included for the terminals corresponding to the current transformer secondaries. The short-circuit bars are visible through an exterior transparent plastic part. The bars make contact before the connection combs interrupt the connection, so the current transformers secondaries are never in an open circuit.

The two test combs can be connected simultaneously. When using only one test comb the connection comb can be left on the other side.

When test combs are connected, the exterior system remains insulated from the MLP where the test signals are concerned.

IMPORTANT!
BRIDGES MUST BE CONNECTED ON THE SYSTEM SIDE IN TERMINALS CONNECTED TO CURRENT TRANSFORMER SECONDARIES. IF THE BRIDGES, INADVERTENTLY, ARE NOT CONNECTED, HIGH VOLTAGES DEVELOP WHICH CAN BE VERY DANGEROUS FOR THE PERSONNEL AND MAY DAMAGE THE CONNECTED EQUIPMENT.

7.6 STANDBY VOLTAGE DISCONNECTION.

The continuous standby voltage can be disconnected by removing any of the connection combs from the test block or extracting the magnetic module.

7.7 EQUIPMENT TESTING PROCEDURES AND CONNECTION AFTER THE EQUIPMENT IS INSTALLED.

The same procedure can be used as for the acceptance tests once the system input and output separation measurements have been taken. When equipment testing is performed without extracting any module keep in mind that XTM test combs interrupt the trip signals and close signals only. The rest of the contacts remain connected and can operate, depending on the test performed To avoid this, the wiring for the related terminals must be disconnected, making sure that when finished all wires are reconnected properly. The external connections scheme of figures 3.1, 3.5, and 3.9 shows which logic and analog inputs pass through the test block (indicated by the sign ><)

8. RECEPTION, HANDLING, AND STORAGE

CAUTION

This relay contains electronic components which could be damaged by electrostatic discharge currents if those currents flow through certain terminals of the components. The main source of electrostatic discharge currents is the human body. Conditions such as low humidity, carpeted floors and isolating shoes are conducive to the generation of electrostatic discharge currents. Where these conditions exist, care should be exercised when removing and handling the modules to make settings on the internal switches. The persons handling the module should make sure that their body charge has been discharged by touching some surface at ground potential before touching any of the components on the modules.

This relay is supplied to the customer in a special package, which adequately protects it during transportation, as long as this is performed under normal conditions.

Immediately after receiving the relay, the customer should check whether it shows any signs of transportation damage. If it is apparent that the relay has been damaged due to inappropriate handling, it must be immediately reported in writing to the transportation carrier, and the damage must be reported to the manufacturer.

For unpacking the relay, care should be taken not to lose the screws also supplied in the box.

If you do not intend to install the relay immediately, it is recommended that the relay be stored in its original packaging and kept in a dry, dust-free place.

It is important to check that the data on the name plate coincides with the data from the order

INSTALLATION

The place where the relay is to be installed must be clean, dry, free of dust and excessive vibration, and well illuminated to facilitate inspection and tests.

MOUNTING

The MLP systems have been designed for mounting in standard 19" racks. The relay must be mounted on a vertical surface. Figure 2 represents the dimensions and drilling diagram of the MLP.

The external connection schemes are represented in figure 3.

GROUND CONNECTION FOR DISTURBANCE SUPPRESSION

The A3 terminal of the relay must be connected to ground so that the disturbance suppression circuits included in the relay may function correctly. This connection to ground must be as short possible to ensure the maximum protection (preferably 25 cm or shorter).

9. FIGURE LIST

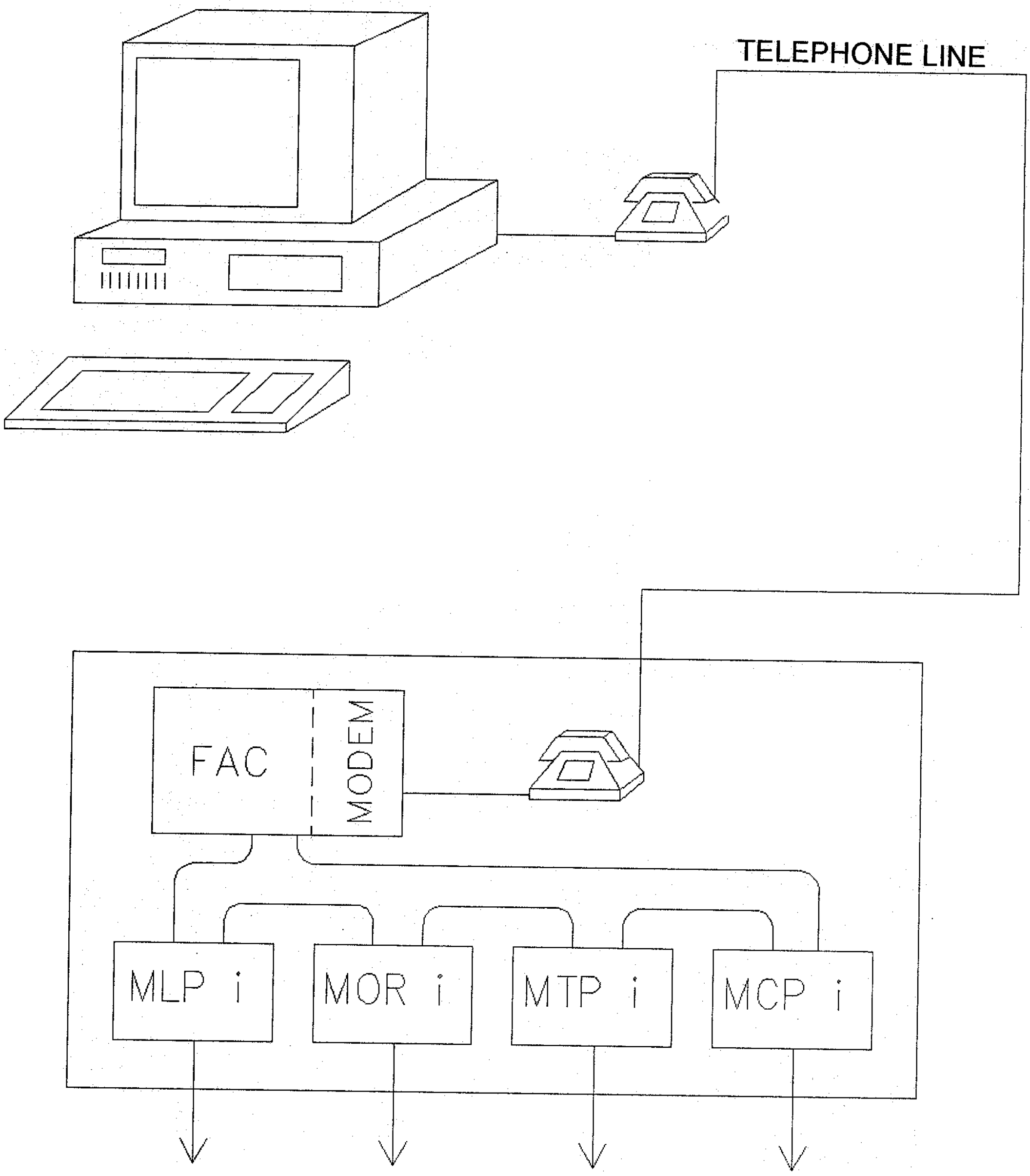


Figure 1. System diagram with MLP, CPR and TTI.

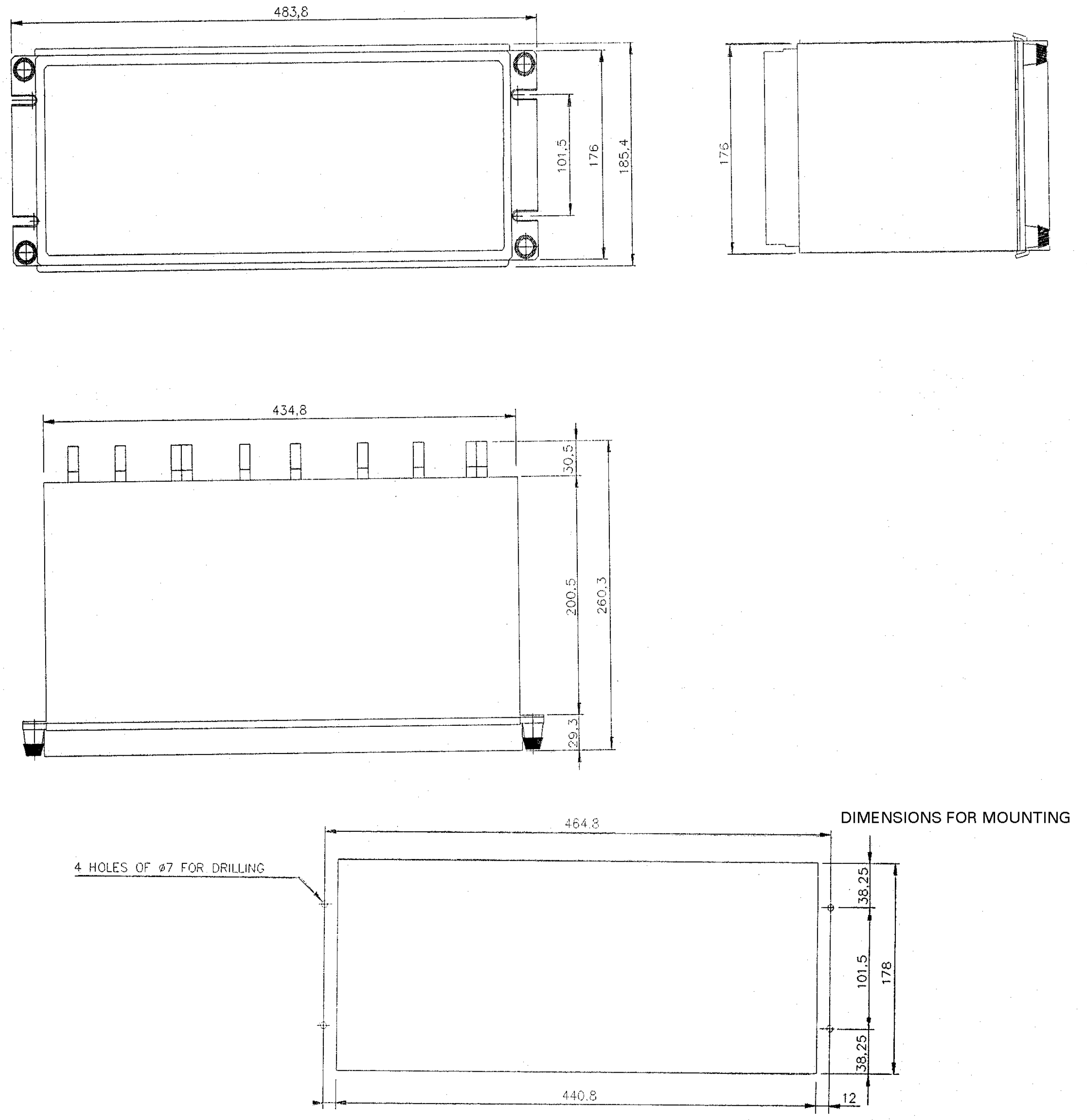


Figure 2. Case dimensions and drilling form 1 rack.

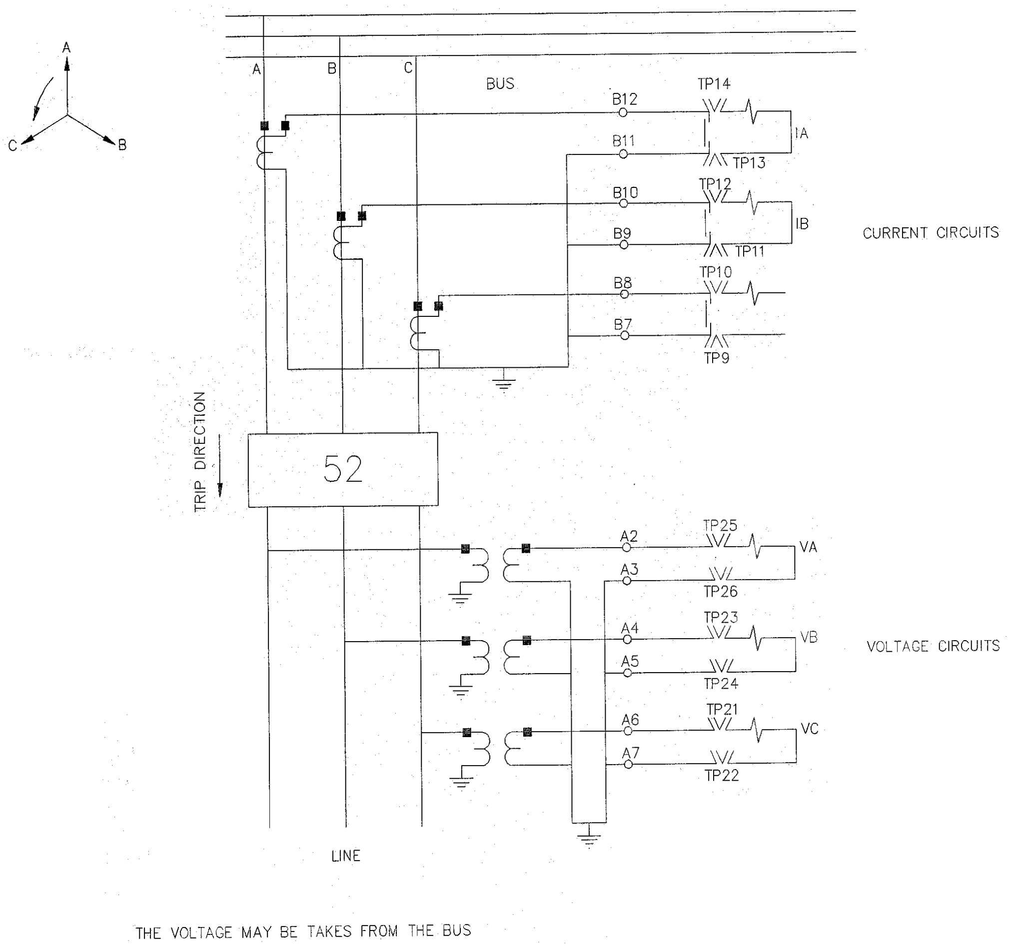
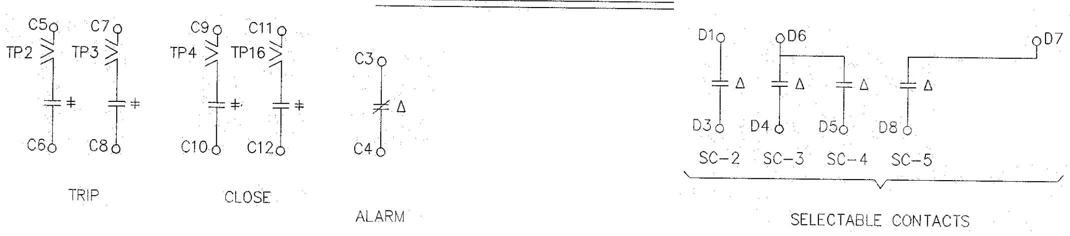


Figure 3.1. External Connections MLP1000

TRIP AND ALARM CONTACTS



CONTACTS ALARM CONFIGURATION

ANY SELECTABLE CONTACT CAN BE ASSIGNED (AT FACTORY) TO ONE LOGIC SIGNAL FROM LIST-2. STANDARD CONFIGURATION IS SHOW AT LIST-1

LIST-1

(STANDARD CONFIGURATION)

SC-2 BREAKER FAILURE INITIATION

SC-3 ZONE II TIMER OUT

SC-4 ZONE III TIMER OUT

SC-5 PULLBACK EXTENDED ZONE I

LIST-2 SEE SH-3

(ǂ) CONTACTS RATED 60VA WITH L/R = 0,04

(Δ) CONTACTS RATED 30VA WITH L/R = 0,04

(◇) CONTACTS RATED 10 WATTS.

