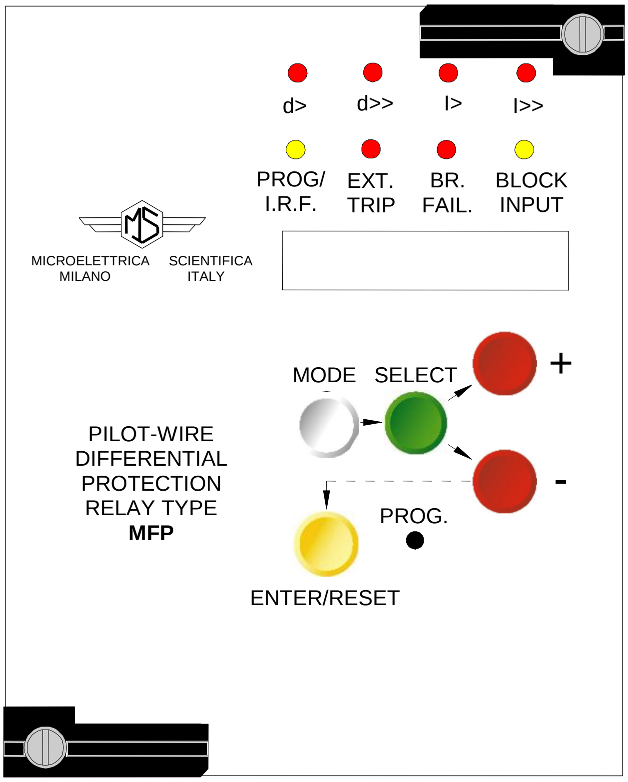
DIGITAL
PILOT-WIRE
DIFFERENTIAL RELAY

TYPE

MFP

OPERATION MANUAL



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1. General utilization and commissioning directions

Always make reference to the specific description of the product and to the Manufacturer's instruction. Carefully observe the following warnings.

1.1 - Storage and Transportation

must comply with the environmental conditions stated on the product's instruction or by the applicable IEC standards.

1.2 - Installation

must be properly made and in compliance with the operational ambient conditions stated by the Manufacturer.

1.3 - Electrical Connection

must be made strictly according to the wiring diagram supplied with the Product, to its electrical characteristics and in compliance with the applicable standards particularly with reference to human safety.

1.4 - Measuring Inputs and Power Supply

carefully check that the value of input quantities and power supply voltage are proper and within the permissible variation limits.

1.5 - Outputs Loading

must be compatible with their declared performance.

1.6 - Protection Earthing

When earthing is required, carefully check its efficiency.

1.7 - Setting and Calibration

Carefully check the proper setting of the different functions according to the configuration of the protected system, the safety regulations and the co-ordination with other equipment.

1.8 - Safety Protection

Carefully check that all safety means are correctly mounted, apply proper seals where required and periodically check their integrity.

1.9 - Handling

Notwithstanding the highest practicable protection means used in designing M.S. electronic circuits, the electronic components and semiconductor devices mounted on the modules can be seriously damaged by electrostatic voltage discharge which can be experienced when handling the modules. The damage caused by electrostatic discharge may not be immediately apparent but the design reliability and the long life of the product will have been reduced. The electronic circuits reduced by M.S. are completely safe from electrostatic discharge (8 KV IEC 255.22.2) when housed in their case; withdrawing the modules without proper cautions expose them to the risk of damage.

a. Before removing a module, ensure that you are at the same electrostatic potential as the equipment by touching the case.

b. Handle the module by its front-plate, frame, or edges of the printed circuit board. Avoid touching the electronic components, printed circuit tracks or connectors.

c. Do not pass the module to any person without first ensuring that you are both at the same electrostatic potential. Shaking hands achieves equipotential.

d. Place the module on an antistatic surface, or on a conducting surface which is at the same potential as yourself.

e. Store or transport the module in a conductive bag.

More information on safe working procedures for all electronic equipment can be found in BS5783 and IEC 147-OF.

1.10 - Maintenance

Make reference to the instruction manual of the Manufacturer ; maintenance must be carried-out by specially trained people and in strict conformity with the safety regulations.

1.11 - Fault Detection and Repair

Internal calibrations and components should not be alterated or replaced.
For repair please ask the Manufacturer or its authorised Dealers.

Misapplication of the above warnings and instruction relieves the Manufacturer of any liability.

2. GENERAL CHARACTERISTICS

Input currents from system's CTs at both ends of the protected line are supplied to the Summation Transformer unit “ TAS “ which energizes the MFP relays and the Pilot-Wire loop.
Inside the MFP relay, three independent Current Transformers respectively measure:

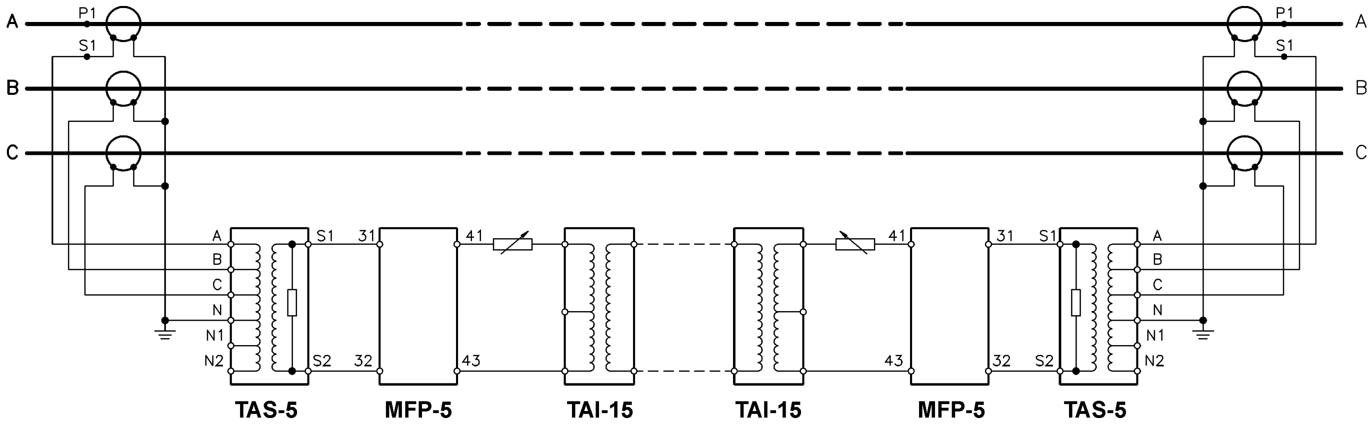
- The Input current at the end of the circuit where the relay is located.
- The Differential current circulating in the Pilot-Wire circuit.
- The Through Current flowing in the protected circuit, used as stabilizing quantity.

The summation Transformers “ TAS “ are available in three version “ TAS-1, TAS-2, TAS-5” respectively for system CTs. rating 1 – 2 – 5 secondary Ampere.

The relay MFP with the transformer “ TAS “ guarantees a 5kV insulation level for the Pilot-wire circuit and allows for operating with Pilot-Wire circuit resistance up to 1000Ω.
This performance is normally suitable for the protection of Cables and Lines rating up to 36kV with length up to 13Km.
By interposing at both ends of the Pilot-Wire circuit the additional insulation transformer “ TAI-15 “, the insulation level of the Pilot-wire circuit is increased to 15kV and the resistance of the Pilot-wires loop can be increased up to 2500Ω which allows for a distance up to 32Km between the two ends of the protected feeder and application is systems rating over 36kV.

In any case the total resistance of the Pilot-Wire loop must be 1000Ω.; this is obtained by means of a Padding Resistor “ RPP “ properly combinated at each end of the circuit.
(When using the insulation Transformer “TAI-15” the actual Pilot-Wire resistance connected to its secondary can be 2500Ω with reported to the primary less than 1000Ω)

Fig.1



2. GENERAL CHARACTERISTICS

2.1 - Power Supply

The relay can be fitted with two different types of **power supply** module :

a) - **24V(-20%) / 110V(+15%) a.c.** / **24V(-20%) / 125V(+20%) d.c.**

b) - **80V(-20%) / 220V(+15%) a.c.** / **90V(-20%) / 250V(+20%) d.c.**

Before energising the unit check that supply voltage is within the allowed limits.

2.2 - Summation Transformer

As already mentioned, at each end of the protected circuit, the three currents from the secondary of the three system CTs, are supplied to different portions of the primary winding of the Summation Transformer " TAS " so that their vector summation always produces a resultant current at the "TAS" secondary, even when the three currents are perfectly balanced. The partition of the primary winding and the turn ratio is designed to produce 20mA secondary current when the rated current (1A or 2A or 5A) is supplied to the " TAS " primary.

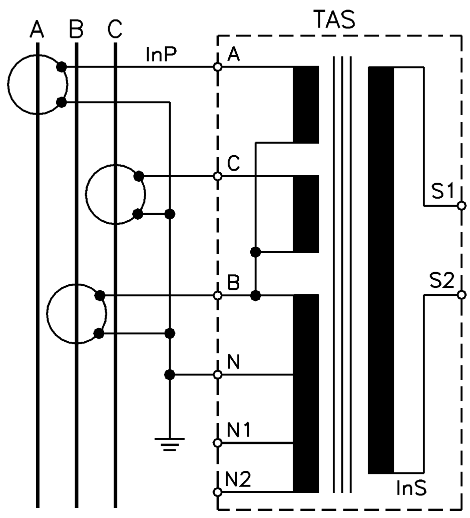


Fig 2

Response to different Faults	
FAULT TYPE	**% OUTPUT**
3 phase Symm. **A-B-C**	100
2-phase **A-B**	115.5
2-phase **A-C** or **B-C**	57.7
Phase **A** to Earth (Tap N)	288.7
Phase **A** to Earth (Tap N1)	375.3
Phase **B** to Earth (Tap N)	173.2
Phase **B** to Earth (Tap N1)	259.8
Phase **C** to Earth (Tap N)	230.9
Phase **C** to Earth (Tap N1)	317.5
Phase **A** to Earth (Tap N2)	460
Phase **B** to Earth (Tap N2)	345.6
Phase **C** to Earth (Tap N2)	403.2

Due to the arrangement of the summation transformer, the output is different for the different types of fault according to the n° of turns they involve.
The table above reports the % output at “ TAS “ secondary for the different type of Faults when using for the CTs neutral the Tap “ N “ or “ N1 “ or “ N2 “.

For example:

- A three phase fault with current “ 10 In’ “ at the “ TAS “ primary is reported “ 10 In” “ at the “ TAS “ secondary terminals.

- A phase A-to-ground fault with current “ 10 In’ “ at the primary is reported “ 28.87 In” “ at the “ TAS “ secondary terminals.

According to what above, the Taps “ N1 ” or “ N2 “ are used instead of the Tap “ N “ when an increased Earth Fault sensitivity is needed.

2.3 - Pilot-wire circuit

The relay “ MFP “ is calibrated to operate with a Pilot-wire loop impedance of 1000Ω.
If the impedance of the wires loop is more than 1kΩ, a transformer is needed to adapt the impedance (TA15).
If, as it is normally the case, the wires loop impedance is less than 1000Ω, it must be increase by a series resistor “ R_{PR} “ properly adjusted.

