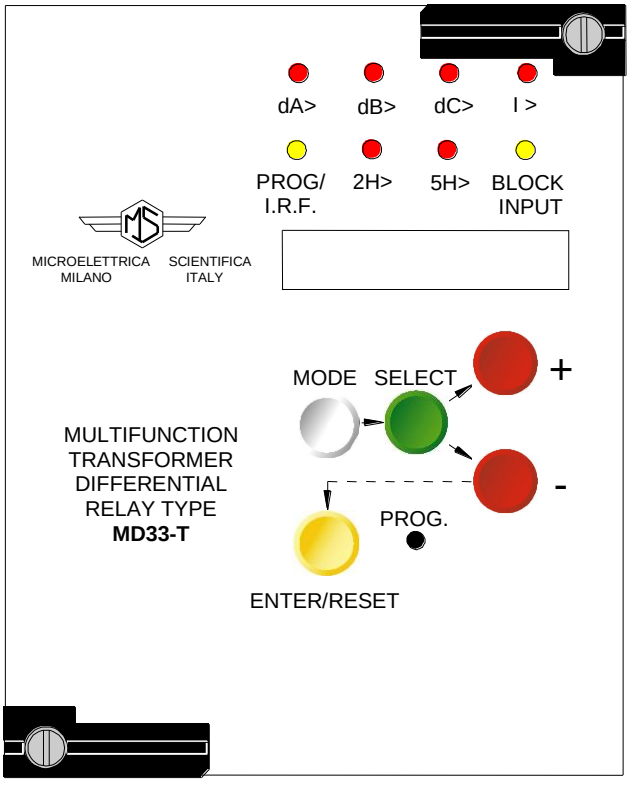
DIGITAL-MULTIFUNCTION TRANSFORMER DIFFERENTIAL PROTECTION RELAY

TYPE

MD33-T

OPERATION MANUAL



CE

INDEX

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 produced by M.S. are completely safe from electrostatic discharge (15 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.

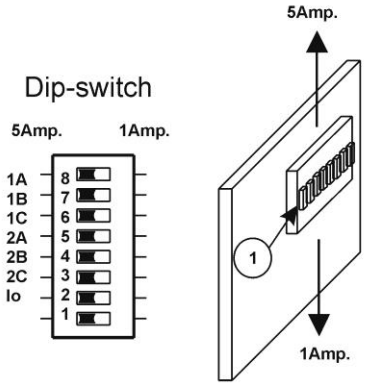
Misapplication of the above warnings and instruction relieves the Manufacturer of any liability.

2. GENERAL CHARACTERISTICS

The apparatus includes two modules :

- The summation module TX33 which receives the current input from the main CTs and produces the bias output proportional to the summation of the currents of the three windings.
  This module is available in two versions for 1A rated input (TX33-1) or 5A rated input (TX33-5)

- The biased differential relay MD33-T which receives the current and bias input via the TX33 module.
  Input rated current 1 or 5A can be selected by setting 7 dip-switches provided on relay's card.



The currents from the main CTs of the primary winding and from one of the secondary windings of the transformer are directly input to the module TX33; the currents from the other secondary (third winding) must go through an external set of adapting transformers (TAD) to adapt vector group and CTs' ratio of this winding to that of the other secondary.

2.1 - POWER SUPPLY

The auxiliary power is supplied by a built-in interchangeable module fully isolated an self protected. Two options are available :

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 - Differential Protection F87T

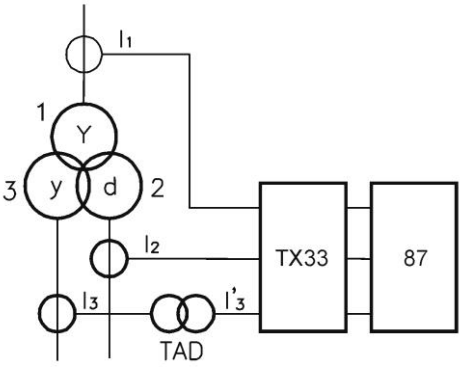
The relay performs a percentage biased differential protection of three-windings Power Transformers against:

- Two or three-phase internal faults

- Interturn faults

- Earth Fault in transformers with low-impedance or directly earthed neutral.