Figure 3.2. External Connections MLP1000

LIST - 2

BREAKER FAILURE INITIATION

LINE PICK UP TRIP

ZONE SWITCHING

ZONE I TIMER OUT

ZONE II TIMER OUT

ZONE III TIMER OUT

RECLOSE IN PROGRESS (RECLOSER)

LOCK-OUT (RECLOSER)

PULL BACK EXTENDED ZONE I

ANY MEASURING UNIT
(M1AG, M1BG, M1CG, M1AB, M1BC, M1CA,
M3AG, M3BG, M3CG, M3AB, M3BC, M3CA)

ANY GROUND MEASURING UNIT

ANY ZONE 1 GROUND MEASURING UNIT

ANY ZONE 3 GROUND MEASURING UNIT

ANY PHASE MEASURING UNIT

ANY ZONE 1 PHASE MEASURING UNIT

ANY ZONE 3 PHASE MEASURING UNIT

Figure 3.3. ·External connections MLP1000

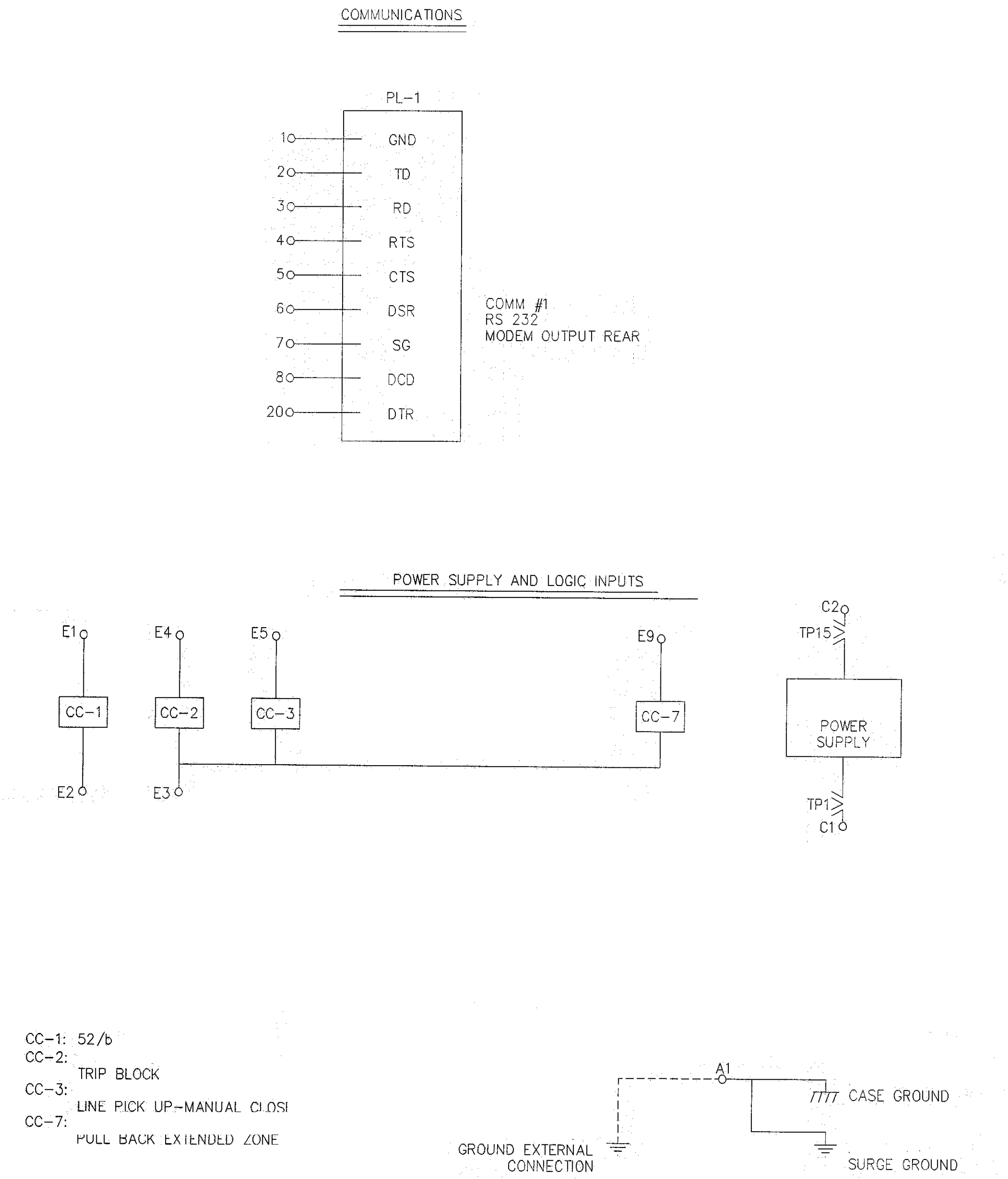


Figure 3.4. External Connections MLP1000

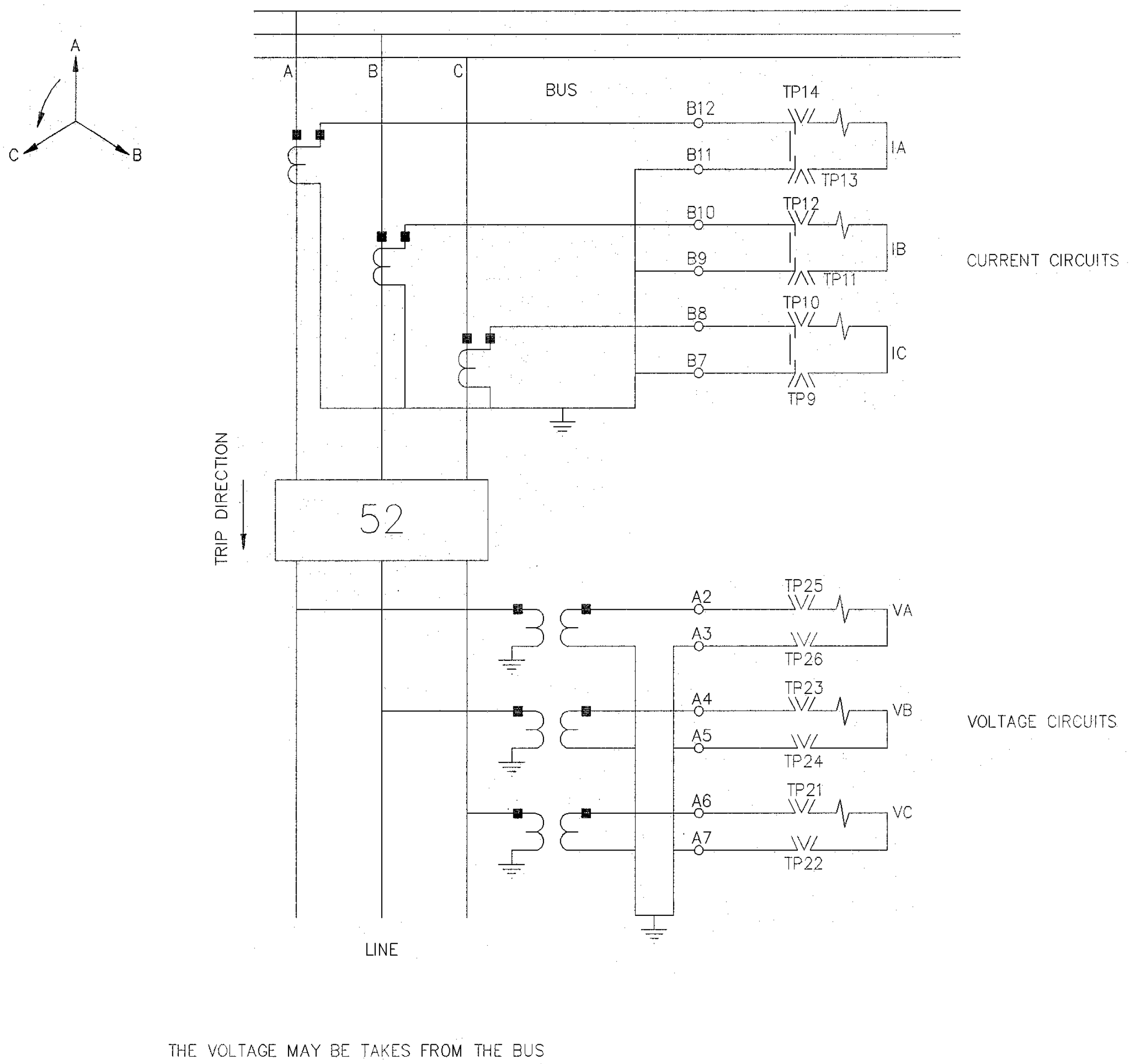
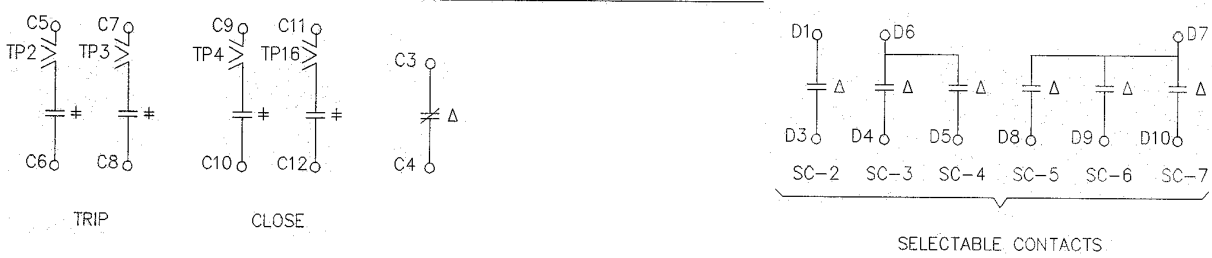


Figure 3.5. External Connections MLP2000

TRIP AND ALARM CONTACTS



CONTACTS ALARM CONFIGURATION

ANY SELECTABLE CONTACT CAN BE ASSIGNED (AT FACTORY) TO ONE LOGIC SIGNAL FROM LIST−2. STANDARD CONFIGURATION IS SHOW AT LIST−1.

LIST−1

(STANDARD CONFIGURATION)

SC−2 BREAKER FAILURE INITIATION
SC−3 ZONE II TIMER OUT
SC−4 ZONE III TIMER OUT
SC−5 PULLBACK EXTENDED ZONE I
SC−6 RECLOSE IN PROGRESS (RECLOSER)
SC−7 LOCK−OUT (RECLOSER)

LIST−2 SEE SH−3

(⧧) CONTACTS RATED 60VA WITH L/R = 0,04
(Δ) CONTACTS RATED 30VA WITH L/R = 0,04
(◇) CONTACTS RATED 10 WATTS.

Figure 3.6. External Connections MLP2000

LIST - 2

RECLOSE INITIATE

RECLOSE CANCEL

BREAKER FAILURE INITIATION

LINE PICK UP TRIP

ZONE SWITCHING

ZONE I TIMER OUT

ZONE II TIMER OUT

ZONE III TIMER OUT

RECLOSE IN PROGRESS (RECLOSER)

LOCK-OUT (RECLOSER)

PULL BACK EXTENDED ZONE I

ANY MEASURING UNIT
(M1AG, M1BG, M1CG, M1AB, M1BC, M1CA,
M3AG, M3BG, M3CG, M3AB, M3BC, M3CA)

ANY GROUND MEASURING UNIT

ANY ZONE 1 GROUND MEASURING UNIT

ANY ZONE 3 GROUND MEASURING UNIT

ANY PHASE MEASURING UNIT

ANY ZONE 1 PHASE MEASURING UNIT

ANY ZONE 3 PHASE MEASURING UNIT

Figure 3.7. External Connections MLP2000

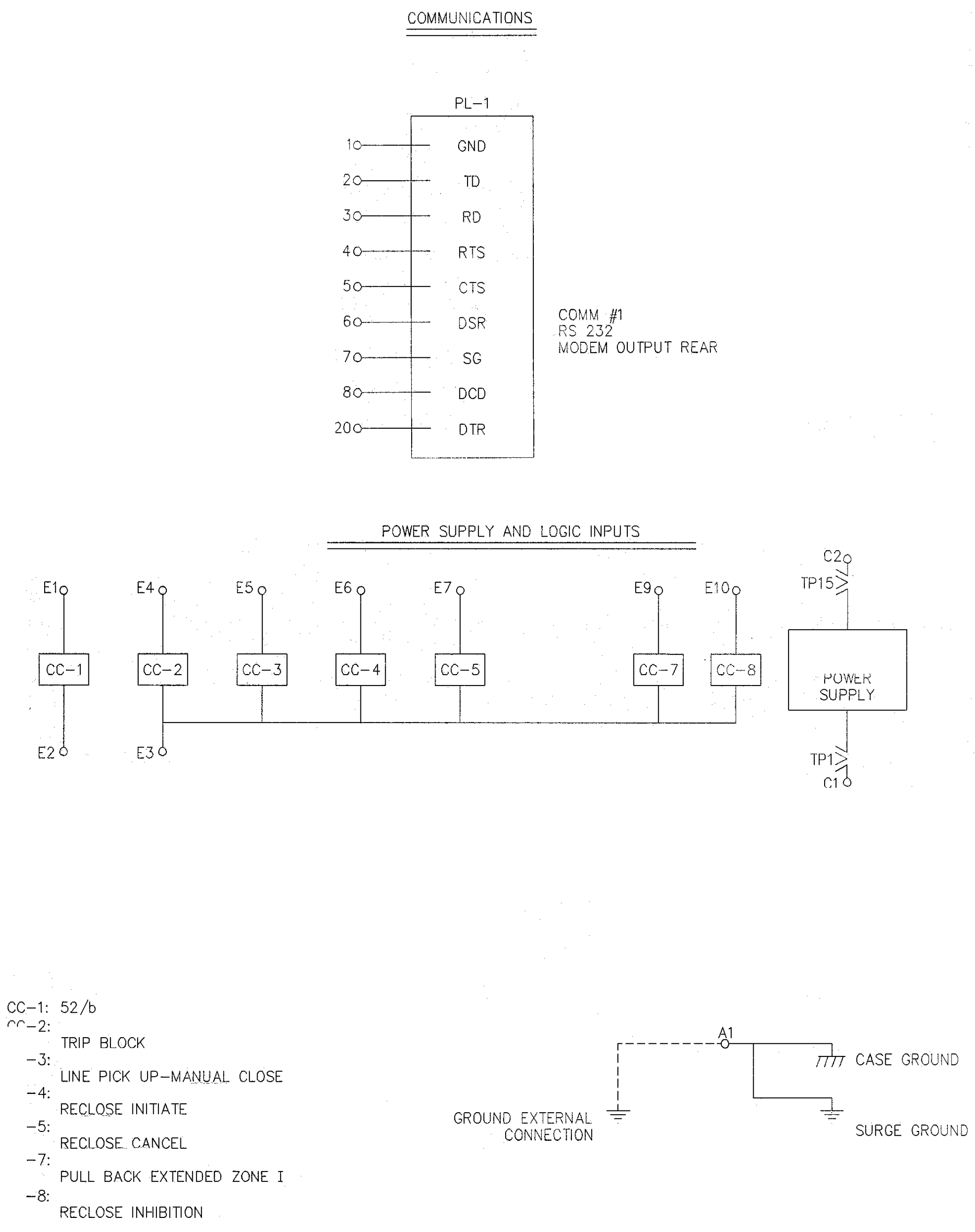


Figure 3.8. External Connections MLP2000

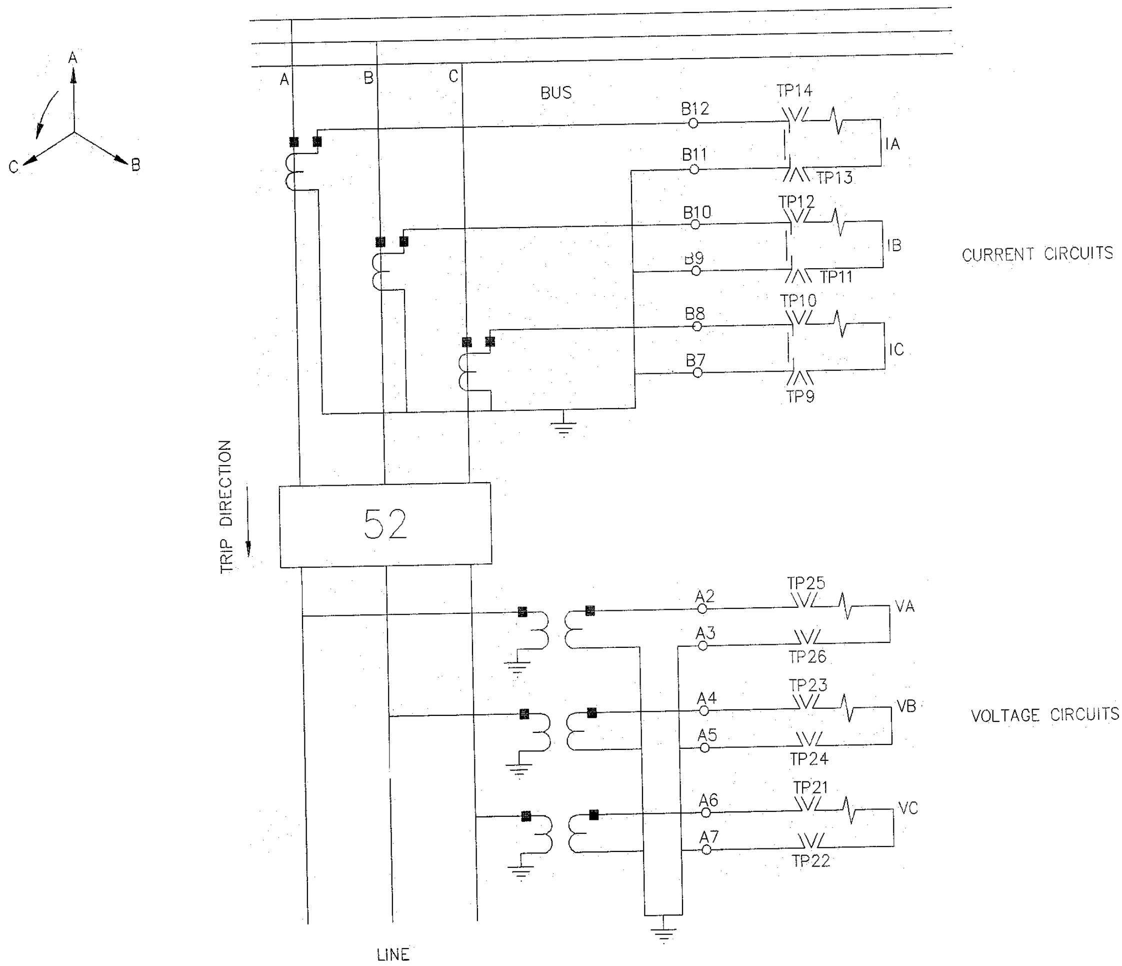
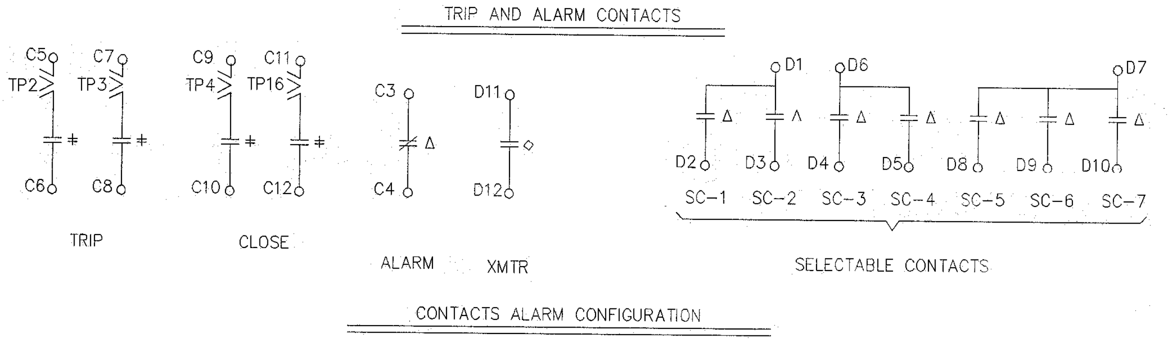


Figure 3.9. External Connections MLP3000



ANY SELECTABLE CONTACT CAN BE ASSIGNED (AT FACTORY) TO ONE LOGIC SIGNAL FROM LIST-2. STANDARD CONFIGURATION IS SHOW AT LIST-1.