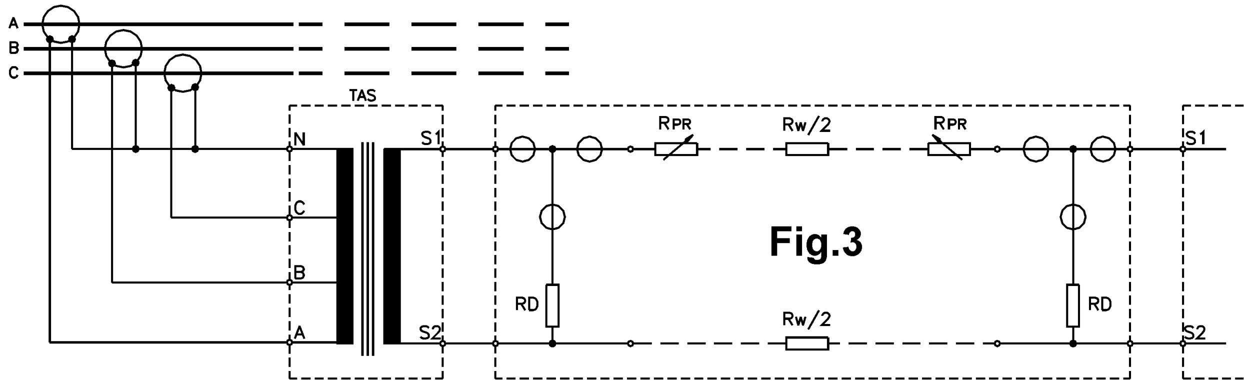


Fig.3

$$R_D = 1000\Omega = 2R_{PR} + R_W \Rightarrow R_{PR} = \frac{R_D - R_W}{2}$$

$$R_{PR} = \left(\frac{1000 - R_W}{2}\right)\Omega$$

Example:

$$RW = 600\Omega \rightarrow R_{PR} = \left(\frac{1000 - 600}{2}\right) = 200\Omega$$

For the pilot circuit it is recommended to use a twisted pair of cooper wires with cross section 0.5 mm^2 giving a resistivity of approximately 73Ω/Km and a capacitance of approximately 60nF/Km.
It is recommended that the pair of wires is shielded with the shield grounded at one point only.
The adjustment of the Padding Resistors does not need to be precisely accurate.
The un accuracy is compensates by the relay “ MFP “ as explained at § 2.4.2

This adjustment also compensates for the capacity of the pilot-wire circuit.

2.4 - Differential protection F87

The operation of the “ MFP “ relay is based on the circulating current principle.

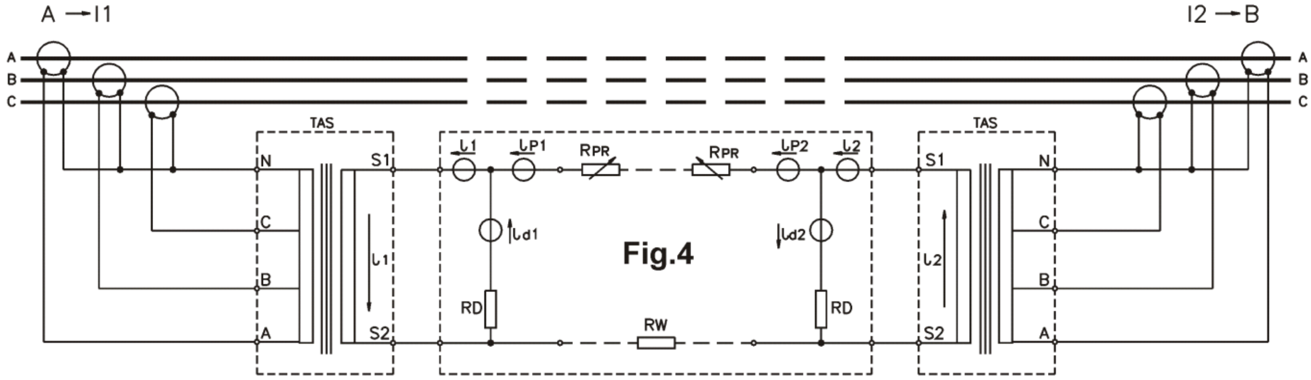


Fig.4

With the above arrangement each of the two relays measures the following quantities.

- The current i (i_1 or i_2) proportional to current I (I_1 or I_2) flowing at relay’s installation point : “ $i = \mathrm{K}i \cdot \mathrm{I}$ “
- The current id circulating in the resistors “ Rd “.
- The current i_P circulating in the pilot-wires.

With reference to the diagram of Fig. 4 and 5 when no fault is experienced in the zone between the two relays, considering the contribution of each of the two relays, the current in the circuit are distributed as follows:

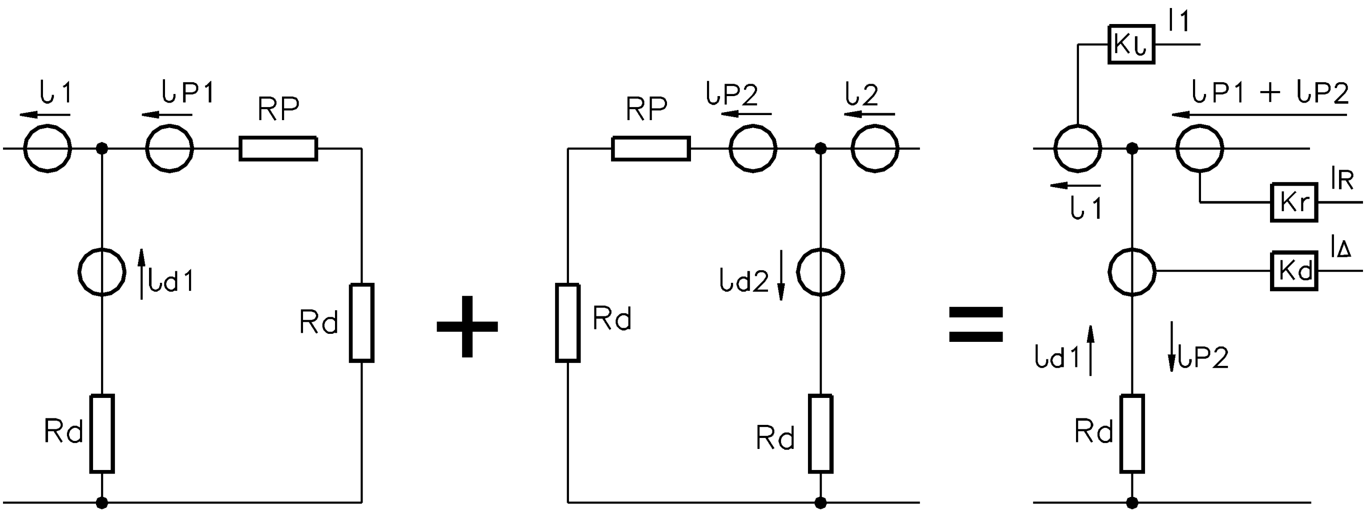


FIG.5

$$R_P = 2R_{PR} + R_W \quad ; \quad R_T = R_D + (R_D + R_P) = 2R_D + R_P$$

$$i_{p1} = i_1 \frac{R_D}{R_T} \quad ; \quad i_{p2} = i_2 \frac{R_D}{R_T}$$

$$i_{d1} = i_1 \frac{R_P + R_D}{R_T} \quad ; \quad i_{d2} = i_2 \frac{R_P + R_D}{R_T}$$

Considering the relay at the end 1 (same as for the relay at the end 2), the converters supplied by the internal CTs will provide the following output.

$$I_R = K_R(i_{P1} + i_{P2}) = K_R \frac{R_D}{R_T}(i_1 + i_2)$$

$$I_1 = -Ki \cdot i_1$$

$$I_\Delta = K_d(i_{d1} - i_{P2}) = K_d\left(\frac{R_P + R_D}{R_T} i_1 - \frac{R_D}{R_T} i_2\right)$$

- I_R is used as bias input that must be proportional to $(i_1 + i_2)$:
  if we take the coefficient $K_R = \frac{R_T}{R} \Rightarrow I_R = i_1 + i_2$
- As a measurement of the fault differential current we use $I_d = I_\Delta + I_1$

$$I_d = K_d(i_{d1} - i_{P2}) - Ki \cdot i_1 = i_1\left(K_d \frac{R_P + R_D}{R_T} - Ki\right) - i_2 \cdot K_d \frac{R_D}{R_T}$$

To have I_d proportional to $(i_1 - i_2)$, the coefficients Ki and K_d must be:

$$K_d \frac{R_P + R_D}{R_T} - Ki = 1 \Rightarrow \quad Ki = \frac{R_P}{R_D}$$

$$K_d \frac{R_D}{R_T} = 1 \quad \Rightarrow \quad K_d = \frac{R_T}{R_D}$$

Being in our arrangement $R_P = R_D = \frac{1}{3} R_T \qquad Ki = 1 \;\; ; \;\; K_d = 3 \;\; ; \;\; K_R = 3$

Applying the above coefficients the relay provides the three measurements.

$$I = I_1,\ I_2 \qquad I_R = I_1 + I_2 \qquad I_d = i_1 - i_2$$

In the different operation conditions the above measurements give the following results:

A) Normal situation or External Fault " I1 = I2 "

$I_R = 2I$ Maximum stabilization

$I_d = 0$ No differential current

$$K_S = \frac{I_d}{I_R} = 0$$

B) Internal Fault fed from one end only $I_1 = I, I_2 = 0$ or $I_1 = 0, I_2 = I$

$I_R = I$ Moderate stabilization

$I_d = I$ Differential current equal to Fault current

$$K_S = \frac{I_d}{I_R} = 1$$

C) Internal Fault fed from both ends " $I_1 = -I_2$ "

$I_R = 0$ No stabilization

$I_d = 2I$ Differential current up to twice the fault current

$$K_S = \frac{I_d}{I_R} = 2$$

2.4.1 - Low set Differential element

The operation of the Low-set differential protection element takes places instantaneously (less than 30ms) as soon as the value of the ratio $\frac{I_d}{I_R}$ exceeds the set value " Ks ".

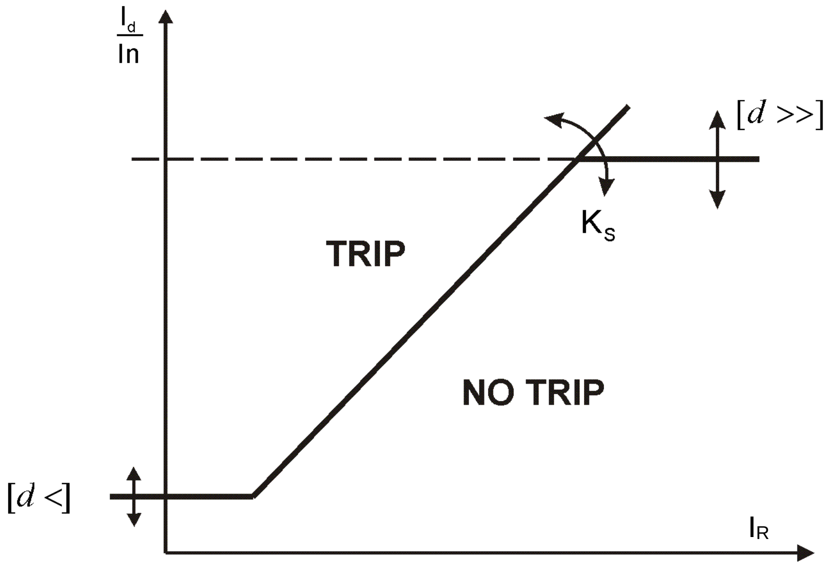
- **Ks** = (0.5 ÷ 1), adjustable in 0.1 steps

To avoid spurious tripping due to CTs errors when the load current is very small, there is a basic level of differential current which must be exceeded to enable the tripping.