Three-winding transformers normally have two wye connected windings and one Delta connected winding. One of the wye connected windings (1) is the “Primary” supplied by the High Voltage System and rated for the total power (summation of the powers of the other two windings). One external set of auxiliary transformer (TAD) is needed to adapt the Vector Group and the CTs’ ratio of the secondary wye connected winding (3) to those of the delta connected winding (2). Inside the module TX33, the currents of the third winding properly adapted by the TAD auxiliary CTs (I_3’) are summated with the currents of the second winding (I_2) and are then supplied to the relay MD33-T which computes for each phase (A-B-C) the differential current.



$$d_x = \left| \bar{I}_{1x} - (\bar{I}_{2x} + \bar{I}'_{3x}) \right| \qquad (x = A,B,C)$$

2.2.1 - CT's ratio and vector Group compensation

The relay automatically compensates CT's ratio mismatch as well as phase displacement due to power transformer's vector group between windings 1 and 2 (Adaptation of winding 3 to winding 2 is made by the additional transformer TAD).
Compensation is based on the setting of the following parameters.

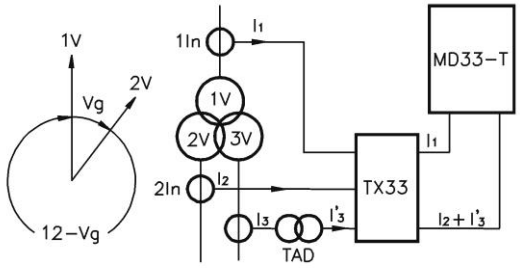
Fn = System frequency

1In = Rated primary current of CT's on transformer winding 1

2In = Rated primary current of CT's on transformer winding 2

1V = Rated voltage of transformer winding 1 (Y connected)

2V = Rated voltage of transformer winding 2 (Δ connected)



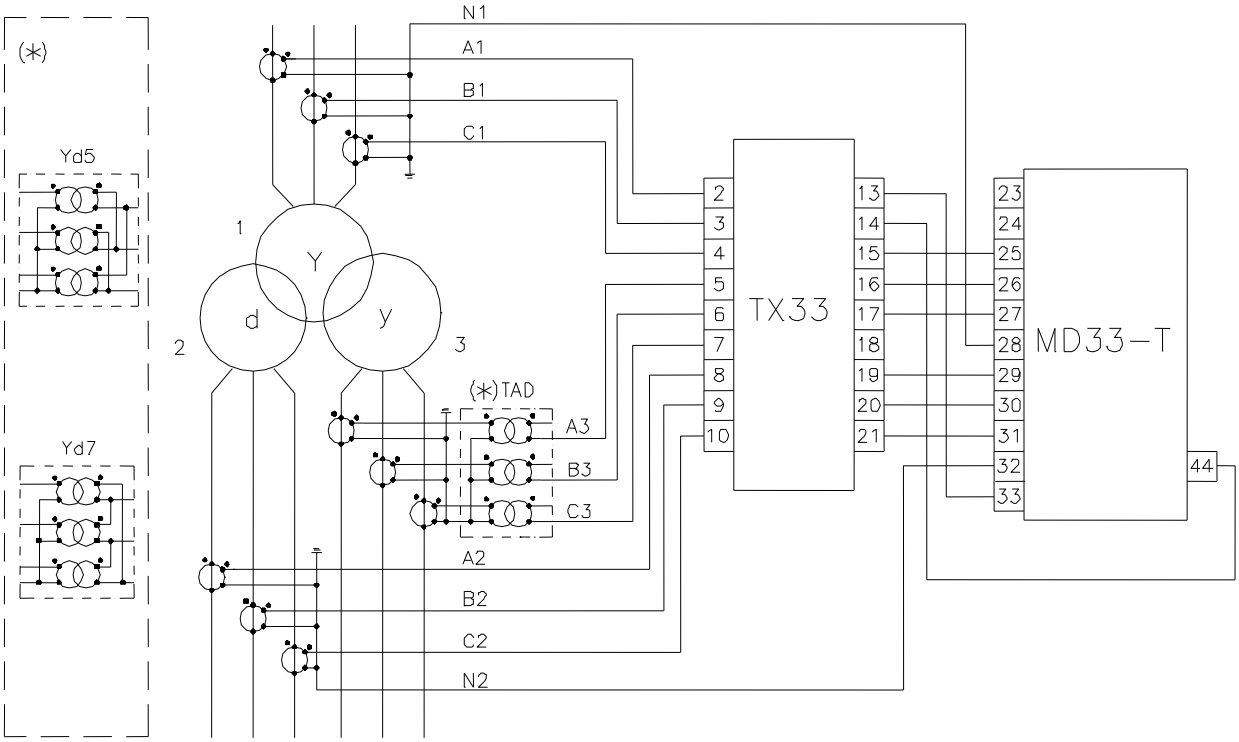
α = Vector group of Power Transformer's winding 1-2
Yd1 – Yd5 – Yd7 – Yd11 - Yy0 - Yy6 – Dd0 – Dd6
Dz6 – Dy1 – Dy5 – Yz5 – Yz11 – Dy7 – Dy11 - Yz1
Yz7.