LIST-1

(STANDARD CONFIGURATION)

SC-1	FUSE FAILURE
SC-2	BREAKER FAILURE INITIATION
SC-3	ZONE II TIMER OUT
SC-4	ZONE III TIMER OUT
SC-5	PULLBACK EXTENDED ZONE I
SC-6	RECLOSE IN PROGRESS (RECLOSER)
SC-7	LOCK-OUT (RECLOSER)

LIST-2 SEE SH-3

(⧧) CONTACTS RATED 60VA WITH L/R = 0,04

(Δ) CONTACTS RATED 30VA WITH L/R = 0,04

(◇) CONTACTS RATED 10 WATTS.

Figure 3.10. External Connections MLP3000

LIST - 2

RECLOSE INITIATE

RECLOSE CANCEL

FUSE FAILURE

BREAKER FAILURE INITIATION

LINE PICK UP TRIP

ZONE SWITCHING

ZONE I TIMER OUT

ZONE II TIMER OUT

ZONE III TIMER OUT

RECLOSE IN PROGRESS (RECLOSER)

LOCK-OUT (RECLOSER)

PULL BACK EXTENDED ZONE I

REMOTE OPEN POLE DETECTOR MEASURING UNIT

ANY MEASURING UNIT
(M1AG, M1BG, M1CG, M1AB, M1BC, M1CA,
M3AG, M3BG, M3CG, M3AB, M3BC, M3CA)