- **d>** = (0.02 ÷ 1)In, adjustable in 0.01In steps

Tripping of the low-set differential protection takes place when both the conditions are present.

$$\frac{I_d}{I_R} \geq [K_S] \quad \& \quad I_d \geq [d>]$$



2.4.2 - High-set differential protection element

When the differential current exceeds the high-set level, the relay trips instantaneously without any other condition

- **d>>** = (0.5 – 9.90)In, steps 0.1In

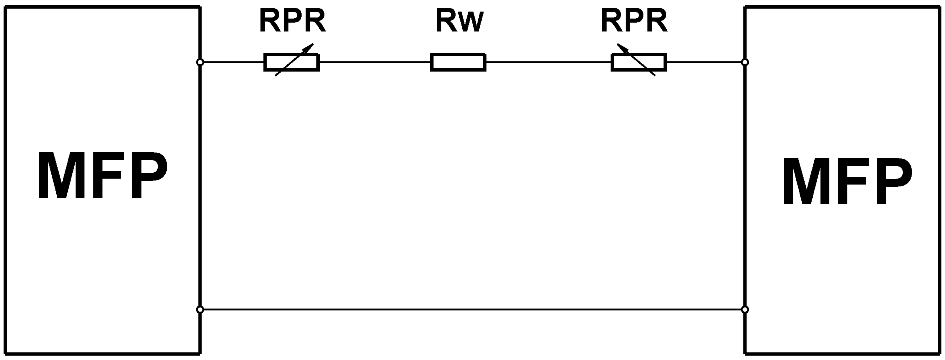
2.4.3 - Compensation of the impedance of the pilot-wire loop

2.4.3.1 - Adjusting the Padding Resistor R_{PR}

As already reported the relay are calibrated to operate with a normal pilot-wire circuit resistance

$R_P = 1000\Omega$

The difference between the resistance of the wire loop " R_W " and the nominal pilot circuit resistance " R_P ", is compensated by regulating the adjustable resistor " R_{PR} " connected to one of two relays.



To adjust the padding resistor;

1 - measure or evaluate the resistance " R_W " of the pilot-wires loop only

2 - than adjust each " R_{PR} " at the value $R_{PR} = \frac{1000 - R_W}{2}\Omega$

Example :

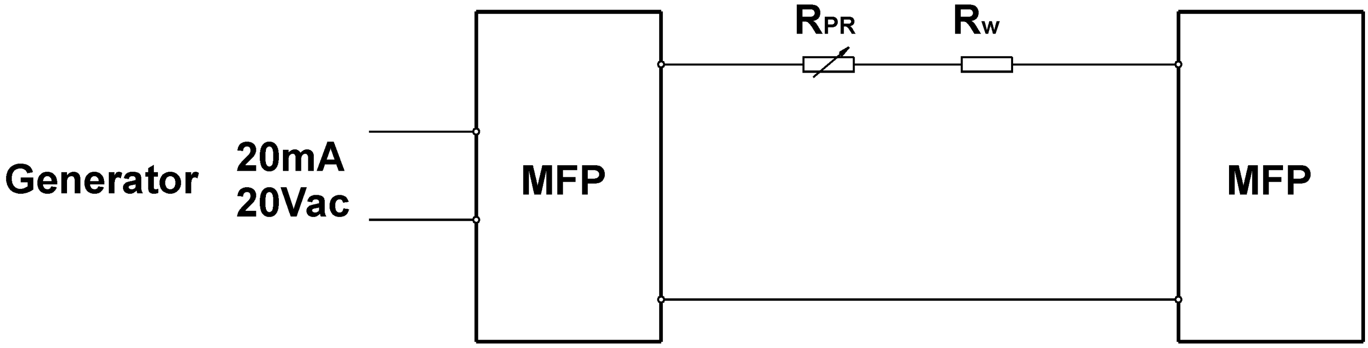
Pilot wire loop resistance : $R_W = 600\Omega \Rightarrow R_{PR} = \frac{1000 - 600}{2} = 200\Omega$

R_{PR} = Adjustable resistor type RSR 16x90 – (0-500)Ω - 50W.

2.4.3.2 - Fine tuning

The tuning of the relays by adjusting the padding resistors cannot be very accurate.
To precisely tune the relay the following procedure is recommended.

- After having adjusted the padding resistors, inject 20mA as show in the figure herebelow



1 - Read the " I_R " measurement from relay's display and, if different from 100%, adjust the variable " α_P " accordingly.

Example: $I_R = 97\%$

$$\alpha_P = \frac{100}{97} = 1.03$$

1 - Than read from relay's display the " I_d " measurement: its value should also be 100%.

If it is different adjust the variable " α_i " accordingly.

Example: $I_d = 105\%$

$$\alpha_i = \frac{105}{100} = 1.05$$

Set α_i = 1.05 and recheck the measurement of " I_Δ " which should now be 100%.

The same procedure must be carried out on the relay MFP at the other end of the protected line.

N.B. The above mentioned measurements must be 100% provided that the injected current is exactly 20mA. If it is not the measurements instead of 100% must indicate the same value that the relay show for the quantity " I ".

Example: $I = 80$

$$I_R = 78 \rightarrow \alpha_P = \frac{80}{78} = 1.03$$

$$I_d = 84 \rightarrow \alpha_i = \frac{84}{80} = 1.05$$

2.4.5 - Pilot-wire Supervision

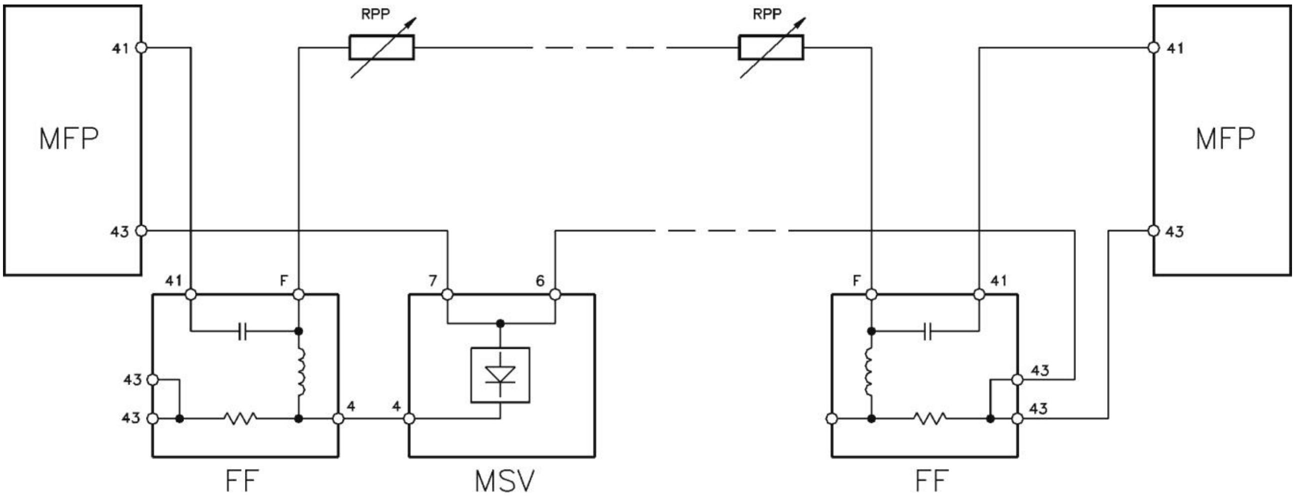
Any interruption of the pilot-wires during operation (with current flowing in the protected feeder), produces the tripping of the relays at both ends.
Reading the value of the recorded quantities will allow to clearly discriminate the situation from a tripping due to a system fault.

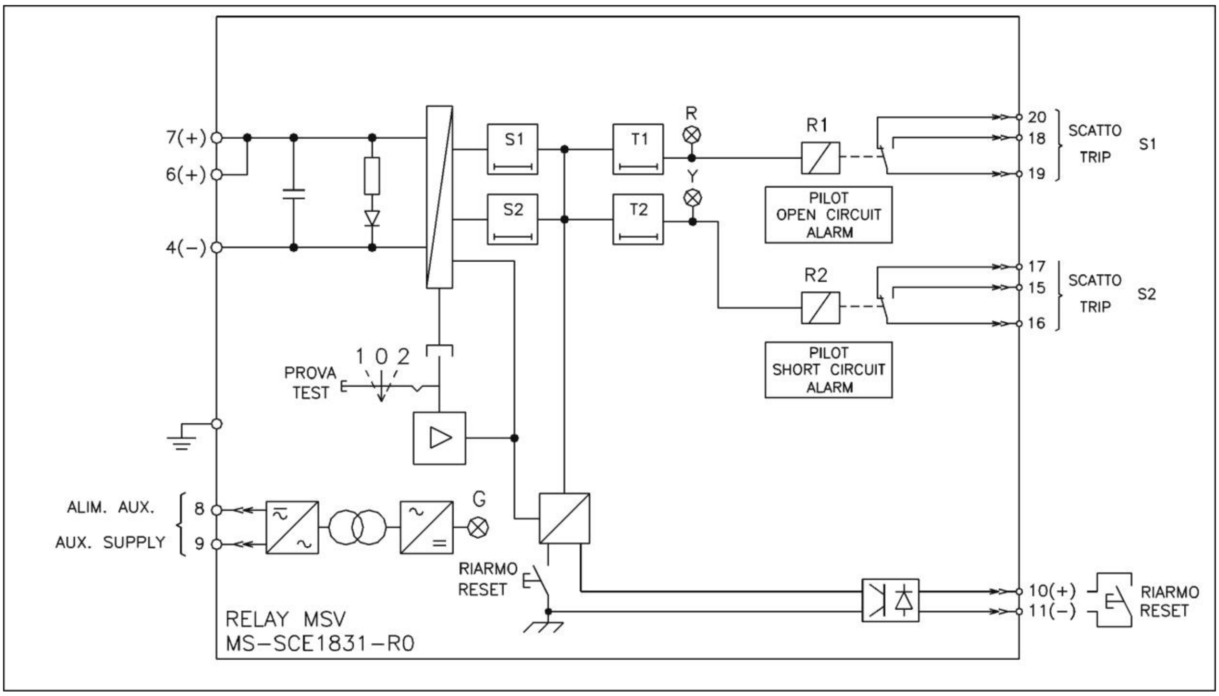
2 Pilot-wire interruption : $I_d=I$ $I_R=0$

3 Single end fed fault : $I_d=I$ $I_R=I$

4 Double end fed fault : $I_d=2I$ $I_R=0$

When a complete continuous supervision of the pilot-wires is required even without current flowing in the protected feeder, an additional supervision unit " **MSV** " is available.
This unit injects through proper filters a small DC current in the pilots circuits and by comparing it with under/over thresholds, detects any situation of open or short circuit.





2.5 - Overcurrent Protection

As explained as § 2.2 the current input in the relay is the vector summation of the three phase-current " IA, IB, IC " each multiplied by a different coefficient.
When currents are unbalanced the relay measures a current which is different from any of the three currents circulating in the system and normally greater than the value of the system currents (see table § 2.2).
Never the less when a through fault take place the current measured is likely to largely exceed the rated value as the overcurrent set threshold.

2.5.1 - First Overcurrent Element

- Minimum pick-up level : **I>** = (0.5 – 9.99)In, step 0.01In
- Minimum pick-up time : 0.03s
- Time delayed element : **tI>** = (0.05 – 9.99)s, step 0.01s

2.5.2 - Second Overcurrent Element

- Minimum pick-up level : **I>>** = (0.5 – 30)In step 0.1In
- Minimum pick-up time : 0.03s
- Time delayed element : **tI>>** = (0.05 – 9.99)s step 0.01 up to 1s, 0.1s from 1 to 1.9s.

2.6 - Breaker Failure Protection

- **tBF** = (0.05-1.00)s, step 0.01s

If within the set time tBF from tripping of the output relay R1 the fault is not cleared , a proper output relay is energized to operate the second opening circuit of the Circuit Breaker or a back-up breaker.

2.7 - Characteristic required for C.Ts.

Current transformers must meet the requirements hereunder specified
(C.Ts. with 1A - Class X - secondary are recommended) for stability on through Faults.

- $\mathbf{R_R}$ = Relay + Summation CT + Pilot-wire Burden = $\begin{cases} 0.5\ \Omega \text{ for In = 1A} \\ 0.1\ \Omega \text{ for In = 5A} \end{cases}$
- $\mathbf{R_C}$ = Resistance of the Cable loop between C.T. and relay
- $\mathbf{R_2}$ = Resistance of C.T's secondary winding
- $\mathbf{I_F}$ = Maximum Through Fault Secondary Current
- $\mathbf{I_N}$ = Relay rated current 1 or 5 A
- $\mathbf{V_k}$ = C.T's Knee point voltage

The minimum knee point voltage of line CTs must be: $V_K = \frac{50}{I_N} + I_F(R_C + R_2)$

The rated power of the CTs must be: $P \geq (In)^2 (R_C + R_R)$
if In = 1A $P \geq (R_C + R_R)$

2.8 - Functions Blocking

Any function can be permanently disactivated setting to " **Dis "** the relevant variable, or temporarily blocked via the digital input " B1 ".
The operation of the blocking inputs can be programmed to block (when activated) any of the relay functions by programming the variables " Bd " and " B*i* ".

Input **B1** : Blocks the starting of the function

When block " B1 " is activated the led 8 goes flashing.

Input **B1** (Terminals 1 – 2) : **Bd: dL; DH**
BI: IL; IH

BI	=	-	-	No Block	**Bd**	=	-	-	No Block
BI	=	-	IL	Only I>	**Bd**	=	-	dL	Only d>
BI	=	IH	-	Only I>>	**Bd**	=	dH	-	Only d>>
BI	=	IH	IL	I> + I>>	**Bd**	=	dH	dL	d> + d>>

Input **B2** (Terminals 1 – 3) : **External Trip**

2.9 - Clock and Calendar

2.9.1 - Clock synchronization.

The clock can be synchronized via the serial communication interface.
The following synchronization periods can be set: 5, 10, 15, 30, 60 minutes.
Synchronization can also be disabled, in which case the relay ignores the serial broadcast signal.
In case synchronization is enabled, the unit expects to receive a sync signal at the beginning of every hour and once every T_{syn} minutes. When a sync signal is received, the clock is automatically set to the nearest expected synchronization time.
For example: if T_{syn} is 10min and a sync signal is received at 20:03:10 January the 10^{th}, 98, then the clock is set to 20:00:00 January the 10^{th}, 1998.
On the other hand, if the same sync signal were received at 20:06:34, the clock would be set to 20:10:00, January the 10^{th} 98.
Note that if a sync signal is received exactly in the middle of a T_{syn} period, the clock is set to the previous expected synchronization time.

2.9.2 - Date and time setting.

When the PROG/SETTINGS menu is entered, the current date is displayed with one of the groups of digits (YY, MMM or DD) blinking.
The DOWN key operates as a cursor. It moves through the groups of digits in the sequence YY => MMM => DD => YY => …
The UP key allows the user to modify the currently blinking group of digits.
If the ENTER button is pressed the currently displayed date is set.
Pressing the SELECT button the current time is displayed which can be modified using the same procedure as for the date.
If synchronization is enabled and the date (or time) is modified, the clock is stopped until a sync signal is received via the serial port. This allows the user to manually set many units and have them to start their clocks in a synchronized fashion.
If synchronization is disabled the clock is never stopped.
Note that the setting of a new time always clears 10ths and 100ths of sec.

2.9.3 - Time resolution.

The clock has a 10ms resolution. This means that any event can be time-stamped with a 10ms accuracy, although the information concerning 10ths and 100ths of sec. can be accessed only via the serial communication interface.

2.9.4 - Operation during power off.

The unit has an on board Real Time Clock which maintains time information for at least 1 hour in case of power supply failure.

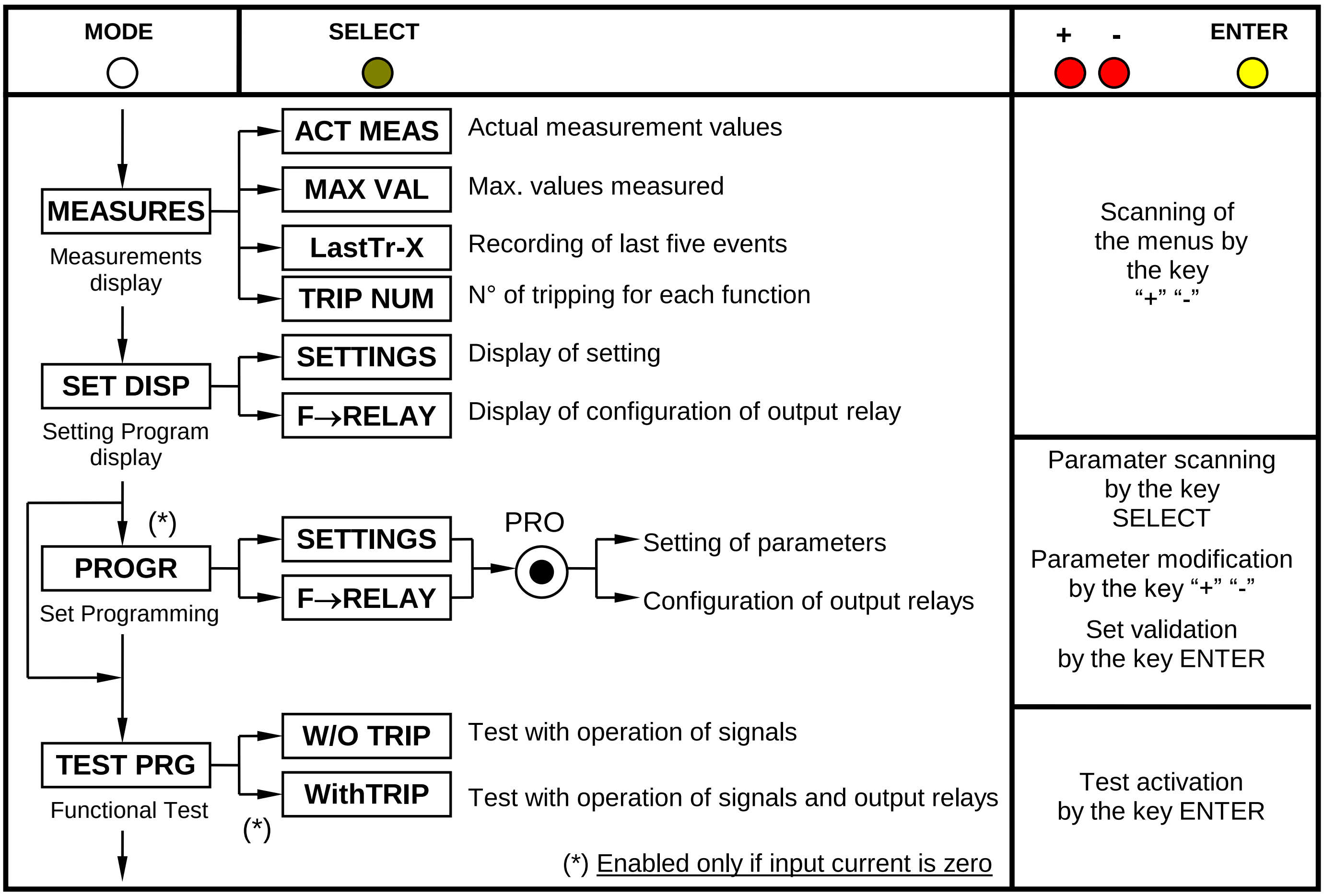
2.9.5 - Time tolerance.

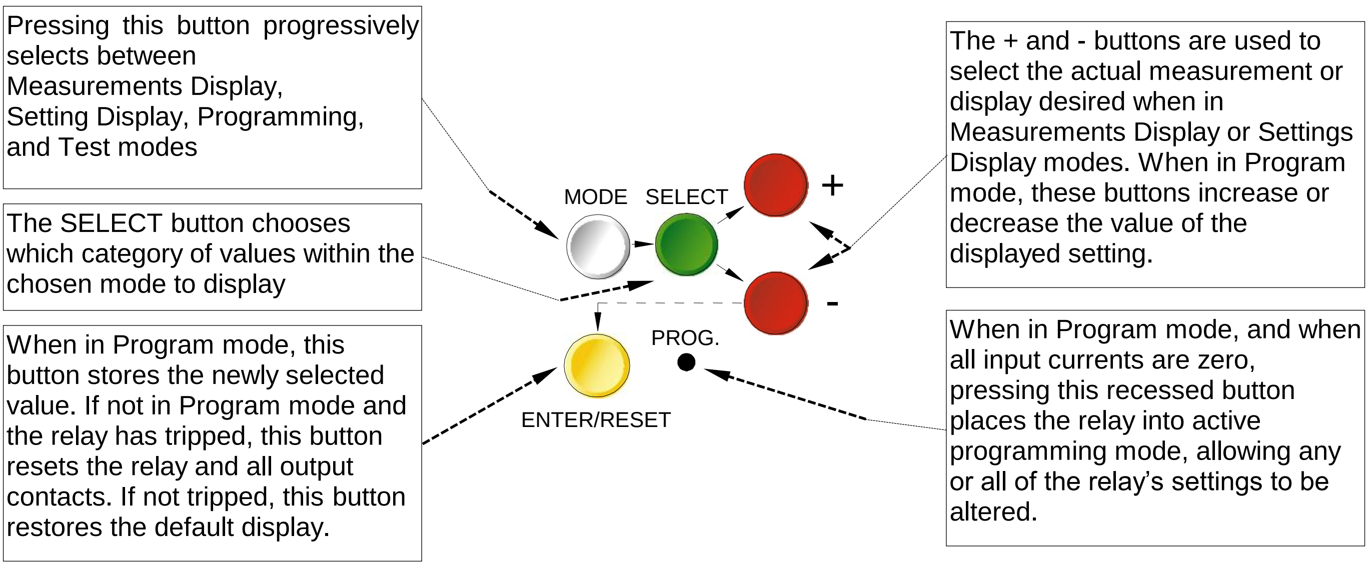
During power on, time tolerance depends on the on board crystal (+/-50ppm typ, +/-100ppm max. over full temperature range).
During power off, time tolerance depends on the RTC’s oscillator (+65 /–270 ppm max over full temperature range).

3. CONTROLS AND MEASUREMENTS

Five key buttons allow for local management of all relay's functions.
A 8-digit high brightness alphanumerical display shows the relevant readings **(xxxxxxxx)**
(see synoptic table fig.1)

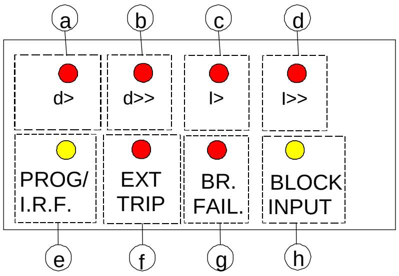
FIG.1





4. SIGNALIZATIONS

Eight signal leds (normally off) are provided:



a) Red LED	**d>**	❑ Illuminated on tripping of biased differential element (Id > [d>])
b) Red LED	**d>>**	❑ Illuminated on tripping of high-set differential element (Id > [d>>])
c) Red LED	**I>**	❑ Flashing when the current exceeds the set level [I>] (I>[I>]) ❑ Illuminated on trip at the end of time delay tI>
d) Red LED	**I>>**	❑ Flashing when the current exceeds the set level [I>>] (I>[I>>]) ❑ Illuminated on trip at the end of time delay tI>>
e) Yellow LED	**PROG I.R.F.**	❑ Flashing during the programming of the parameters or in case of Internal Relay Fault.
f) Red LED	**EXT TRIP**	❑ Illuminated when the digital input B2 is activated
g) Red LED	**BR. FAIL.**	❑ Illuminated on trip of the Breaker Failure function
h) Yellow LED	**BLOCK INPUT**	❑ Flashing when digital input B1 is activated

The reset of the leds takes place as follows:

- ❑ From flashing to off, automatically when the lit-on cause disappears.
- ❑ From ON to OFF, by "ENTER/RESET" push button only if the tripping cause has disappeared.

In case of auxiliary power supply failure the status of the leds is recorded and reproduced when power supply is restored.

5. OUTPUT RELAYS

Five output relays are available (R1, R2, R3, R4, R5)

- The relays **R1,R2,R3,R4** are normally deenergized (energized on trip): these output relays are user programmable and any of them can be associated to any of the M-HIB3's functions.
  For function **I>** and **I>>** both instantaneous and time delayed elements are provided.
  Any relay associated to the instantaneous element of a function picks-up as soon as the measured input value exceeds the set minimum pick-up level.
  The reset after tripping of the relays (when tripping cause has been cleared) can be programmed as Manual or Automatic (Variable FRes=Man/Aut).