ANY GROUND MEASURING UNIT

ANY ZONE 1 GROUND MEASURING UNIT

ANY ZONE 3 GROUND MEASURING UNIT

ANY PHASE MEASURING UNIT

ANY ZONE 1 PHASE MEASURING UNIT

ANY ZONE 3 PHASE MEASURING UNIT

Figure 3.11. External Connections MLP3000

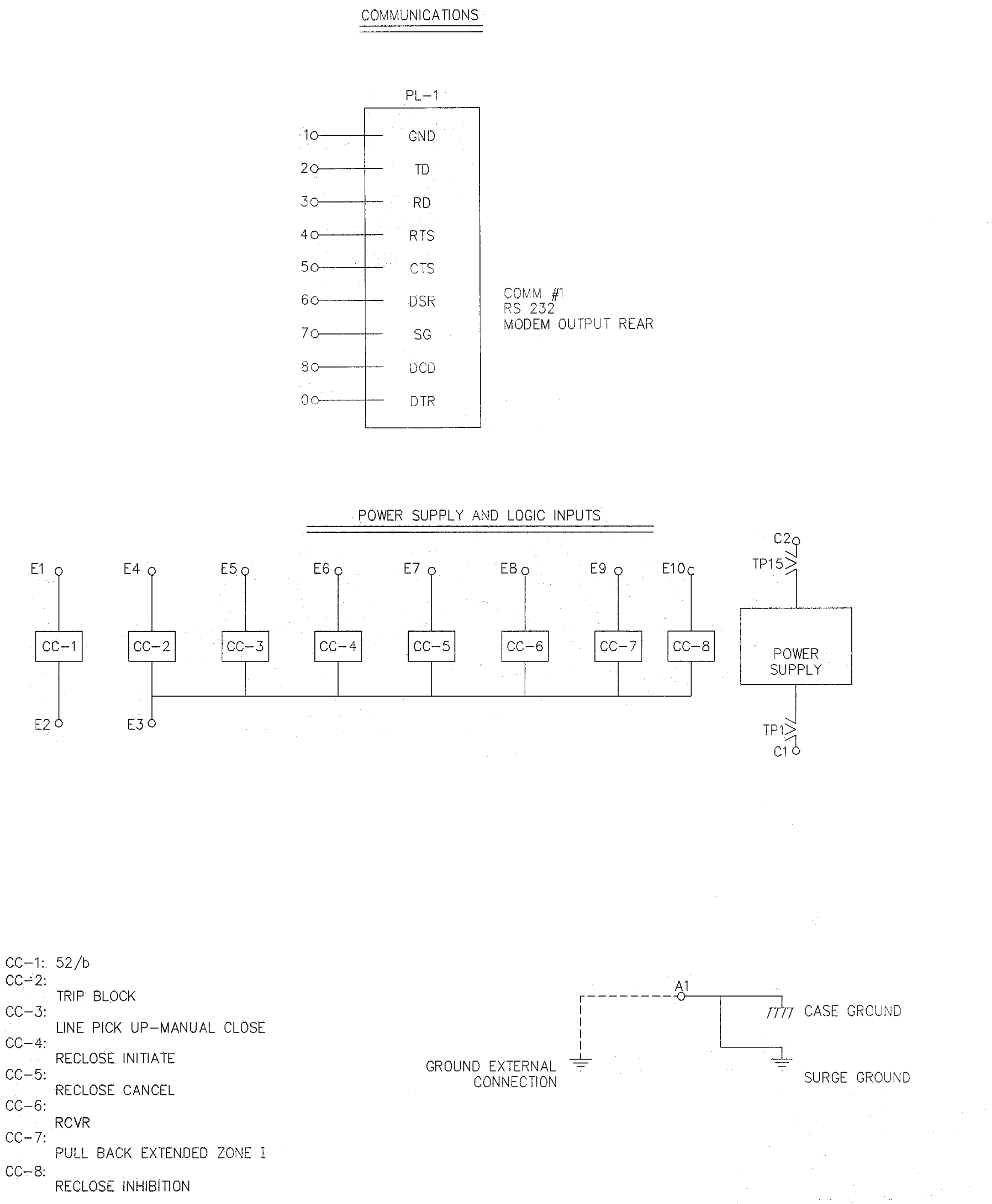


Figure 3.12. External Connections MLP3000

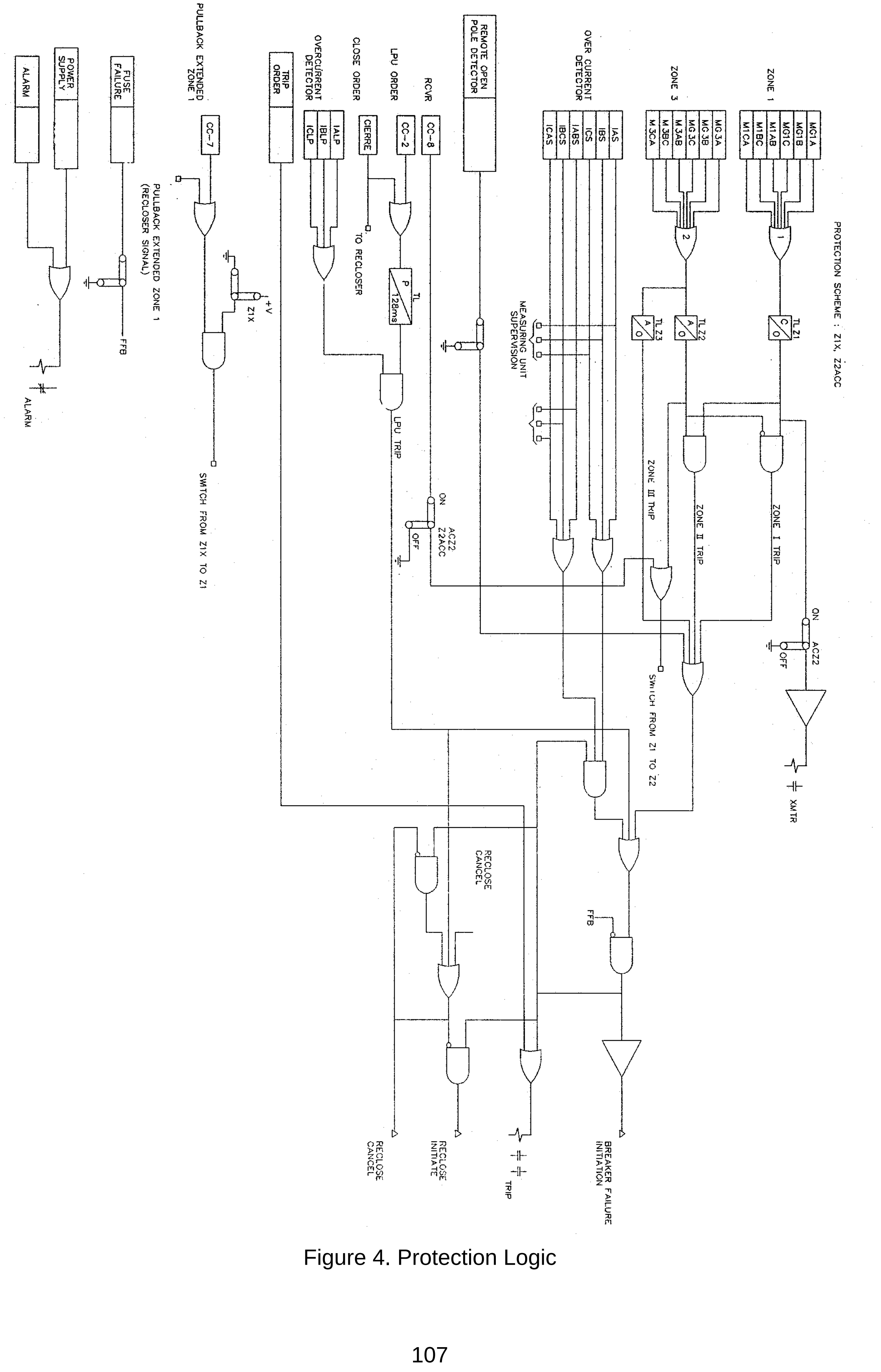


Figure 4. Protection Logic

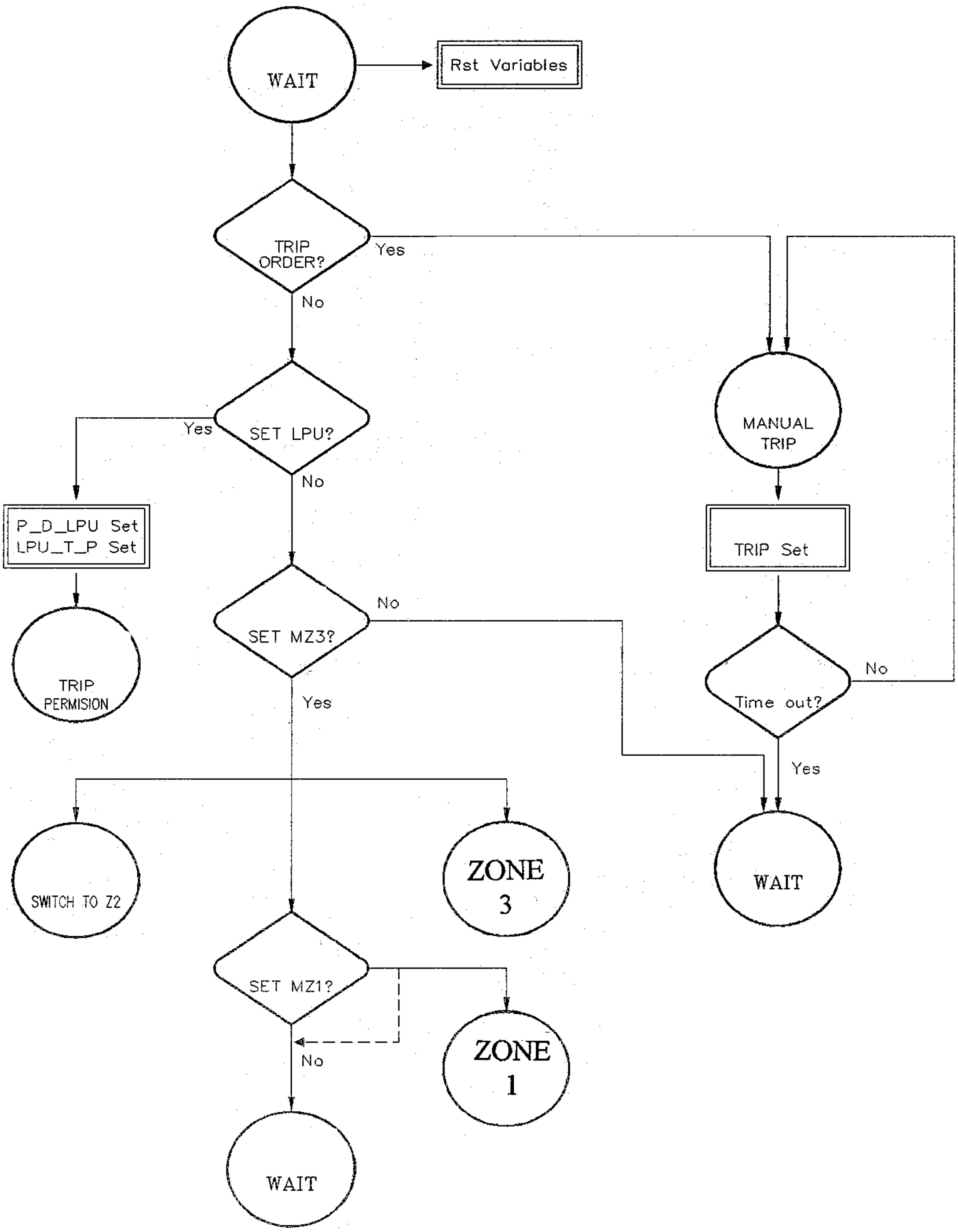


Figure 5.1. Trip decision diagram

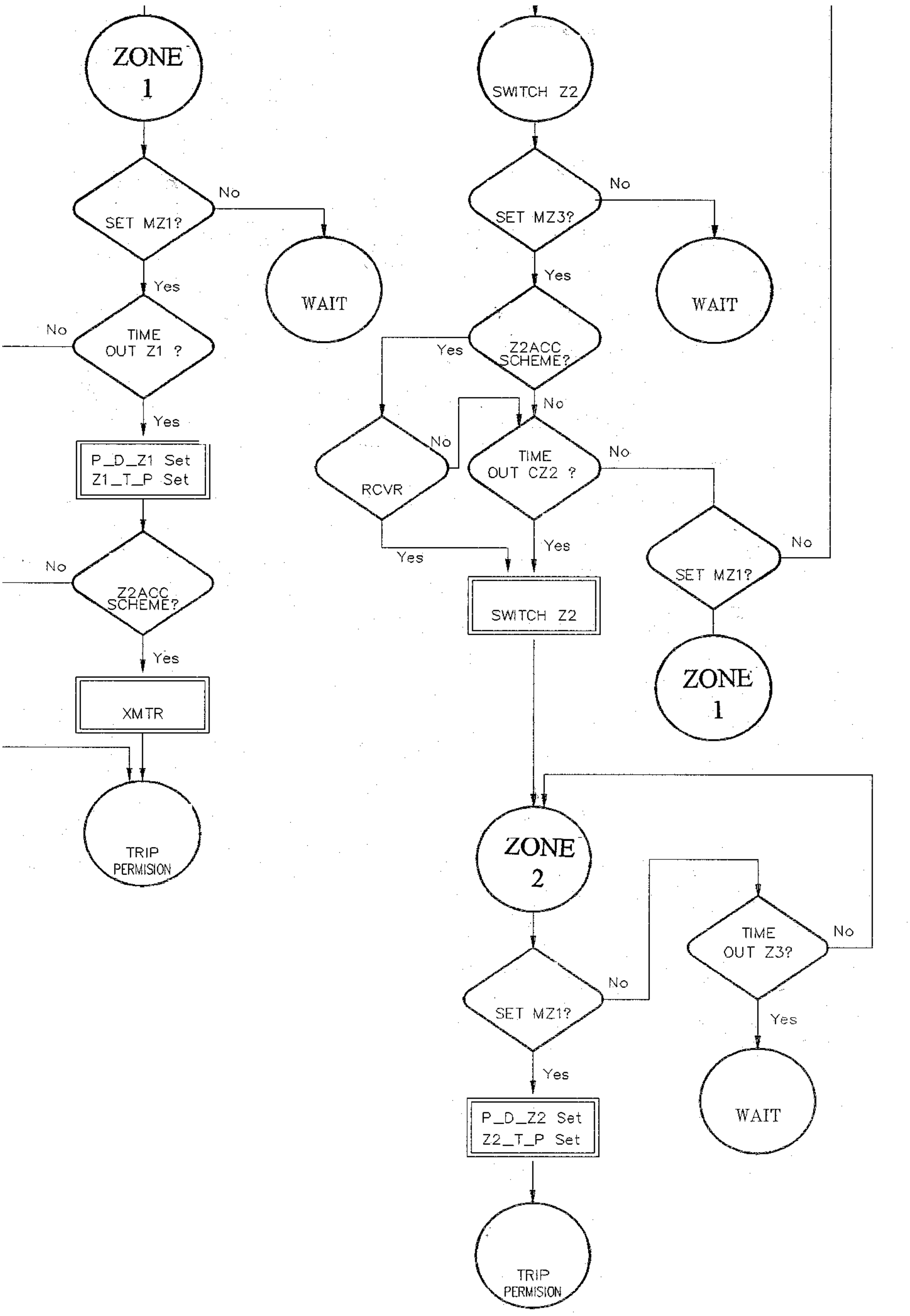


Figure 5.2. Trip decision diagram

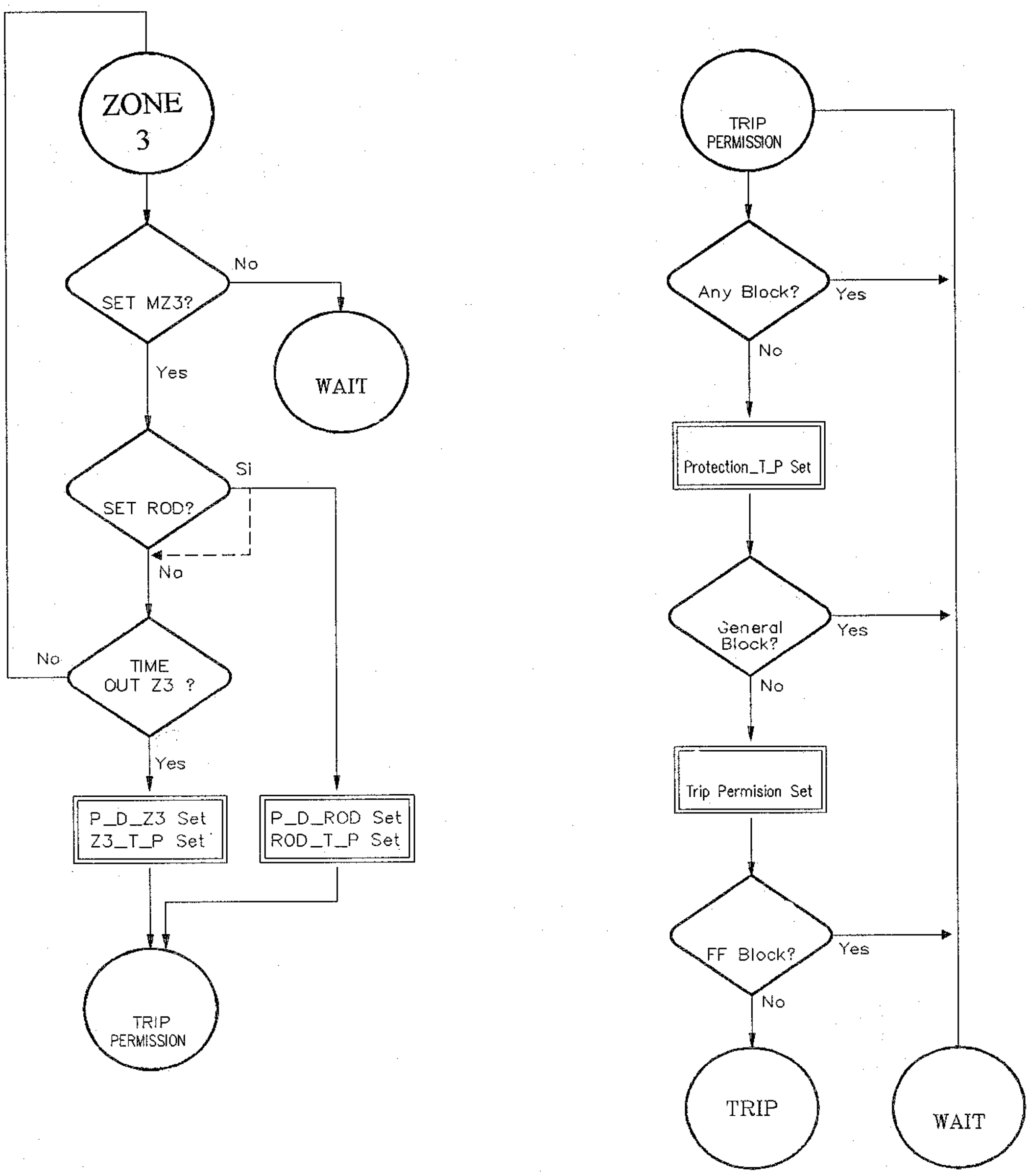