  FRes = Aut : Automatic Reset as soon as pick-up cause has been cleared.

  FRes = Man : Reset by ENT/RESET KEY on relay's front or via serial port

- The relay **R5**, normally energised, is not programmable and is deenergized on:
  - internal fault
  - power supply failure
  - during the programming

6. SERIAL COMMUNICATION

The relays fitted with the serial communication option can be connected via a cable bus or (with proper adapters) a fiber optic bus for interfacing with a Personal Computer (type IBM or compatible).
All the operations which can be performed locally (for example reading of measured data and changing of relay's settings) are also possible via the serial communication interface.
Furthermore the serial port allows the user to read the event recording data.
The unit has a RS232 / RS485 interface and can be connected either directly to a P.C. via a dedicated cable or to a RS485 serial bus, thus having many relays to exchange data with a single master P.C. using the same physical serial line. A RS485/232 converter is available on request.
The communication protocol is MODBUS RTU.
Each relay is identified by its programmable address code (NodeAd) and can be called from the P.C.
A dedicated communication software (MSCOM) for Windows 95/98 (or later) is available.
Please refer to the MSCOM instruction manual for more information.

7. DIGITAL INPUTS

The relay has tree user available inputs that are activated shorting the relevant terminals by a cold contact. Max external resistance ≤ 3 kΩ

B1	Terminals (1 – 2)	:	❑ For blocking functions
B2	Terminals (1 – 3)	:	❑ For Remote Relay Tripping
B3	Terminals (1 – 14)	:	❑ External trigger for oscillographic records

8. OSCILLOGRAPHY RECORDS

The relay continuously records in a buffer the samples of the input current.
The buffer contains samples for approximately 112 periods.
Recording is stopped after approximately 8 periods after a trigger signal and the content of the buffer is stored into memory.
Therefore in the memory are stored the wave forms for 8 cycles before and 8 cycles after the trigger instant.
The trigger can be operated either internally on tripping of any function programmed d>, d>>, I>, I>> or externally by activation of the digital input B3.
Selection between the two modes is made by programming the variable **TRG** = EXT, d>, d>>, I>, I>>
The last oscillographic record of the six input currents is stored; a second record replaces the first one.

9. TEST

Besides the normal "WATCHDOG" and "POWERFAIL" functions, a comprehensive program of self-test and self-diagnostic provides:

- Diagnostic and functional test, with checking of program routines and memory's content, run every time the aux. power is switched-on: the display shows the type of relay and its version number and then switches over to the default display.

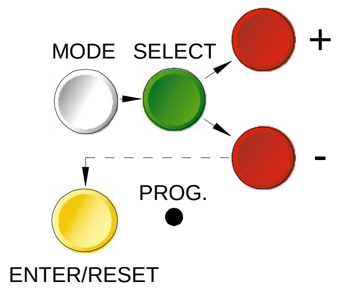
- Dynamic functional test run during normal operation every 15 min. (relay's operation is suspended for less than ≤4 ms).

- Complete test activated by the keyboard or via the communication bus either with or without tripping of the output relays.

- If any internal fault is detected, the display shows a fault message, the Led "PROG/IRF" illuminates and the relay R5 is deenergized.

10. KEYBOARD AND DISPLAY OPERATION

All controls can be operated from relay's front or via serial communication bus.
The keyboard includes five hand operable buttons **(MODE) - (SELECT) - (+) - (-) - (ENTER/RESET)** plus one indirectly operable key **(PROG)** (see synoptic table a fig.1):



a) -	White key	**MODE**	:	when operated it enters one of the following operation modes indicated on the display :
		MEASURES	=	Real time measurements of input quantities and reading of the data stored in to relay memory
		SET DISP	=	Reading of the settings and of the configuration of the output relays as programmed.
		PROG	=	Access to the programming of the settings and of output relays configuration.
		TEST PROG	=	Access to the manual test routines.
b) -	Green key	**SELECT**	:	When operated it selects one of the menus available in the actual operation MODE
c) -	Red key	"**+**" AND "**-**"	:	When operated they allow to scroll the different information available in the menu entered by the key SELECT and to increase-decrease the settings when in Prog mode.
d) -	Yellow key	**ENTER/RESET**	:	It allows the validation of the programmed settings - the actuation of test programs - the forcing of the default display indication - the reset of signal Leds.
e) -	Indirect key	●	:	Enables access to the programming.

11. READING OF MEASUREMENTS AND RECORDED PARAMETERS

Enter the MODE "MEASURE", SELECT the menus "ACT.MEAS"-"MAX VAL"-"LASTTRIP"-"TRIP NUM", scroll available information by key "+" or "-" .

11.1 - ACT.MEAS

Real time measurements during the normal operation. The values displayed are continuously updated.

Display			Description
xxxxxxx			Current date in the DDMMMYY format.
xx:xx:xx			Current time in the HH:MM:SS format.
Id	xx.xx	**n**	R.M.S. value of differential current : (0-99.99) per unit of rated input current
IR	xx.xx	**n**	R.M.S. value of the through current
I	xxxxxx	**A**	R.M.S. value of the input current : (0-99.99)p.u.
KS	xxxxx		Ratio Id / IR : (0 – 9.99)p.u.

11.2 - INRUSH

Highest values recorded from Breaker closing, (updated any time the breaker closes).

Display			Description
Id	xx.xx	**n**	Differential current : (0-99.99) per unit of rated phase input current
IR	xx.xx	**n**	Through Current : (0-99.9) p.u. of phase input current
I	xxxxxx	**A**	Input current

11.3 - LASTTRIP

Display of the function which caused the tripping of the relay plus values of the parameters <u>at the moment of tripping</u>. The memory buffer contains the records of the last five trippings (FIFO).

Display			Description
LastTr-x			Indication of the recorded event (x= 0 to 4) Example: Last event (LastTr -0) Last but one event (LastTr-1) etc...
xxXXXxx			Date : Day, Month, Year
xx:xx:xx			Hour : Hours, Minutes, Seconds
Cau:xxxx			Function which produced the event being displayed: **d>, d>>, I>, I>>, Ext**
Id	xx.xx	**n**	Differential current
IR	xx.xx	**n**	Through Current
I	xxxxxx	**A**	Input current
KS	xxxxx		Ratio Id / IR

11.4 - TRIP NUM

Counters of the number of operations for each of the relay's function. The memory is non-volatile and can be cancelled only with a secret procedure.

Display		Description
d>	xxxx	Low-set Biased Differential element
d>>	xxxx	High-set Differential element
I>	xxxx	Low-set Overcurrent element
I>>	xxxx	High-set Overcurrent element
EXT	xxxx	External Trip

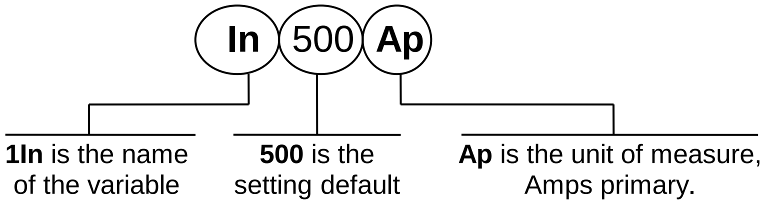
12. READING OF PROGRAMMED SETTINGS AND RELAY'S CONFIGURATION

Enter the mode "SET DISP", select the menu "SETTINGS" or "F→RELAY", scroll information available in the menu by keys "+" or "-".
SETTINGS= values of relay's operation parameters as programmed
F→RELAY= output relays associated to the different functions as programmed.

13. PROGRAMMING

The relay is supplied with the standard default programming used for factory test. [Values here below reported in the “ Display “ column].
All parameters can be modified as needed in the mode PROG and displayed in the mode SET DISP
Local Programming by the front face key board is enabled only if no input current is detected (main switch open). Programming via the serial port is always enabled but a password is required to access the programming mode. The default password is the null string; in the standard application program for communication “MS-COM” it is also provided an emergency password which can be disclosed on request only.
As soon as programming is enabled, the Led PRG/IRF flashes and the alarm relay R5 is deenergized..
Enter MODE "PROG" and SELECT either "SETTINGS" for programming of parameters or "F→RELAY" for programming of output relays configuration; enable programming by the indirect operation key PROG.
The key SELECT now scrolls the available parameters. By the key (+) , (-) the displayed values can be modified; to speed up parameter's variation press the key SELECT while "+" or "-" are pressed.
Press key "ENTER/RESET" to validate the set values.

13.1 - PROGRAMMING OF FUNCTIONS SETTINGS

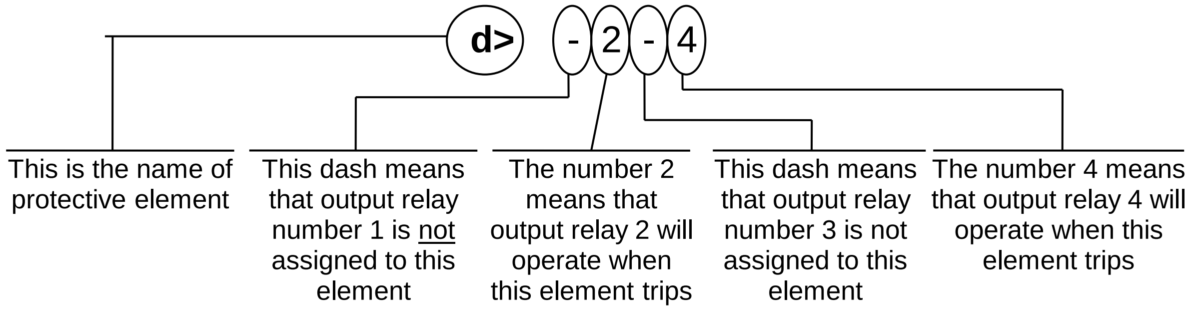


Mode PROG menu SETTINGS. (Production standard settings here under shown).

Display			Description	Setting Range	Step	Unit
xxxxxxx			Current date	DDMMMYY	-	-
xx:xx:xx			Current time	HH:MM:SS	-	-
Fn	50	**Hz**	System frequency	50 - 60	10	Hz
d>	0.15	**n**	Basic minimum pick-up level of biased phase differential element	0.02-1.00-Dis	0.01	In
KS	0.5		Bias pick-up level KS = IΔ / IR	0.5-1.0	0.01	-
d>>	5.00	**n**	High set differential element	0.5-9.9-Dis.	0.1	In
I>	5.00	**n**	Minimum pick-up level of low set overcurrent element	0.5-9.99-Dis.	0.01	In
tI>	3.00	**s**	Time delay of low set overcurrent element	0.05-9.99	0.01	s
I>>	5.0	**n**	Minimum pick-up level of high set overcurrent element	0.5-30-Dis.	0.1	In
tI>>	3.0	**s**	Time delay of high set overcurrent element	0.05-9.9	0.01	s
tBF	0.25	**s**	Breaker Failure time delay	0.05-1.00	0.01	s
Bd	-dL		Digital input B1 blocks the functions selected	dL, dH	any combination	
BI	-IL		Digital input B1 blocks the functions selected	IL, IH	any combination	
Trg:	d>		Trigger for oscillographic records is Internal or External (via digital input B3)	Ext, d>, d>>, I>, I>>		-
Tsyn	Dis	**m**	Synchronisation Time Expected time interval between sync. pulse.	5 - 60 - Dis	5-10 15-30 60-Dis	m
αP=	1.00		fine pilot timing coefficient for Bias current	0.90-1.10	0.01	-
α*i* =	1.00		fine pilot timing coefficient for Differential current	0.90-1.10	0.01	-
NodAd	1		Identification number for connection on serial communication bus	1 - 250	1	-

The setting Dis indicates that the function is disactivated.