Figure 5.3. Trip decision diagram

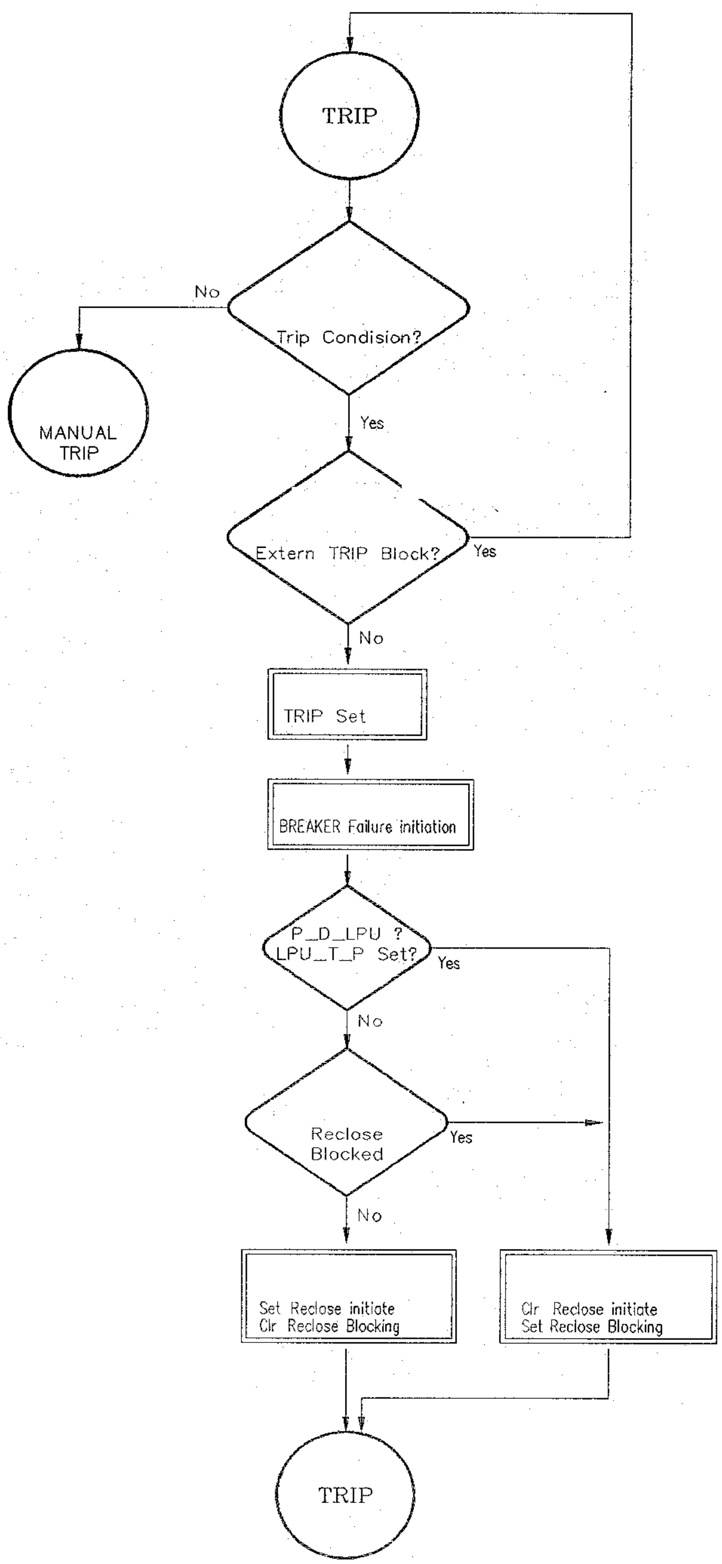


Figure 5.4. Trip decision diagram

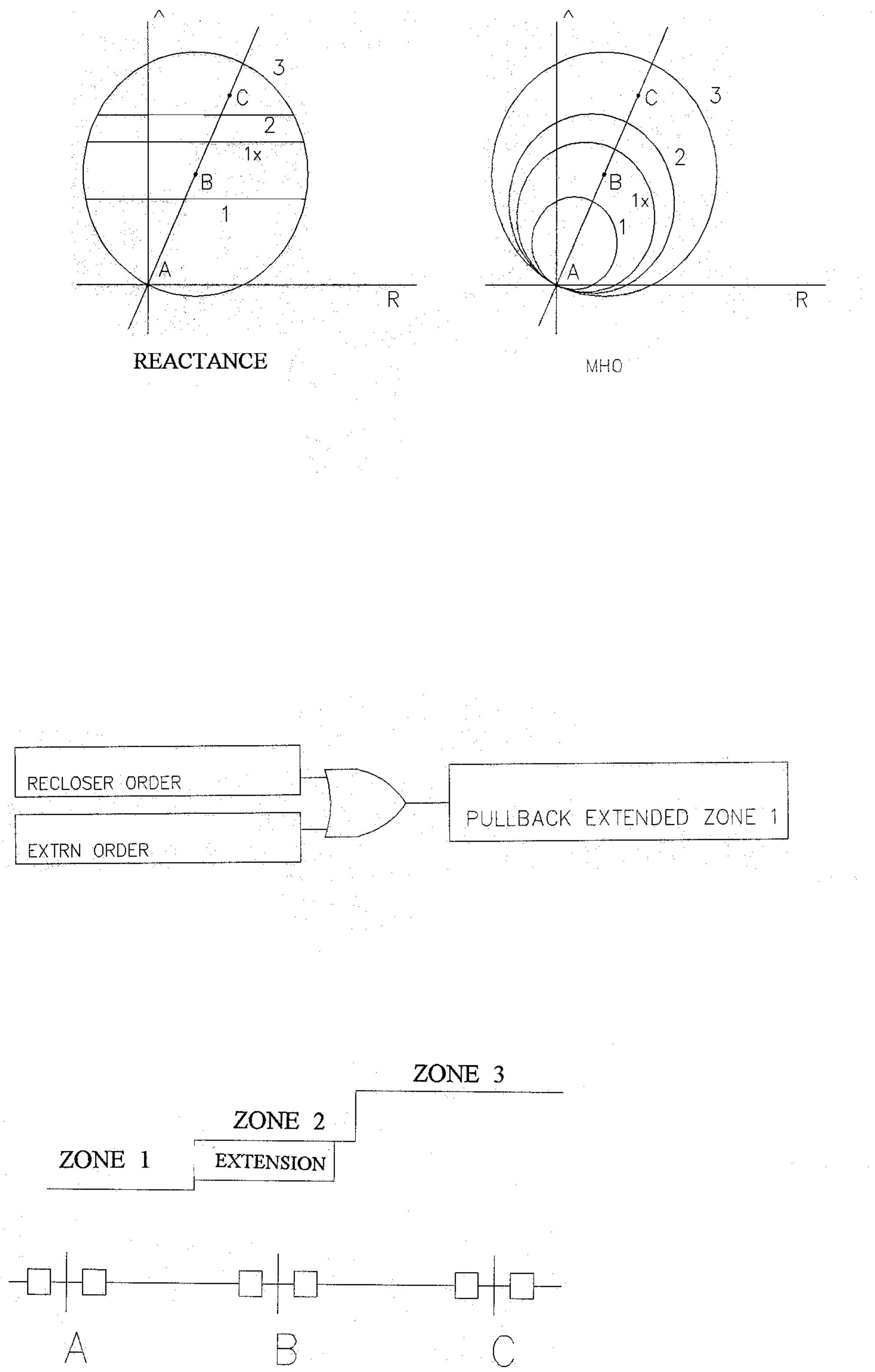


Figure 6.1. Z1X protection scheme

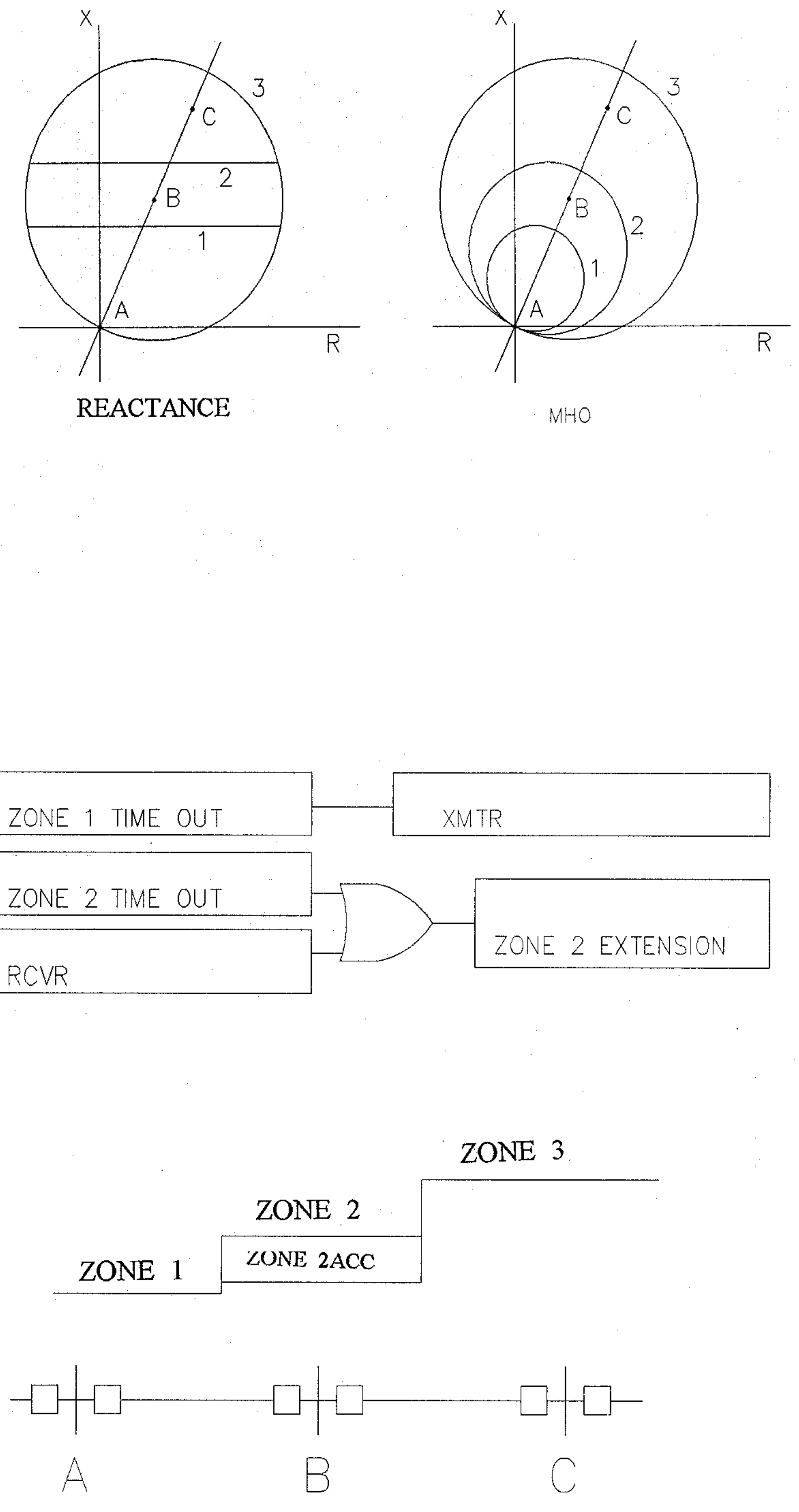


Figure6.2. ACCZ2 Protection scheme

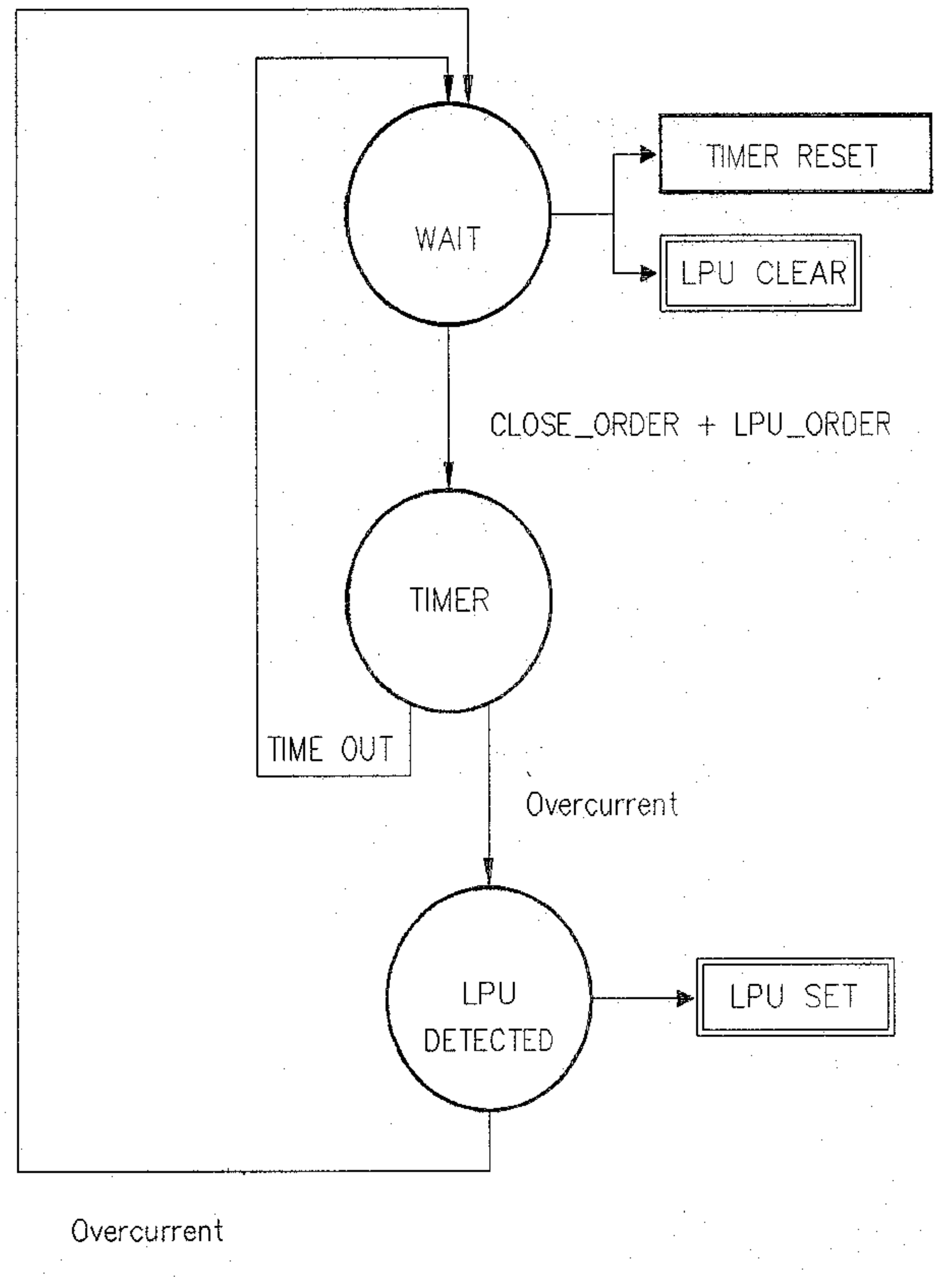


Figure7. LPU function diagram

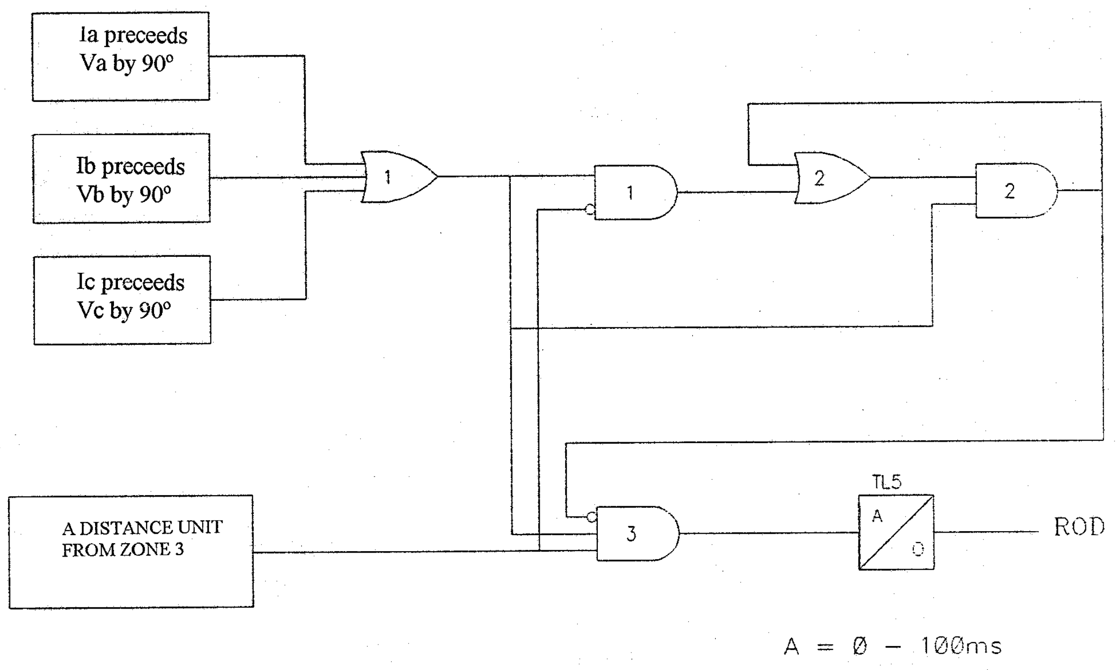


Figure 8.1. ROD function logic

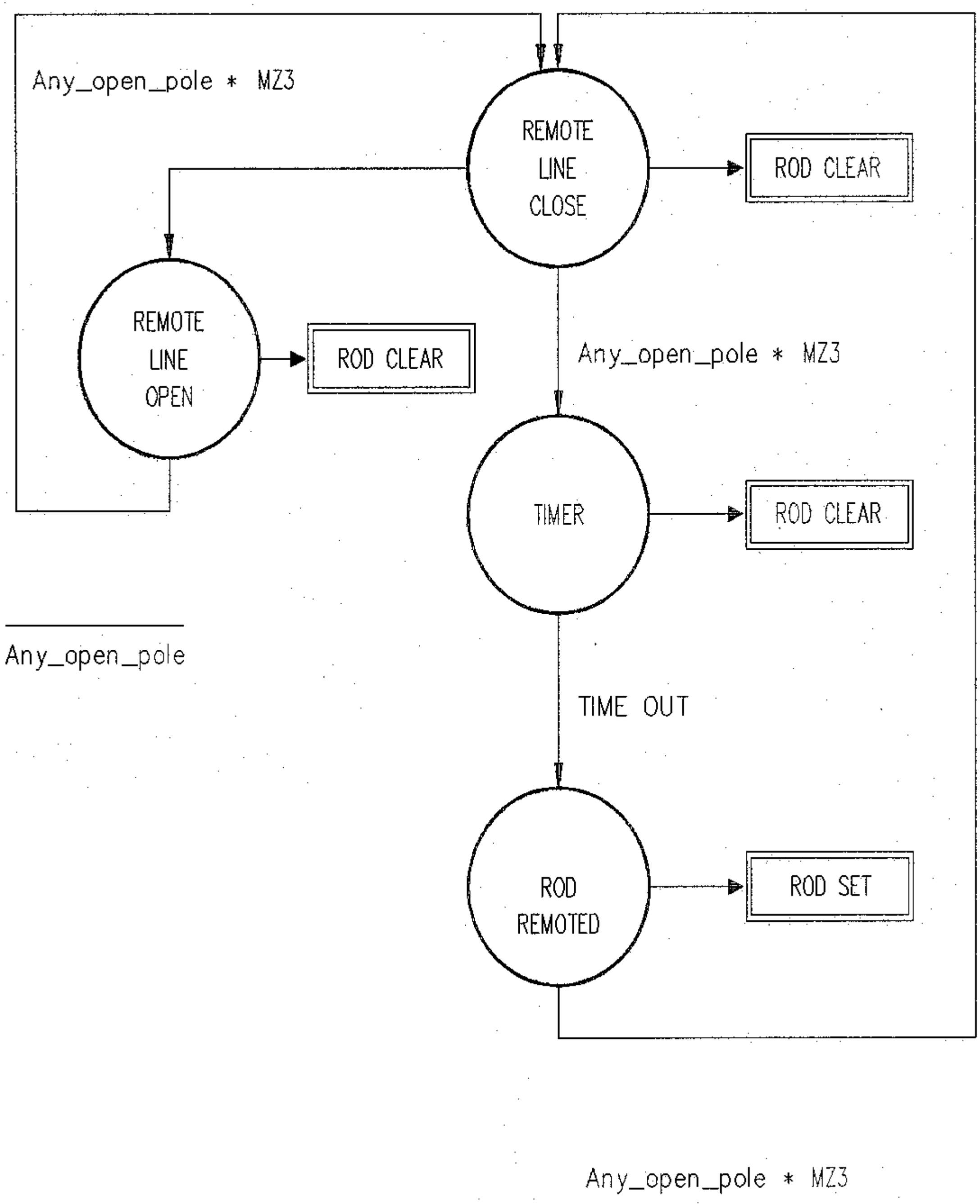


Figure 8.2. ROD function diagram

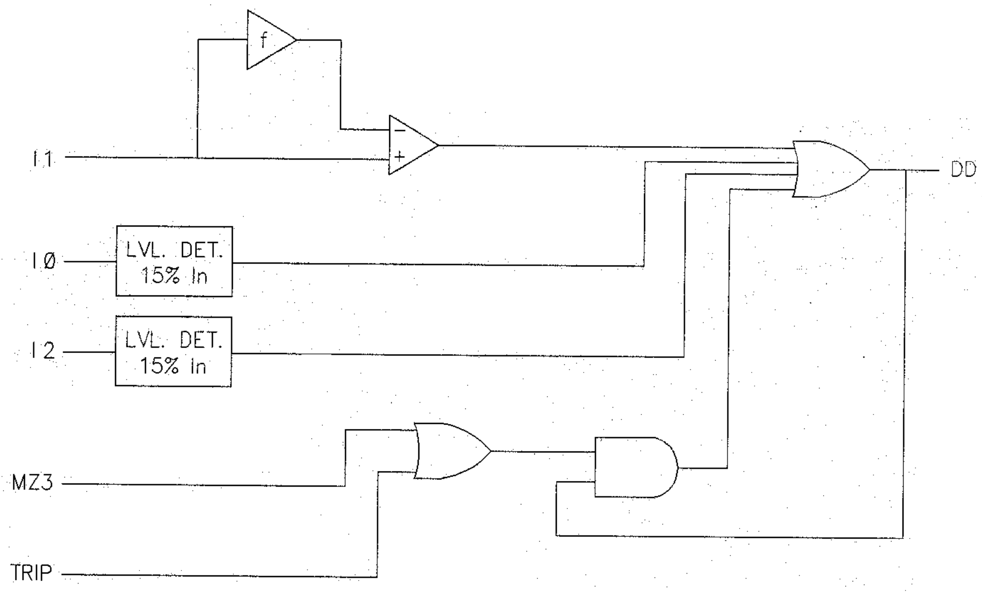


Figure 9.1. DD function logic