13.2 - PROGRAMMING THE CONFIGURATION OF OUTPUT RELAYS



Mode PROG menu F→RELAY (Production standard settings here under shown).
The key "**+**" operates as cursor; it moves through the numbers corresponding to the four programmable relays in the sequence 1,2,3,4,(1= relay R1, etc.) and makes start flashing the information actually present in the digit. The information present in the digit can be either the number of the relay (if this was already associated to the function actually on programming) or a dot (-) if the relay was not yet addressed.
The key "**-**" changes the existing status from the dot to the relay number or viceversa.
After having programmed all the four relay, press " ENTER " to validate the programmed configuration.

Display		Description	
d>	1 - - -	Biased Differential element	operates relay R1,R2,R3,R4 as programmed
d>>	- 2 - -	High set of differential element	operates relay R1,R2,R3,R4 as programmed
I>	- - 3 -	Instantaneous Overcurrent low set element	operates relay R1,R2,R3,R4 as programmed
tI>	- - - 4	Time delayed Overcurrent low set element	operates relay R1,R2,R3,R4 as programmed
I>>	- - 3 -	Instantaneous Overcurrent high set element	operates relay R1,R2,R3,R4 as programmed
tI>	- - - 4	Time delayed Overcurrent high set element	operates relay R1,R2,R3,R4 as programmed
tBF	- - - -	Breaker Failure function	operates relay R2,R3,R4 as programmed
EXT	- - - -	Digital input B2	operates relay R1,R2,R3,R4 as programmed
FRes:	Aut	Reset of output relays after tripping is: **Aut** = Automatic **Man** = Manually key Enter /Reset or via serial bus	

14. MANUAL AND AUTOMATIC TEST OPERATION

14.1 - Mode "TESTPROG" subprogram "W/O TRIP"

Operation of the yellow key activates a complete test of the electronics and the process routines. All the leds are lit-on and the display shows (TEST RUN). If the test routine is successfully completed the display switches-over to the default reading (xx:xx:xx).
If an internal fault is detected, the display shows the fault identification code and the relay R5 is deenergized. This test can be carried-out even during the operation of the relay without affecting the relay tripping in case a fault takes place during the test itself.

14.2 - Mode "TESTPROG" subprogram "WithTRIP"

Access to this program is enabled only if the current detected is zero (breaker open).
Pressing the yellow key the display shows "TEST RUN?". A second operation of the yellow key starts a complete test which also includes the activation of all the output relays.
The display shows (TEST RUN) with the same procedure as for the test with W/O TRIP.
Every 15 min during the normal operation the relay automatically initiates an auto test procedure (duration ≤ 10ms). If any internal fault is detected during the auto test, the relay R5 is deenergized, the relevant led is activated and the fault code is displayed.

WARNING

Running the **WithTRIP** test will operate all of the output relays. Care must be taken to ensure that no unexpected or harmful equipment operations will occur as a result of running this test.
It is generally recommended that this test be run only in a bench test environment or after all dangerous output connections are removed.

15. MAINTENANCE

No maintenance is required. Periodically a functional check-out can be made with the test procedures described under MANUAL TEST chapter. In case of malfunctioning please contact Microelettrica Scientifica Service or the local Authorised Dealer mentioning the relay's Serial No reported in the label on relays enclosure.

WARNING

In case of Internal Relay Fault detection, proceed as here-below indicated :

- If the error message displayed is one of the following “DSP Err”, “ALU Err” ,”KBD Err” ,”ADC Err”, switch off power supply and switch-on again. If the message does not disappear send the relay to Microelettrica Scientifica (or its local dealer) for repair.
- If the error message displayed is “E2P Err”, try to program any parameter and then run “W/OTRIP”.
- If message disappear please check all the parameters.
- If message remains send the relay to Microelettrica Scientifica (or its local dealer) for repair.

16. POWER FREQUENCY INSULATION TEST

Every relay individually undergoes a factory insulation test according to IEC255-5 standard at 2 kV, 50 Hz 1min. Insulation test should not be repeated as it unusefully stresses the dielectrics.
When doing the insulation test, the terminals relevant to serial output must always be short circuited to ground. When relays are mounted in switchboards or relay boards that have to undergo the insulation tests, the relay modules must be drawn-out of their enclosures and the test must only include the fixed part of the relay with its terminals and the relevant connections.
This is extremely important as discharges eventually tacking place in other parts or components of the board can severely damage the relays or cause damages, not immediately evident to the electronic components.

17. ELECTRICAL CHARACTERISTICS

APPROVAL: CE
REFERENCE STANDARDS IEC 60255 - EN50263 - CE Directive - EN/IEC61000 - IEEE C37

❑ Dielectric test voltage	IEC 60255-5	2kV, 50/60Hz, 1 min.
❑ Impulse test voltage	IEC 60255-5	5kV (c.m.), 2kV (d.m.) – 1,2/50μs
❑ Insulation resistance	> 100MΩ	

Environmental Std. Ref. (IEC 68-2-1 - 68-2-2 - 68-2-33)

❑ Operation ambient temperature	-10°C / +55°C
❑ Storage temperature	-25°C / +70°C
❑ Humidity	IEC68-2-3 RH 93% Without Condensing AT 40°C

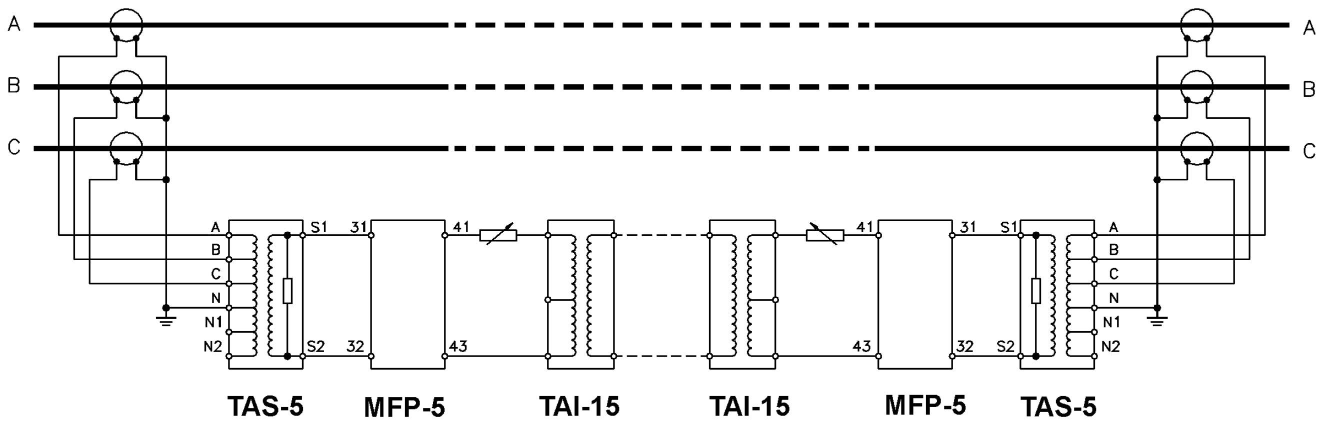
CE EMC Compatibility (EN50081-2 - EN50082-2 - EN50263)

❑ Electromagnetic emission	EN55022		industrial environment	
❑ Radiated electromagnetic field immunity test	IEC61000-4-3 ENV50204	level 3	80-1000MHz 900MHz/200Hz	10V/m 10V/m
❑ Conducted disturbances immunity test	IEC61000-4-6	level 3	0.15-80MHz	10V
❑ Electrostatic discharge test	IEC61000-4-2	level 4	6kV contact / 8kV air	
❑ Power frequency magnetic test	IEC61000-4-8		1000A/m	50/60Hz
❑ Pulse magnetic field	IEC61000-4-9		1000A/m, 8/20μs	
❑ Damped oscillatory magnetic field	IEC61000-4-10		100A/m, 0.1-1MHz	
❑ Electrical fast transient/burst	IEC61000-4-4	level 3	2kV, 5kHz	
❑ HF disturbance test with damped oscillatory wave (1MHz burst test)	IEC60255-22-1	class 3	400pps, 2,5kV (m.c.), 1kV (d.m.)	
❑ Oscillatory waves (Ring waves)	IEC61000-4-12	level 4	4kV(c.m.), 2kV(d.m.)	
❑ Surge immunity test	IEC61000-4-5	level 4	2kV(c.m.), 1kV(d.m.)	
❑ Voltage interruptions	IEC60255-4-11			
❑ Resistance to vibration and shocks	IEC60255-21-1 - IEC60255-21-2 10-500Hz 1g			

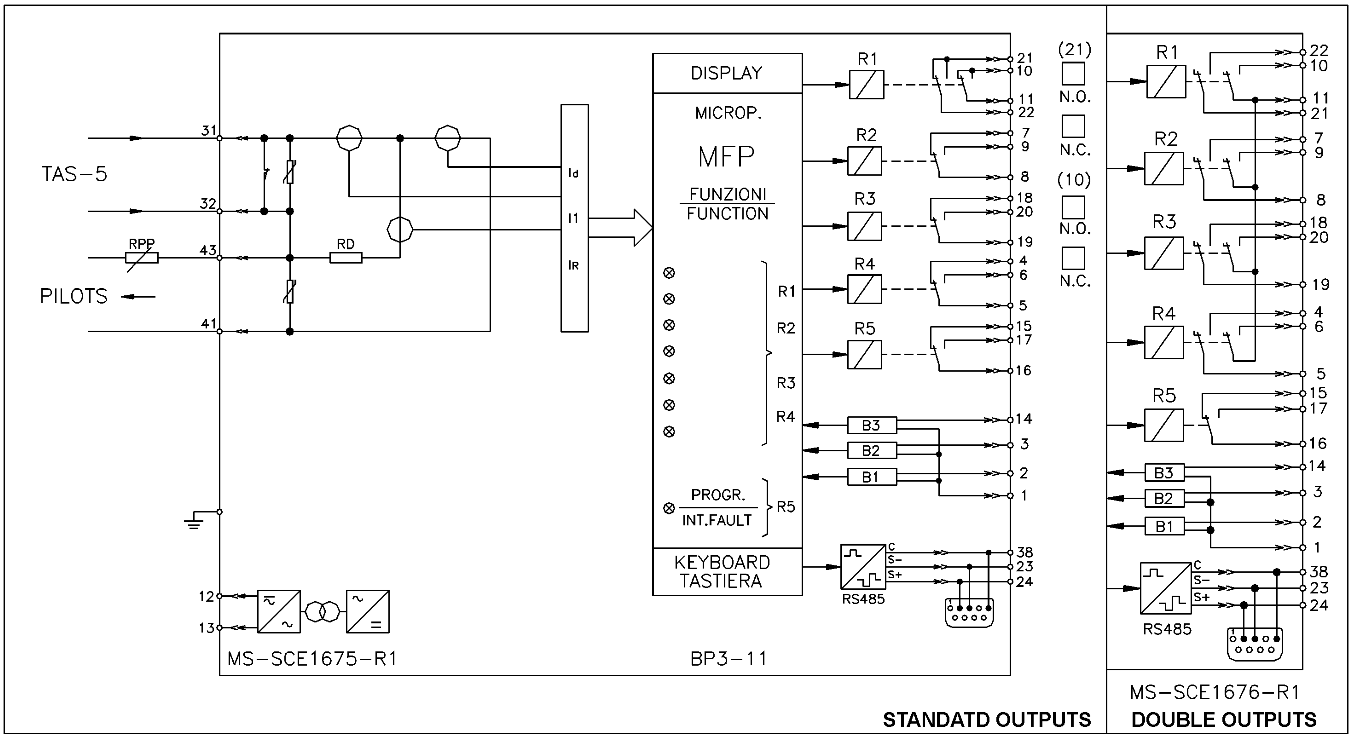
CHARACTERISTICS

❑ Accuracy at reference value of influencing factors	2% Rated Input for measure 2% +/- 10ms for times
❑ Rated Current	In = 1 or 5A
❑ Current overload	100 In for 1 sec; 4In continuous (TAS primary)
❑ Burden on current inputs	Phase : 0.5VA at In
❑ Average power supply consumption	8.5 VA
❑ Output relays	rating 5 A; Vn = 380 V A.C. resistive switching = 1100W (380V max) make = 30 A (peak) 0,5 sec. break = 0.3 A, 110 Vcc, L/R = 40 ms (100.000 op.)