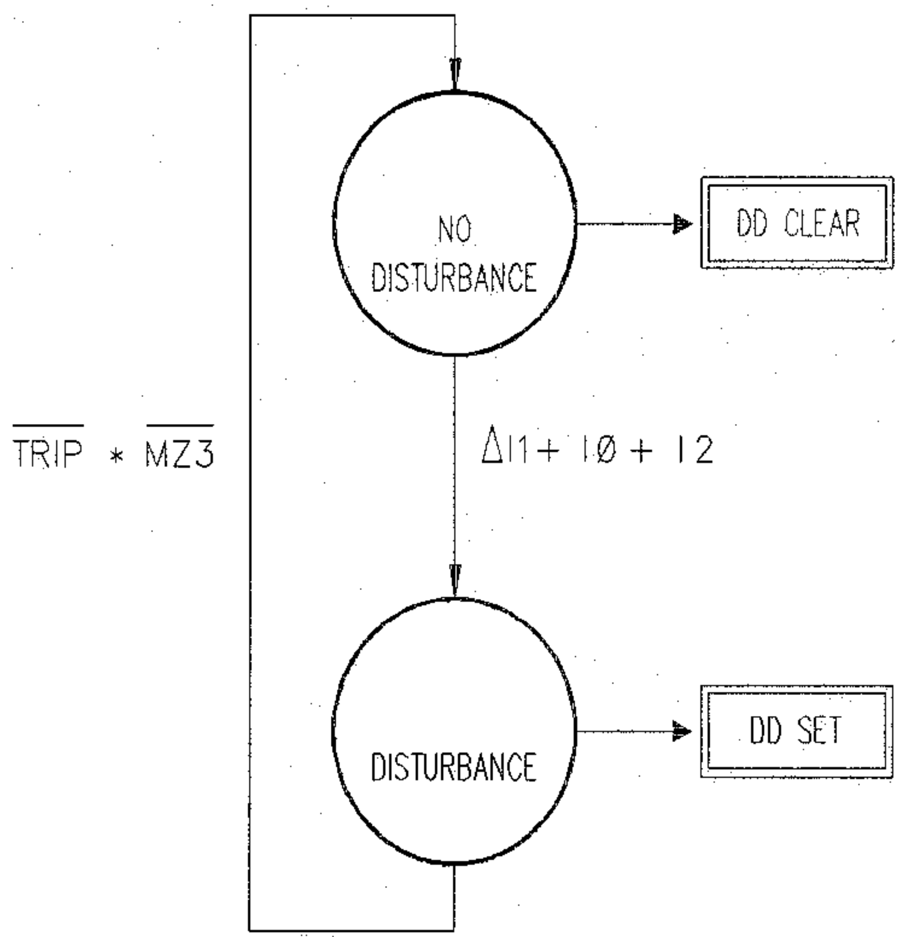


Figure 9.2.. DD function diagram

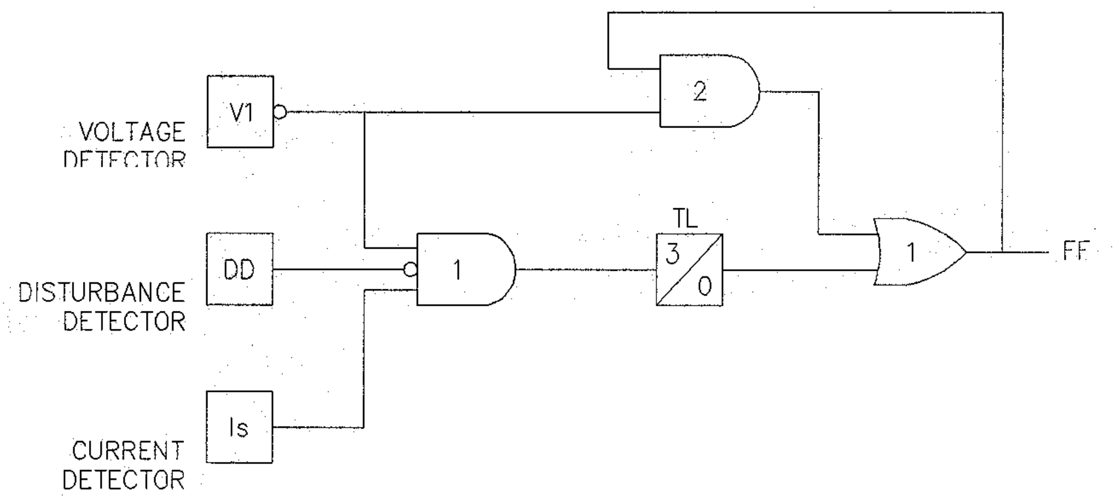


Figure 10.1. FF function logic

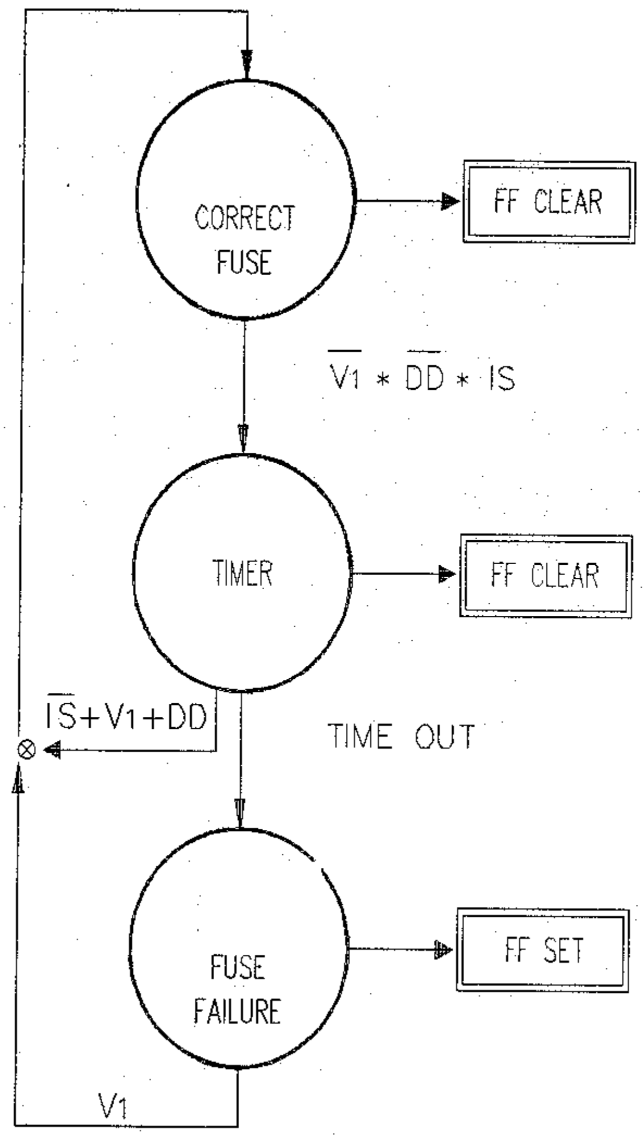


Figure 10.2. FF function diagram

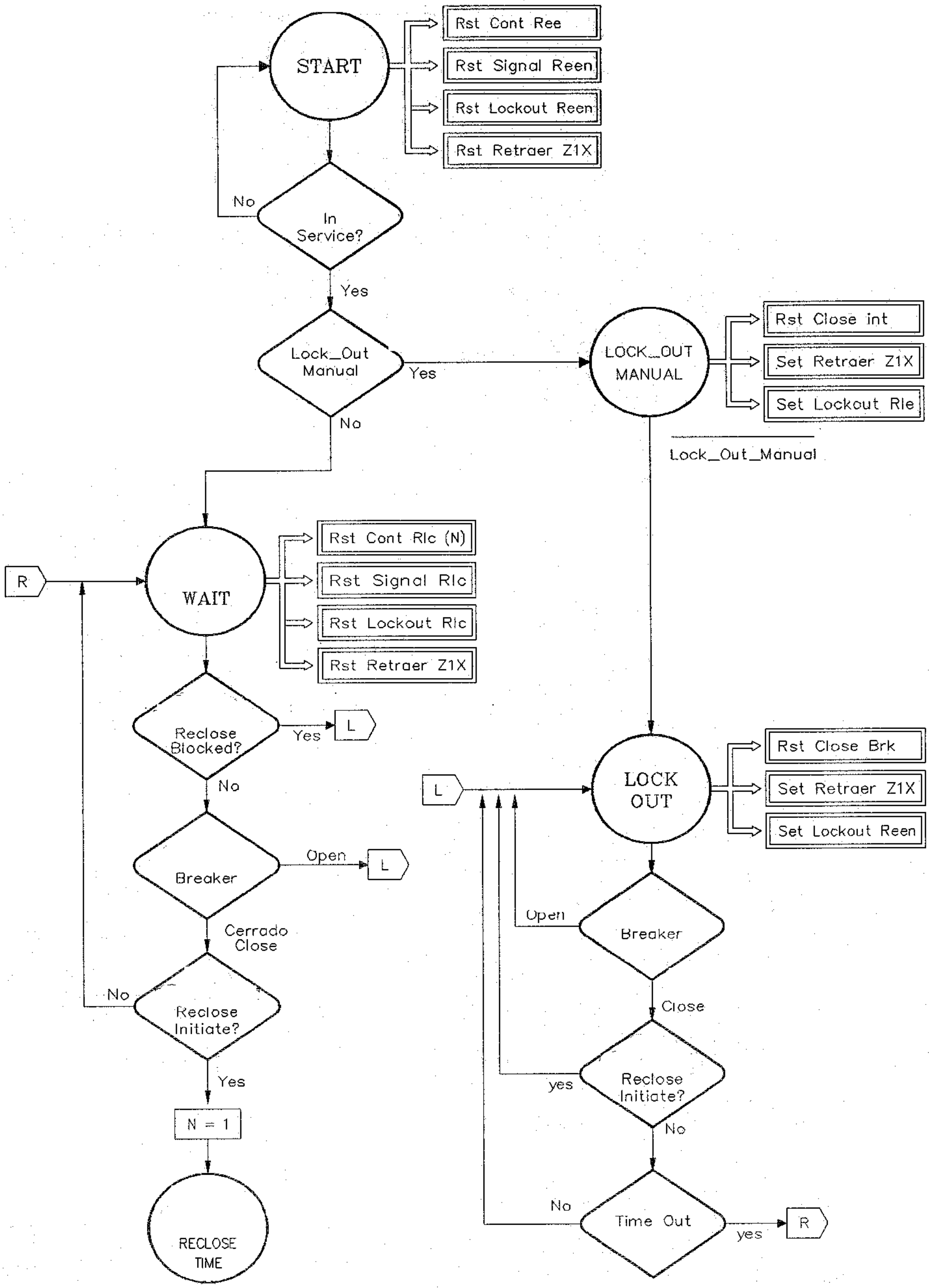


Figure 11.1. Recloser diagram

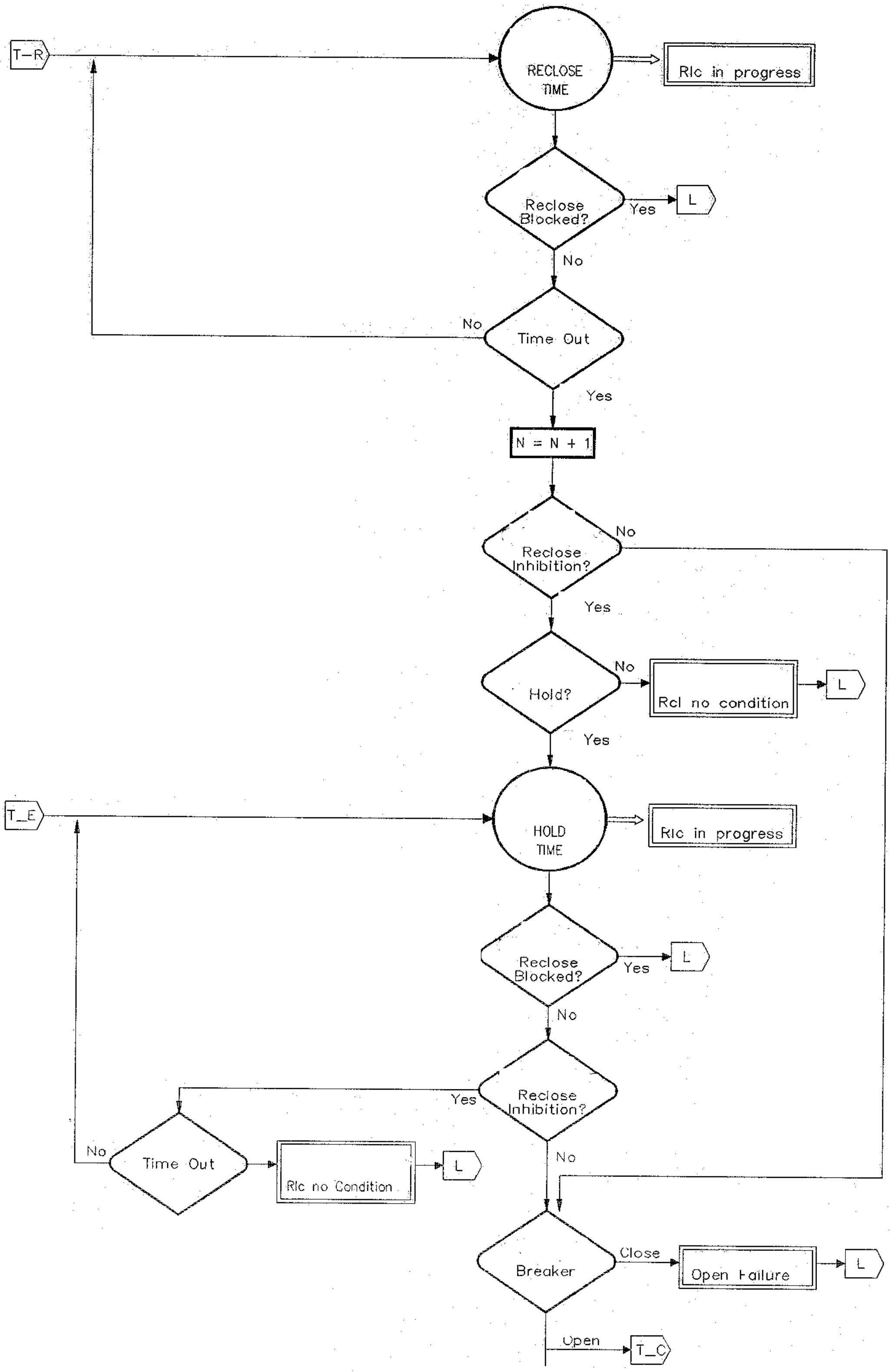


Figure 11.2. Recloser Diagram

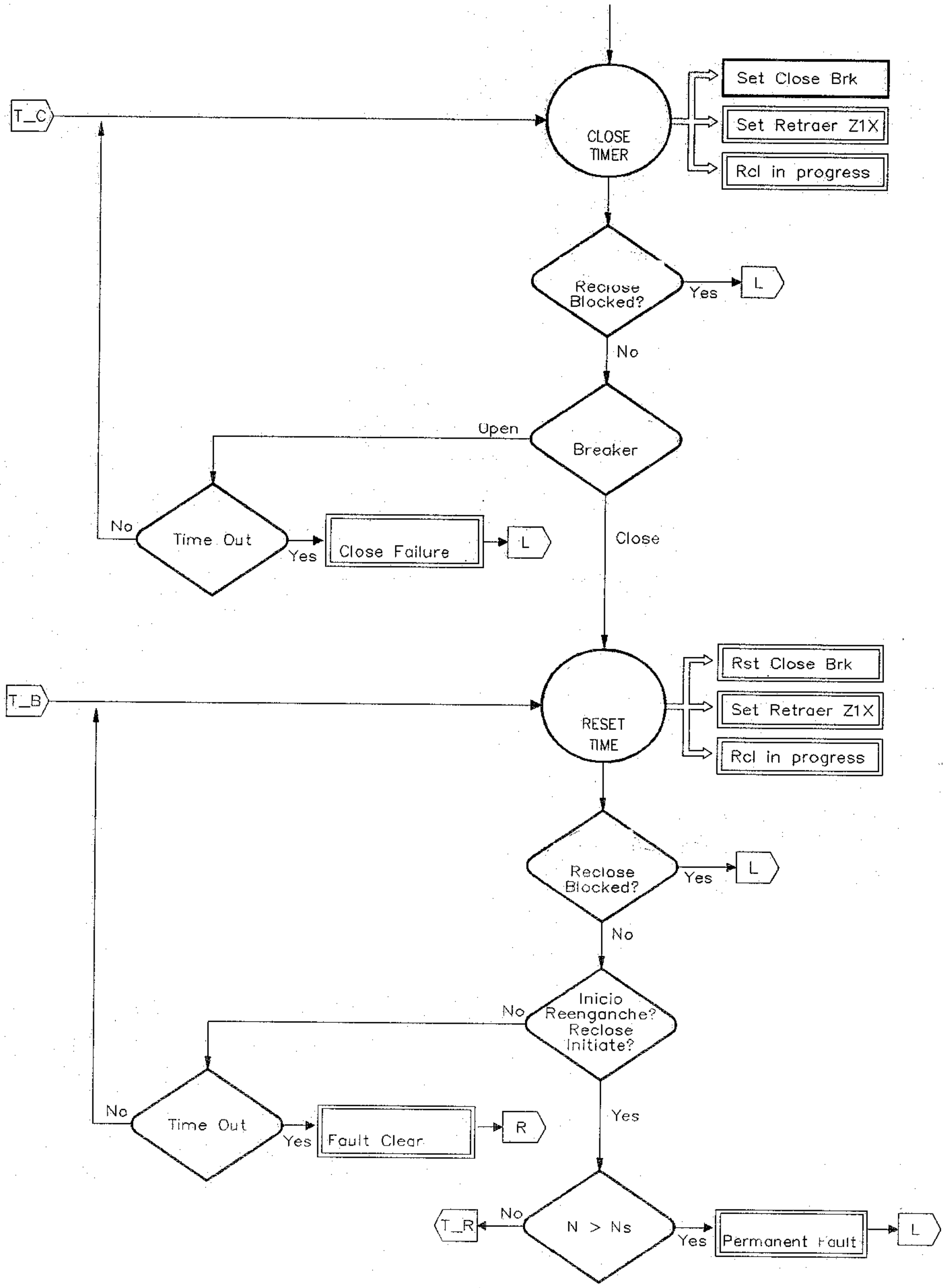


Figure 11.3. Recloser Diagram

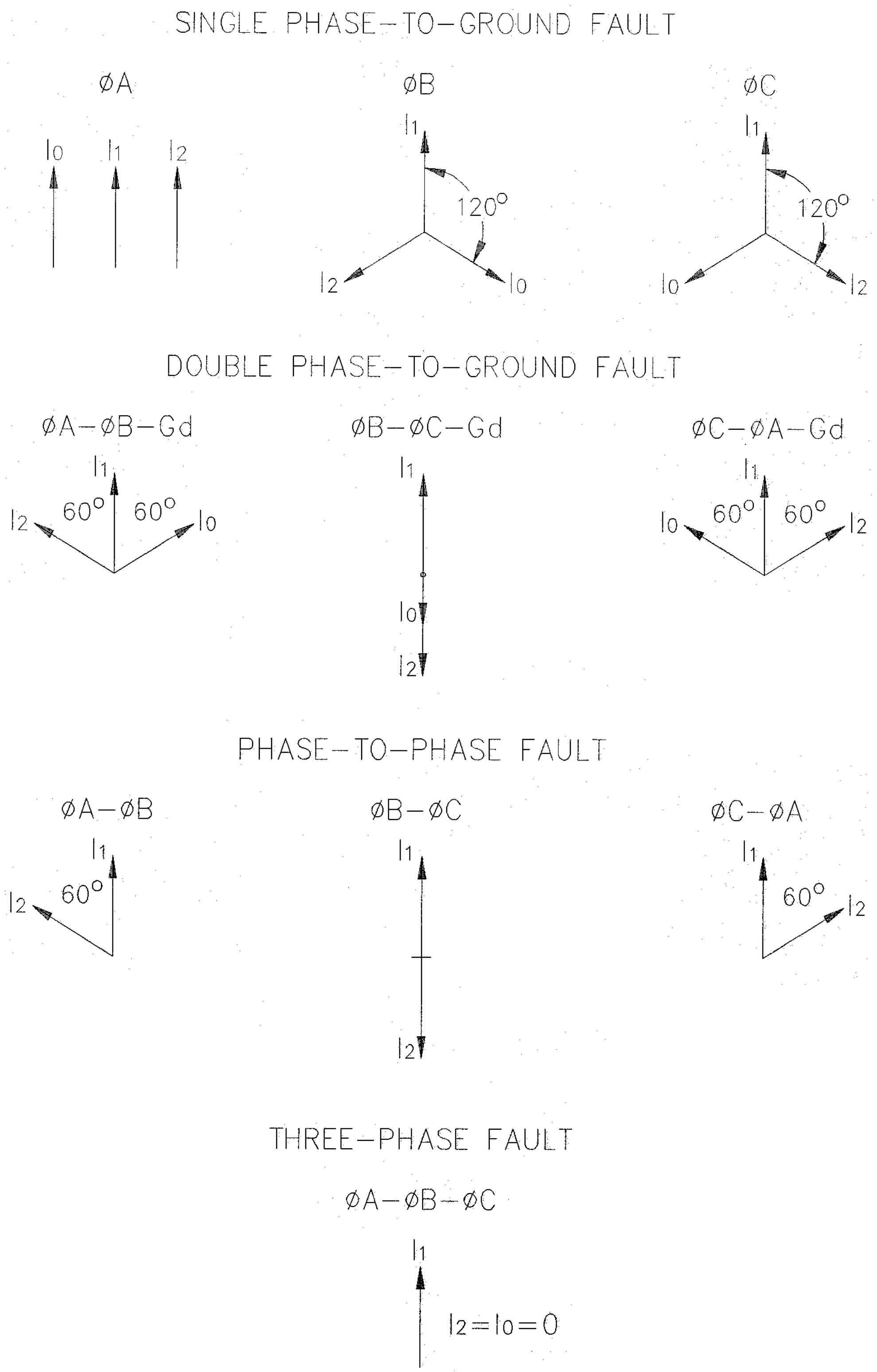


Figure 12. Fault selector

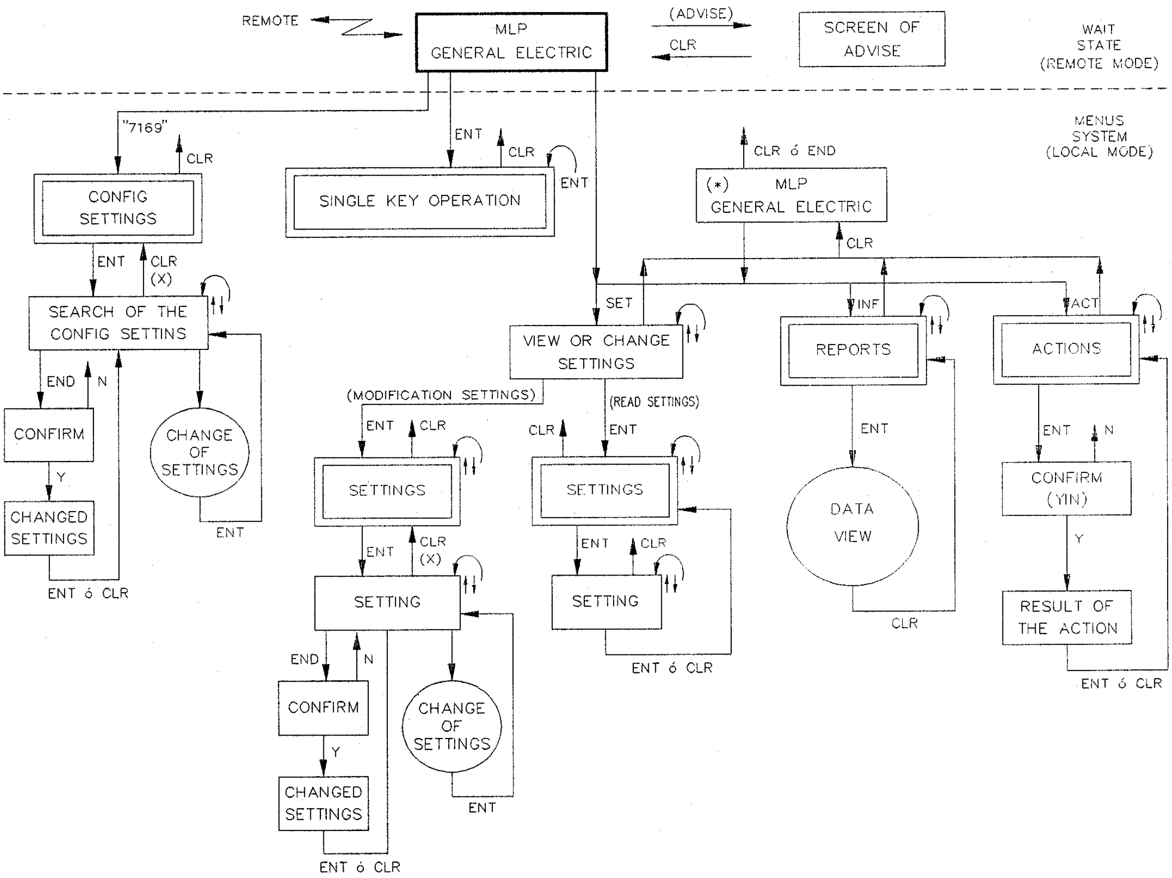


Figure 13. Menu Tree Diagram

CONFIG SETS:

- SPEED (BAUDS)
- PASSWORD
- UNIT NUMBER
- DIST UNIT
- STOP BITS
- SET. LOCAL
- SET. REMOTE
- LOCAL MAN.
- MAN. REMOTE
- LANGUAGE

SINGLE KEY OPERATION:

- Ia & Va
- Ib & Vb
- Ic & Vc
- Ih
- PROT IN SERVICE
- RCL STATUS
- CZ1X
- CZ2
- ROD ACTIVE
- MU Z3 ACTIVE
- DD ACTIVE
- MU Z1 ACTIVE
- ROD TRIP
- LPU TRIP
- Z3 TRIP
- Z2 TRIP
- Z1 TRIP
- LAST FAUTL DATAS

SETTINGS:

- GENERAL SETTINGS
- EVENT MASK
- RECLOSER SETTINGS
- PROTECTION SETTINGS

REPORTS:

- EVENTS
- EVENTS OF POWER OR CURRENT
- STATE
  MODEL:
  HW ERROR
  PROT IN SERVICE
  Ic TRIP DIRECTION
  Ib TRIP DIRECTION
  Ia TRIP DIRECTION
  FF (OUTPUT)
  BFI (OUTPUT)
  TO_Z2 (OUTPUT)
  TO_Z3 (OUTPUT)
  PBZ1X (OUTPUT)
  RP (OUTPUT)
  BLQ (OUTPUT)
  XMTR (OUTPUT)
  INP. IN_RCL
  INP. RZ1X
  INP. BR
  INP. IR
  INP. LPU
  INP. BLQ-TRIP
  INP. RCVR
  INP. S2B
  CZ1X
  CZ2
  LPU ON
  FF ACTIVE
  ROD ACTIVE
  MU Z3 ACTIVE
  DD ACTIVE
  MU Z1 ACTIVE
  RCL STATUS
  ROD TRIP
  LPU TRIP
  TRIP
  PROT TRIP
  Z3 TRIP
  Z2 TRIP
  Z1 TRIP
  15V ERROR
  DEFAULT SETTINGS
  INT HOLD
  CURR. OPEN_INT
  DEFAULT CALIBRATION DATAS
  WITHOUT CLOCK
  DATE AND TIME
  Ih
  Ia
  Ib

ACTIONS:

- OPEN BREAK
- CLOSED BREAKER
- BLOCK RECLOSER
- UN BLOCK RECLOSER

Figure 14. MLP3000 Settings and data

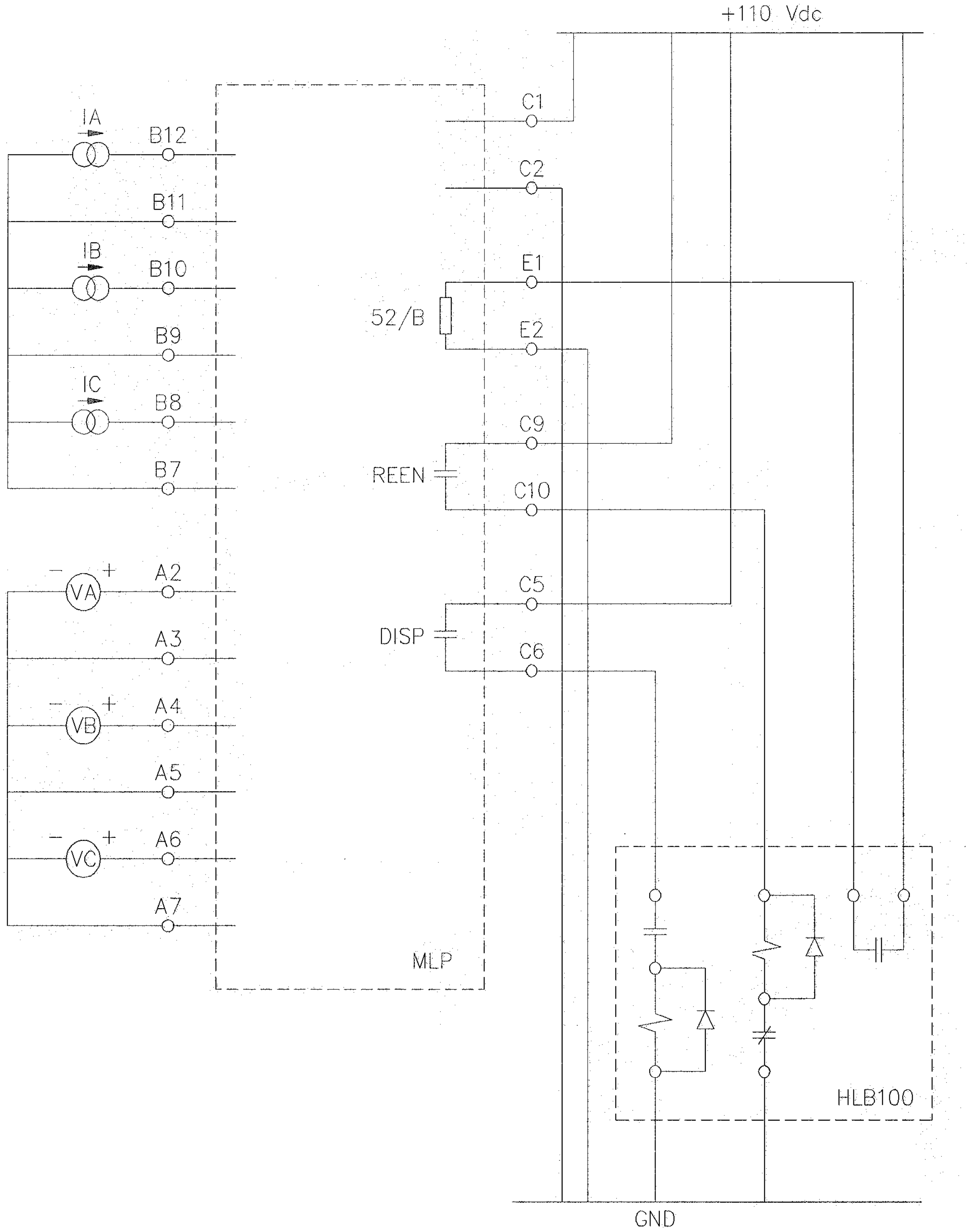


Figure 15. Connection scheme for relay tests

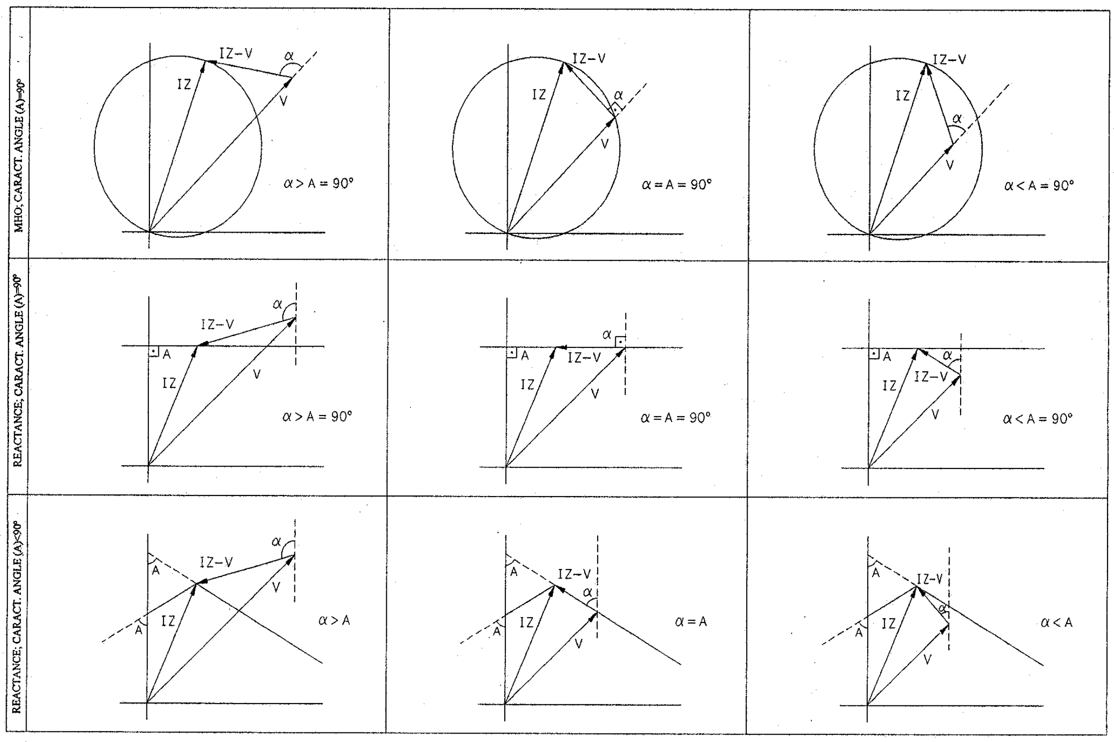
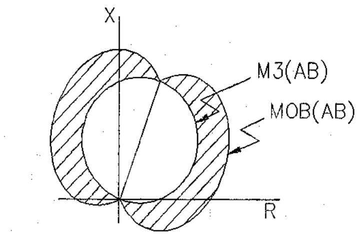


Figure 16. Power swing diagram function



CHARACTERISTC ANGLE MOB = 70° (FIX)
TL3 = 40 - 200 MS (ADJUSTABLE)

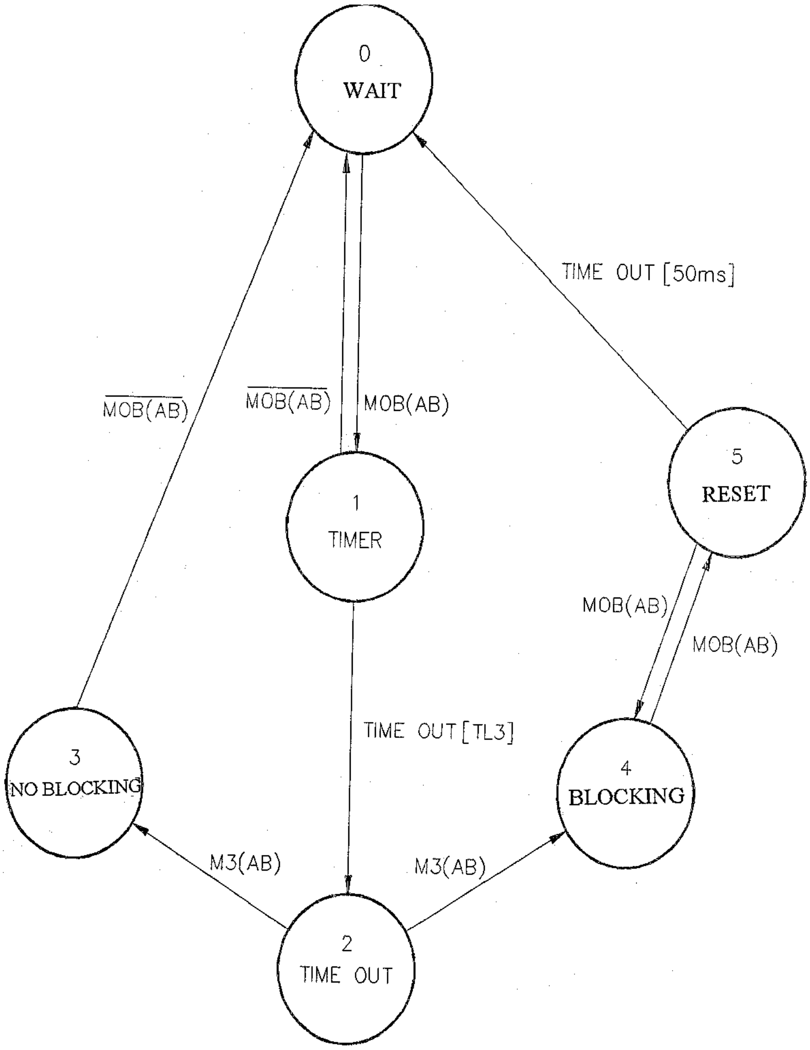
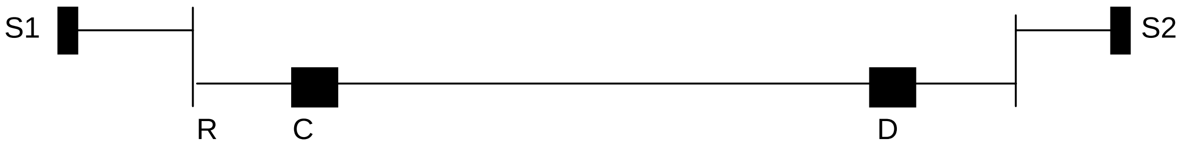


Figure 17. Mho / Reactance characteristics of the MLP

10. FAULT LIST



SOURCE 1 VOLTAGE =	67.00	@	.0	(3/28/1994)
SOURCE 2 VOLTAGE =	67.00	@	.0	

IMPEDANCE	POS. SEQ.			ZERO SEQ.		
SOURCE 1	3.500	@	88.0	3.500	@	88.0
SOURCE 2	3.500	@	88.0	3.500	@	88.0
LINE C-D	5.000	@	87.0	15.50	@	73.0

INTERNAL LINE C-D FAULT AT .00 PER UNIT FROM BUS C IS A-G GROUND FAULT
IMPEDANCE = .0000 @ .0

Relay Currents at C

I1 = 5.993	@ -87.4	IA = 19.14	@ -88.0
= .2769	j -5.986	= .6681	j -19.13
I2 = 5.993	@ -87.4	IB = 1.184	@ -97.9
= .2769	j -5.986	= -.1627	j -1.173
I0 = 7.160	@ -89.1	IC = 1.184	@ -97.9
= .1142	j -7.159	= -.1627	j -1.173

Relay voltages at C

V1 = 46.03	@ - .3	VA = .0000	@ .0
= .46.03	j -.2374	= .0000	j .0000
V2 = 20.97	@ -179.4	VB = 68.53	@ -123.3
= -20.97	j -.2374	= -.37.58	j -57.31
V0 = 25.06	@ 178.9	VC = 69.73	@ 122.6
= -25.05	j .4748	= -37.58	j 58.74

SOURCE 1 VOLTAGE = 67.00 @ .0 (3/28/1994)
SOURCE 2 VOLTAGE = 67.00 @ .0

IMPEDANCE	POS. SEQ.			ZERO SEQ.		
SOURCE 1	3.500	@	88.0	3.500	@	88.0
SOURCE 2	3.500	@	88.0	3.500	@	88.0
LINE C-D	5.000	@	87.0	15.50	@	73.0

INTERNAL LINE C-D FAULT AT .25 PER UNIT FROM BUS C IS A-G GROUND FAULT
IMPEDANCE = .0000 @ .0

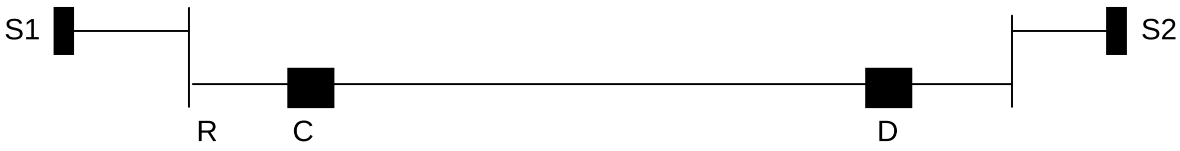
Relay Currents at C

I1 = 3.808	@ -83.7	IA = 11.86		@ -84.1
= .4170	j -3.785	= 1.218		j -11.79
I2 = 3.808	@ -83.7	IB = .4411		@ -94.3
= .4170	j -3.785	= -.3329	E-01	j -.4398
I0 = 4.242	@ -84.8	IC = .4411		@ -94.3
= .3837	j -4.225	= -.3329	E-01	j -.4398

Relay voltages at C

V1 = 53.72	@ - 1.1	VA = 25.75	@ -6.3
= .53.71	j -.9963	= 25.59	j -2.819
V2 = 13.33	@ -175.7	VB = 67.63	@ -121.2
= -13.29	j -.9963	= -.35.03	j -57.85
V0 = 14.85	@ -176.8	VC = 67.93	@ 121.0
= -14.82	j -.8261	= -35.03	j 58.19

The input (system) file has been saved as:
c:\fault\ag25-nw.INP



SOURCE 1 VOLTAGE = 67.00 @ .0 (3/28/1994)
SOURCE 2 VOLTAGE = 67.00 @ .0

IMPEDANCE	POS. SEQ.			ZERO SEQ.		
SOURCE 1	3.500	@	88.0	3.500	@	88.0
SOURCE 2	3.500	@	88.0	3.500	@	88.0
LINE C-D	5.000	@	87.0	15.50	@	73.0

INTERNAL LINE C-D FAULT AT .50 PER UNIT FROM BUS C IS A-G GROUND FAULT
IMPEDANCE = .0000 @ .0

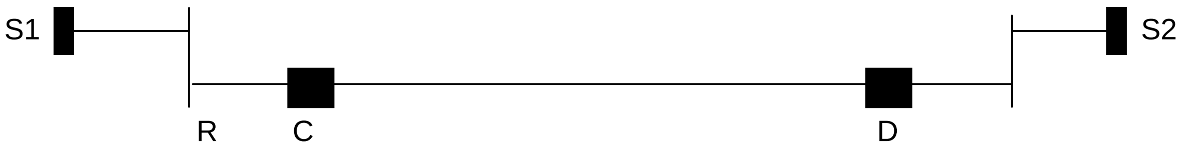
Relay Currents at C

I1 = 2.903	@ -82.8	IA = 8.709	@ -82.8
= .3640	j -2.880	= 1.092	j -8.640
I2 = 2.903	@ -82.8	IB = .0000	@ .0
= .3640	j -2.880	= .0000	j .0000
I0 = 2.903	@ -82.8	IC = .0000	@ .0
= .3640	j -2.880	= .0000	j .0000

Relay voltages at C

V1 = 56.89	@ - .9	VA = 36.75	@ -4.3
= .56.88	j -.9214	= 36.65	j -2.764
V2 = 10.16	@ -174.8	VB = 67.00	@ -120.0
= -10.12	j -.9214	= -.33.50	j -58.02
V0 = 10.16	@ -174.8	VC = 67.00	@ 120.0
= -10.12	j -.9214	= -33.50	j 58.02

The input (system) file has been saved as:
c:\fault\ag50-nw.INP



SOURCE 1 VOLTAGE =	67.00 @	.0	(3/28/1994)
SOURCE 2 VOLTAGE =	67.00 @	.0	

IMPEDANCE	POS. SEQ.			ZERO SEQ.		
SOURCE 1	3.500	@	88.0	3.500	@	88.0
SOURCE 2	3.500	@	88.0	3.500	@	88.0
LINE C-D	5.000	@	87.0	15.50	@	73.0

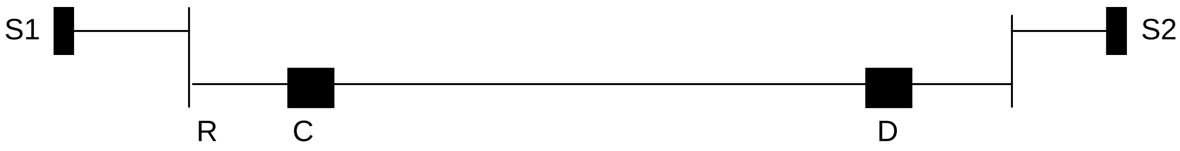
INTERNAL LINE C-D FAULT AT .75 PER UNIT FROM BUS C IS A-G GROUND FAULT
IMPEDANCE = .0000 @ .0

Relay Currents at C

I1 = 2.495	@ -83.5	IA = 7.052	@ -82.8
= .2842	j -2.479	= .8859	j -6.996
I2 = 2.495	@ -83.5	IB = .4411	@ 85.7
= .2842	j -2.479	= .3329 E-01	j .4398
I0 = 2.063	@ -81.1	IC = .4411	@ 85.7
= .3175	j -2.039	= .3329 E-01	j .4398

Relay voltages at C

V1 = 58.30	@ - .7	VA = 42.48	@ -3.0
= .58.30	j -.6914	= 42.42	j -2.244
V2 = 8.732	@ -175.5	VB = 66.40	@ -118.8
= -8.705	j -.6914	= -.31.97	j -58.19
V0 = 7.222	@ -173.1	VC = 66.10	@ 118.9
= -7.170	j -.8615	= -31.97	j 57.85



SOURCE 1 VOLTAGE = 67.00 @ .0 (3/28/1994)
SOURCE 2 VOLTAGE = 67.00 @ .0

IMPEDANCE	POS. SEQ.			ZERO SEQ.		
SOURCE 1	3.500	@	88.0	3.500	@	88.0
SOURCE 2	3.500	@	88.0	3.500	@	88.0
LINE C-D	5.000	@	87.0	15.50	@	73.0

INTERNAL LINE C-D FAULT AT .99 PER UNIT FROM BUS C IS A-G GROUND FAULT
IMPEDANCE = .0000 @ .0

Relay Currents at C

I1 = 2.459	@ -86.5	IA = 6.262	@ -84.5
= .1489	j -2.454	= .5983	j -6.233
I2 = 2.459	@ -86.5	IB = 1.140	@ 82.4
= .1489	j -2.454	= .1517	j .1.130
I0 = 1.358	@ -77.2	IC = 1.140	@ 82.4
= .3006	j -1.324	= .1517	j .1.130

Relay voltages at C

V1 = 58.40	@ - .2	VA = 45.14	@ -1.7
= .58.40	j -.2209	= 45.13	j -1.331
V2 = 8.606	@ -178.5	VB = 65.72	@ -116.7
= -8.603	j -.2209	= -.29.57	j -58.69
V0 = 4.754	@ -169.2	VC = 64.53	@ 117.3
= -4.670	j -.8896	= -29.57	j 57.36

The input (system) file has been saved as:

c:\fault\ag99-nw.INP

SOURCE 1 VOLTAGE = 67.00 @ .0 (3/28/1994)
SOURCE 2 VOLTAGE = 67.00 @ .0

IMPEDANCE	POS. SEQ.			ZERO SEQ.		
SOURCE 1	3.500	@	88.0	3.500	@	88.0
SOURCE 2	3.500	@	88.0	3.500	@	88.0
LINE C-D	5.000	@	87.0	15.50	@	73.0

INTERNAL LINE C-D FAULT AT .00 PER UNIT FROM BUS C IS B-C GROUND FAULT
ARC IMPEDANCE = .0000 @ .0

Relay Currents at C

I1 = 9.571	@ -88.0	IA = .0000	@ .0
= .3340	j -9.566	= .0000	j .0000
I2 = 9.571	@ 92.0	IB = 16.58	@ -178.0
=-.3340	j 9.566	= -16.57	j -.5786
I0 = .0000	@ .0	IC = 16.58	@ 82.4
= .0000	j .0000	= 16.57	j .5786

Relay voltages at C

V1 = 33.50	@ .0	VA = 67.00	@ .0
= 33.50	j .0000	= 67.00	j .0000
V2 = 33.50	@ .0	VB = 33.50	@ 180.0
= 33.50	j .0000	= -.33.50	j .0000
V0 = .0000	@ .0	VC = 33.50	@ 180.0
= .0000	j .0000	= -33.50	j .0000

The input (system) file has been saved as:

c:\fault\bc00-nw.INP

SOURCE 1 VOLTAGE = 67.00 @ .0 (3/28/1994)
SOURCE 2 VOLTAGE = 67.00 @ .0

IMPEDANCE	POS. SEQ.			ZERO SEQ.		
SOURCE 1	3.500	@	88.0	3.500	@	88.0
SOURCE 2	3.500	@	88.0	3.500	@	88.0
LINE C-D	5.000	@	87.0	15.50	@	73.0

INTERNAL LINE C-D FAULT AT .25 PER UNIT FROM BUS C IS B-C GROUND FAULT
ARC IMPEDANCE = .0000 @ .0

Relay Currents at C

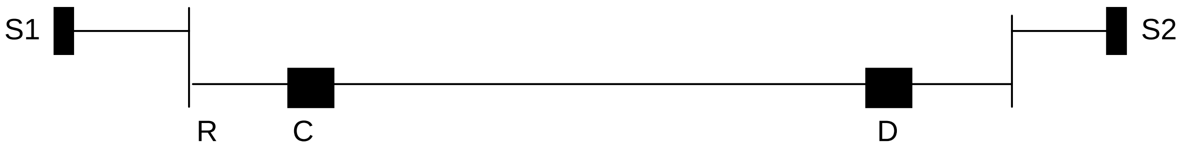
I1 = 7.053	@ -87.7	IA = .0000	@ .0
= .2785	j -7.047	= .0000	j .0000
I2 = 7.053	@ 92.3	IB = 12.22	@ -177.7
=-.2785	j 7.047	= -12.21	j -.4824
I0 = .0000	@ .0	IC = 12.22	@ 2.3
= .0000	j .0000	= 12.21	j .4824

Relay voltages at C

V1 = 42.32	@ .2	VA = 67.00	@ .0
= 42.32	j .1134	= 67.00	j .0000
V2 = 24.68	@ .3	VB = 36.99	@ 155.6
= 24.68	j .1134	= -.33.70	j -15.27
V0 = .0000	@ .0	VC = 36.64	@ 155.4
= .0000	j .0000	= -33.30	j 15.27

The input (system) file has been saved as:

c:\fault\bc25-nw.INP



SOURCE 1 VOLTAGE = 67.00 @ .0 (3/28/1994)
SOURCE 2 VOLTAGE = 67.00 @ .0

IMPEDANCE	POS. SEQ.			ZERO SEQ.		
SOURCE 1	3.500	@	88.0	3.500	@	88.0
SOURCE 2	3.500	@	88.0	3.500	@	88.0
LINE C-D	5.000	@	87.0	15.50	@	73.0

INTERNAL LINE C-D FAULT AT .50 PER UNIT FROM BUS C IS B-C GROUND FAULT
ARC IMPEDANCE = .0000 @ .0

Relay Currents at C

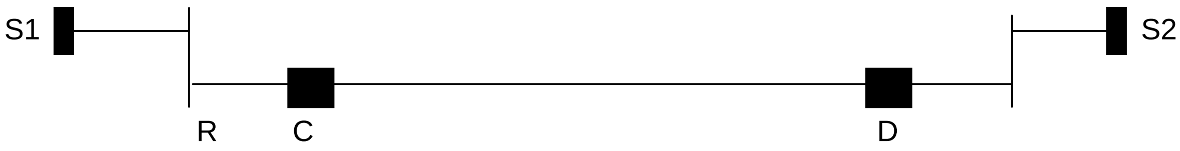
I1 = 5.584	@ -87.6	IA = .0000	@ .0
= .2354	j -5.579	= .0000	j .0000
I2 = 5.584	@ 92.4	IB = 9.671	@ -177.6
=-.2354	j 5.579	= -9.662	j -.4078
I0 = .0000	@ .0	IC = 9.671	@ 2.4
= .0000	j .0000	= 9.662	j .4078

Relay voltages at C

V1 = 47.46	@ .2	VA = 67.00	@ .0
= 47.46	j .1421	= 67.00	j .0000
V2 = 19.54	@ .4	VB = 41.51	@ -144.4
= 19.54	j .1421	= -.33.75	j -24.18
V0 = .0000	@ .0	VC = 41.11	@ 144.0
= .0000	j .0000	= -33.25	j 24.18

The input (system) file has been saved as:

c:\fault\bc50-nw.INP



SOURCE 1 VOLTAGE =	67.00	@	.0	(3/28/1994)
SOURCE 2 VOLTAGE =	67.00	@	.0	

IMPEDANCE	POS. SEQ.			ZERO SEQ.		
SOURCE 1	3.500	@	88.0	3.500	@	88.0
SOURCE 2	3.500	@	88.0	3.500	@	88.0
LINE C-D	5.000	@	87.0	15.50	@	73.0

INTERNAL LINE C-D FAULT AT .75 PER UNIT FROM BUS C IS B-C GROUND FAULT
ARC IMPEDANCE = .0000 @ .0

Relay Currents at C

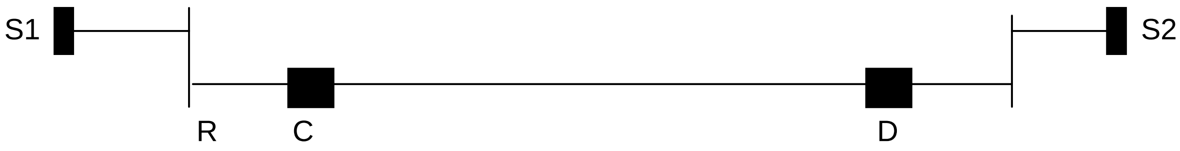
I1 = 4.621	@ -87.5	IA = .0000	@ .0
= .2029	j -4.616	= .0000	j .0000
I2 = 4.621	@ 92.5	IB = 8.004	@ -177.5
=-.2029	j 4.616	= -7.996	j -.3515
I0 = .0000	@ .0	IC = 8.004	@ 2.5
= .0000	j .0000	= 7.996	j .3515

Relay voltages at C

V1 = 50.83	@ -.2	VA = 67.00	@ .0
= 50.83	j -.1460	= 67.00	j .0000
V2 = 16.17	@ .5	VB = 45.17	@ 138.4
= 16.17	j .1460	= -.33.75	j -30.01
V0 = .0000	@ .0	VC = 44.79	@ 137.9
= .0000	j .0000	= -33.25	j 30.01

The input (system) file has been saved as:

c:\fault\bc75-nw.INP



SOURCE 1 VOLTAGE = 67.00 @ .0 (3/28/1994)
SOURCE 2 VOLTAGE = 67.00 @ .0

IMPEDANCE	POS. SEQ.			ZERO SEQ.		
SOURCE 1	3.500	@	88.0	3.500	@	88.0
SOURCE 2	3.500	@	88.0	3.500	@	88.0
LINE C-D	5.000	@	87.0	15.50	@	73.0

INTERNAL LINE C-D FAULT AT .99 PER UNIT FROM BUS C IS B-C GROUND FAULT
ARC IMPEDANCE = .0000 @ .0

Relay Currents at C

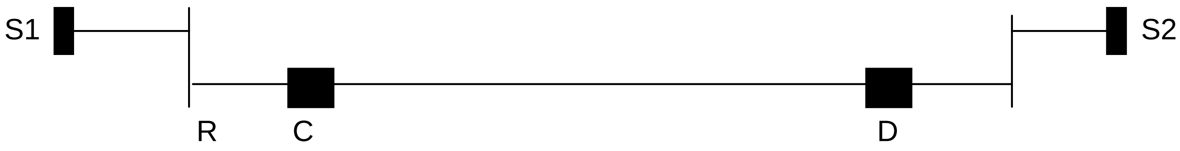
I1 = 3.965	@ -87.4	IA = .0000	@ .0
= .1789	j -3.961	= .0000	j .0000
I2 = 3.965	@ 92.6	IB = 6.867	@ -177.4
=-.1789	j 3.961	= -6.860	j -.3098
I0 = .0000	@ .0	IC = 6.867	@ 2.6
= .0000	j .0000	= 6.860	j .3098

Relay voltages at C

V1 = 53.12	@ -.2	VA = 67.00	@ .0
= 53.12	j -.1419	= 67.00	j .0000
V2 = 13.88	@ .6	VB = 47.90	@ -134.8
= 13.88	j .1419	= -.33.75	j -33.99
V0 = .0000	@ .0	VC = 47.55	@ 134.4
= .0000	j .0000	= -33.25	j 33.99

The input (system) file has been saved as:

c:\fault\bc99-nw.INP



SOURCE 1 VOLTAGE = 67.00 @ .0 (3/28/1994)
SOURCE 2 VOLTAGE = 67.00 @ .0

IMPEDANCE	POS. SEQ.			ZERO SEQ.		
SOURCE 1	3.500	@	88.0	3.500	@	88.0
SOURCE 2	3.500	@	88.0	3.500	@	88.0
LINE C-D	5.000	@	87.0	15.50	@	73.0

INTERNAL LINE C-D FAULT AT .00 PER UNIT FROM BUS C IS B-C-G GROUND FAULT
ARC IMPEDANCE = .0000 @ .0

Relay Currents at C

I1 = 9.571	@ -88.0	IA = .0000	@ .0
= .3340	j -9.566	= .0000	j .0000
I2 = 9.571	@ 92.0	IB = 16.58	@ -178.0
=-.3340	j 9.566	= -16.57	j -.5786
I0 = .0000	@ .0	IC = 16.58	@ 82.4
= .0000	j .0000	= 16.57	j .5786

Relay voltages at C

V1 = 33.50	@ .0	VA = 67.00	@ .0
= 33.50	j .0000	= 67.00	j .0000
V2 = 33.50	@ .0	VB = 33.50	@ 180.0
= 33.50	j .0000	= -.33.50	j .0000
V0 = .0000	@ .0	VC = 33.50	@ 180.0
= .0000	j .0000	= -33.50	j .0000

The input (system) file has been saved as:

c:\fault\bc00-nw.INP