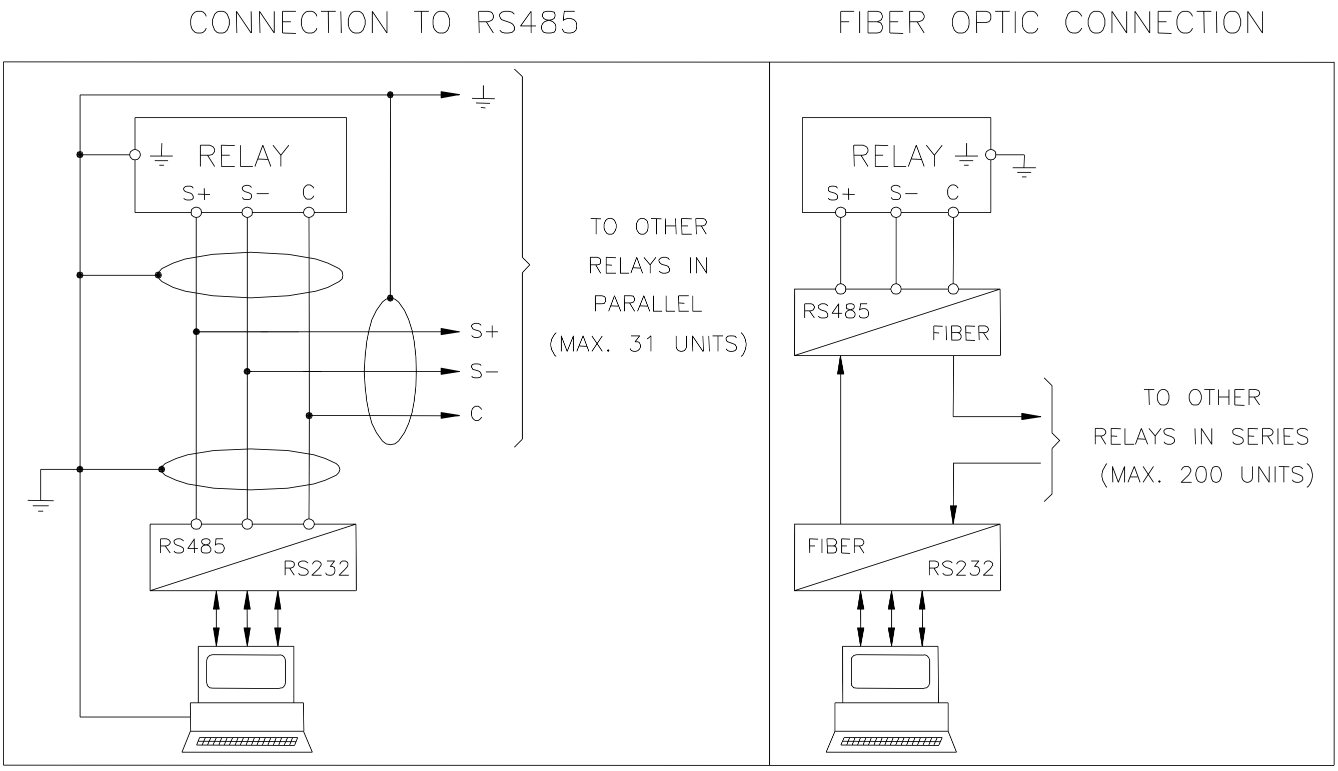
18. GENERAL CONNECTION DIAGRAM



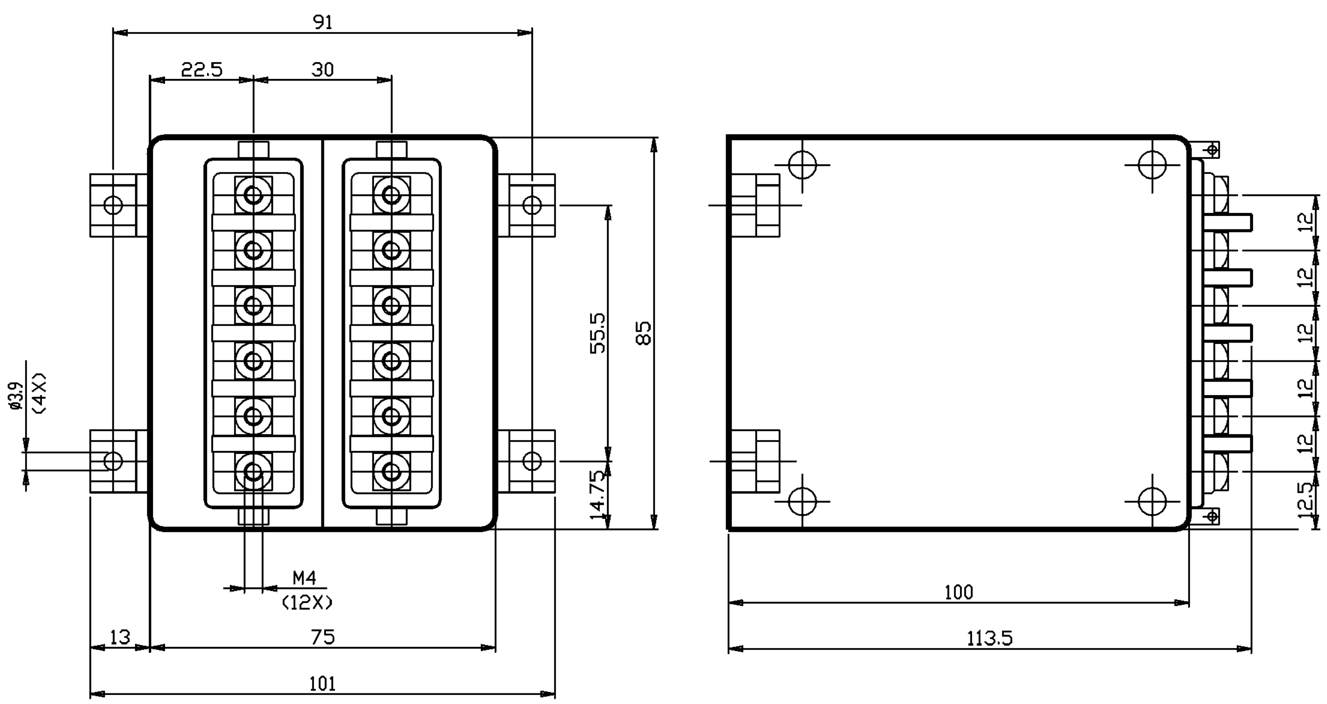
19. CONNECTION DIAGRAM



20. WIRING THE SERIAL COMMUNICATION BUS (SCE1309 Rev.0)



21. SUMMATION TRANFORMER DIMENSIONS



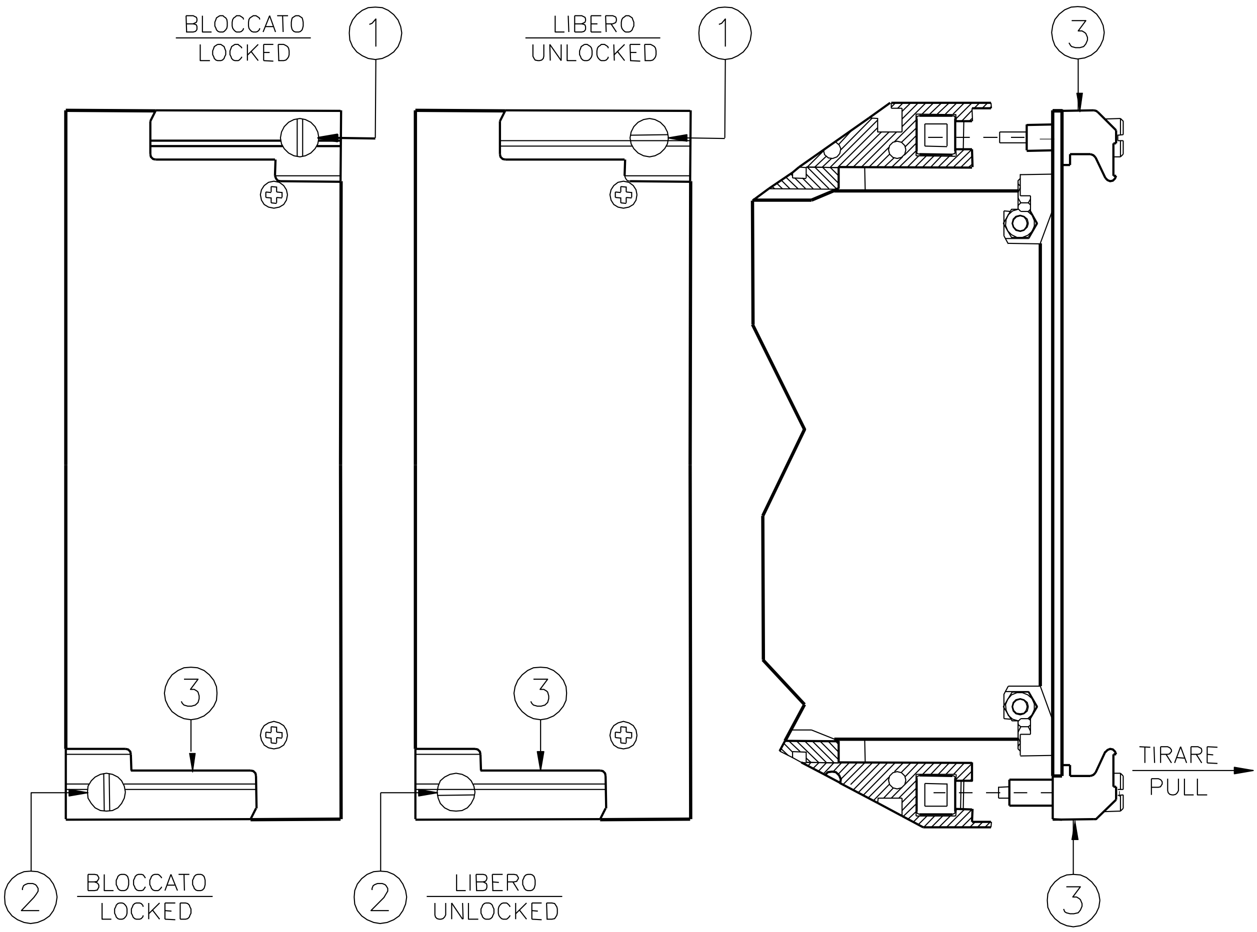
22. DIRECTION FOR PCB'S DRAW-OUT AND PLUG-IN

22.1 - Draw-out

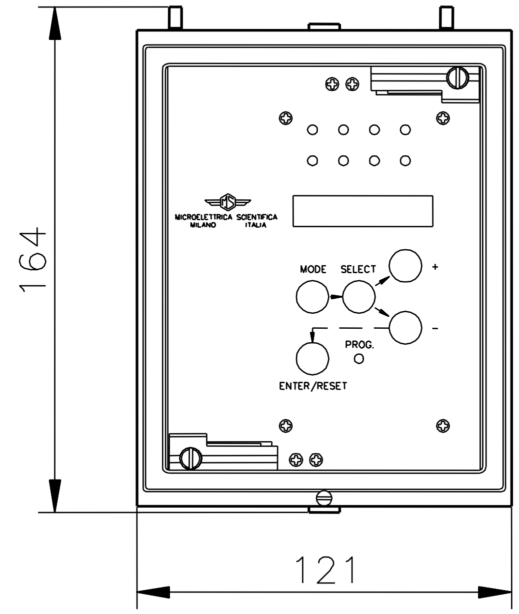
Rotate clockwise the screws ① and ② in the horizontal position of the screws-driver mark.
Draw-out the PCB by pulling on the handle ③

22.2 - Plug-in

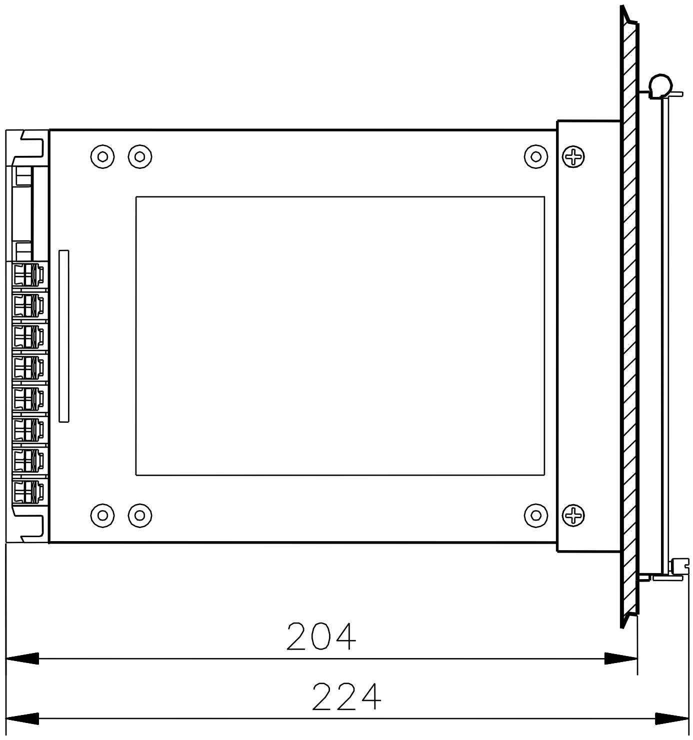
Rotate clockwise the screws ① and ②in the horizontal position of the screws-driver mark.
Slide-in the card on the rails provided inside the enclosure.
Plug-in the card completely and by pressing the handle to the closed position.
Rotate anticlockwise the screws ① and ② with the mark in the vertical position (locked).

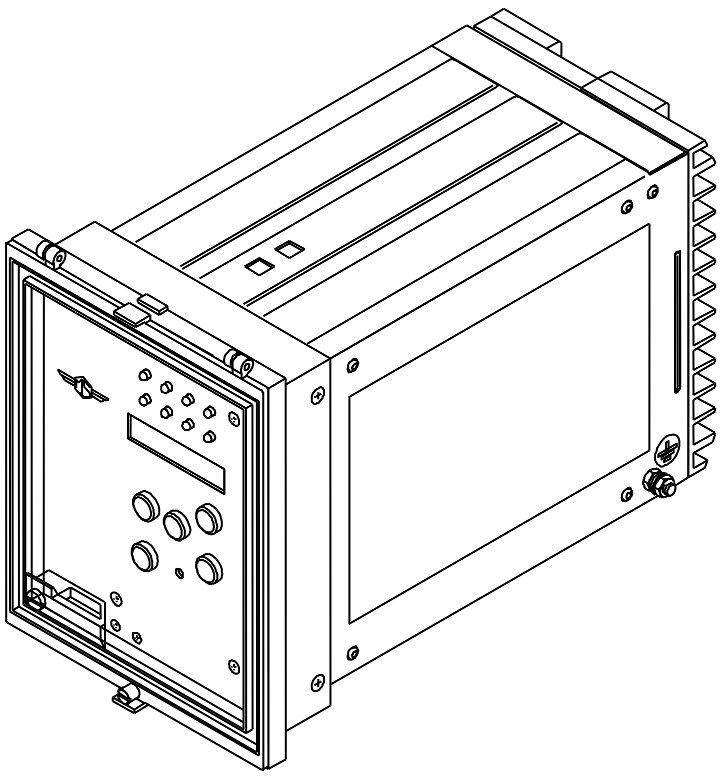


23. Overall Dimensions

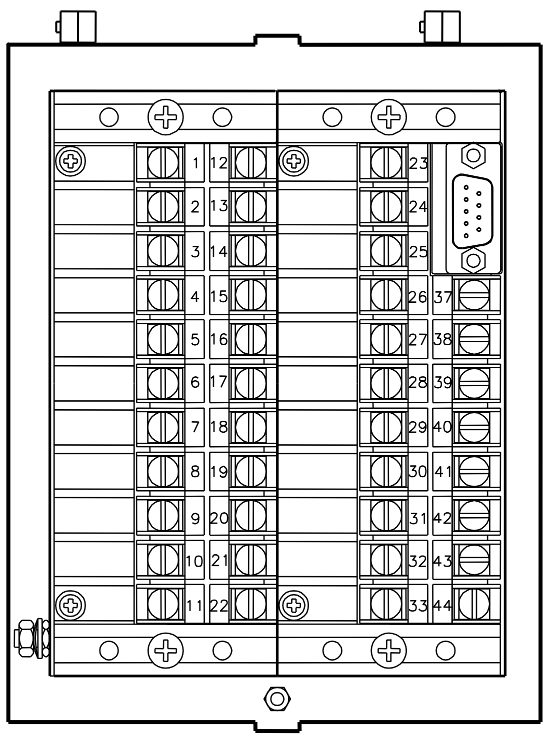


PANEL CUT-OUT 113x142 (LxH)

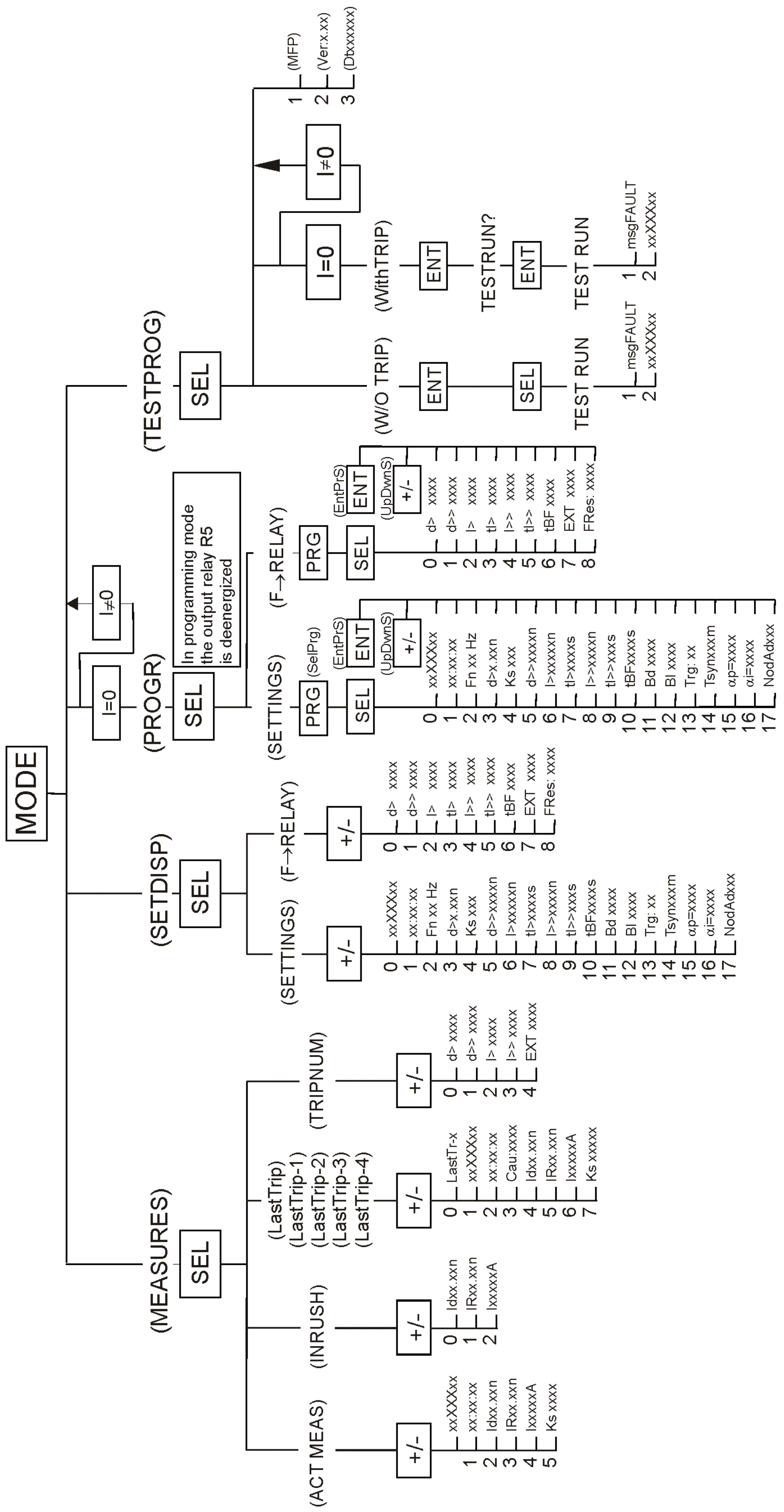




View of Rear
Terminal Connection



24. KEYBOARD OPERATIONAL DIAGRAM



25. SETTING'S FORM

Relay Type	**MFP**	**Station :**	**Circuit :**
Date :	**/ /**	**FW.Version**	**Relay Serial Number :**

Power Supply	☐ 24V(-20%) / 110V(+15%) a.c. 24V(-20%) / 125V(+20%) d.c.	**Rated Current :**	**20mA**
	☐ 80V(-20%) / 220V(+15%) a.c. 90V(-20%) / 250V(+20%) d.c.		

RELAY PROGRAMMING

Variable	Description	Setting Range		Default Setting	Actual Setting	Test Result Pick-up	Test Result Reset
xxxxxxx	Current date	DDMMMYY	-	Random			
xx:xx:xx	Current time	HH:MM:SS	-	Random			
Fn	System frequency	50 - 60	**Hz**	50			
d>	Basic minimum pick-up level of biased phase differential element	0.02-1.00-Dis	**In**	0.15			
KS	Bias pick-up level KS = IΔ / IR	0.5-1.0	-	0.5			
d>>	High set differential element	0.5-9.9-Dis.	**In**	5.00			
I>	Minimum pick-up level of low set overcurrent element	0.5-9.99-Dis.	**In**	5.00			
tI>	Time delay of low set overcurrent element	0.05-9.99	**s**	3.00			
I>>	Minimum pick-up level of high set overcurrent element	0.5-30-Dis.	**In**	5.0			
tI>>	Time delay of high set overcurrent element	0.05-9.9	**s**	3.0			
tBF	Breaker Failure time delay	0.05-1.00	**s**	0.25			
Bd	Digital input B1 blocks the functions selected	dL, dH	-	dL			
BI	Digital input B1 blocks the functions selected	IL, IH	-	IL			
Trg:	Trigger for oscillographic records is Internal or External	Ext, d>, d>>, I>, I>>	-	d>			
Tsyn	Synchronisation Time Expected time interval between sync. pulse.	5 - 60 - Dis	**m**	Dis			
αP	fine pilot timing coefficient for Bias current	0.90-1.10	-	1.00			
αi	fine pilot timing coefficient for Differnetial current	0.90-1.10	-	1.00			
NodAd	Identification number for serial communication bus	1 - 250	-	1			

CONFIGURATION OF OUTPUT RELAYS

Default Setting Prot Elem.	Output Relays				Description	Actual Setting Prot. Elem.	Output Relays			
d>	1	-	-	-	Biased Differential element	**d>**				
d>>	-	2	-	-	High set of differential element	**d>>**				
I>	-	-	3	-	Instantaneous Overcurrent low set element	**I>**				
tI>	-	-	-	4	Time delayed Overcurrent low set element	**tI>**				
I>>	-	-	3	-	Instantaneous Overcurrent high set element	**I>>**				
tI>	-	-	-	4	Time delayed Overcurrent high set element	**tI>**				
tBF	-	-	-	-	Breaker Failure function	**tBF**				
EXT	-	-	-	-	Digital input B2	**EXT**				
FRes:	Aut				Reset of output relays after tripping is: **Aut** = Automatic **Man** = Manually	**FRes:**				

Commissioning Engineer : ______________________ **Date :** ______________

Customer Witness : ______________________ **Date :** ______________