CT ratio mismatch is computed as follows $K = \frac{1In}{2In} \cdot \frac{1V}{2V}$

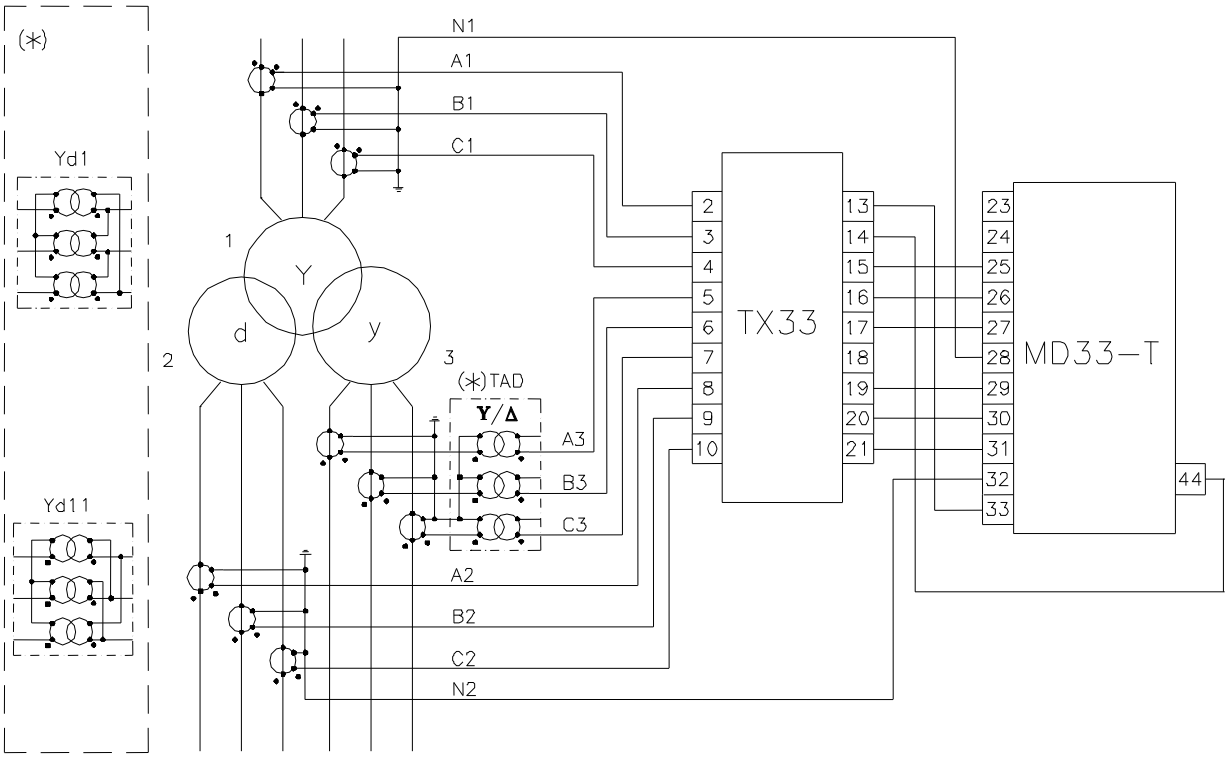
Theoretically, CTs should be selected so that "K" is as near as possible to "1".
The relay MD32-T can compensate CT mismatch up to "K=2" .
Larger mismatch cannot be compensated and adapting transformers are required.
Anyhow selection of CTs on the transformer sides with ratio mismatch larger than "2" is incorrect and can cause spurious tripping even if adapting transformers are used.

Connection of additional transformers TAD adapting winding-3 CTs to winding-2 CTs in the most frequent applications.

Yy0d5 – Yy0d7



Yy0d1 – Yy0d11



2.2.2 - Low set differential level 1F87T

For each phase the relay measures :

- The R.M.S. value of the Vector Difference between side 1 current " $\mathbf{I_1}$ " and side 2 current $\bar{I}'_2 (= \bar{I}_2 + \bar{I}'_3)$ internally compensated to recover CT's ratio mismatch and Vector Group

$$dA = |\bar{I}1A - \bar{I}'2A| \qquad dB = |\bar{I}1B - \bar{I}'2B| \qquad dC = |\bar{I}1C - \bar{I}'2C|$$

- The second harmonic component " $\mathbf{d2_x}$ " and the fifth harmonic component " $\mathbf{d5_x}$ " of d_x (per unit of d_x)

d2A, d2B, d2C - d5A, d5B, d5C

- The Power Transformer's "Through current" (per unit of rated relay's input current In) Supplied by the module TX33

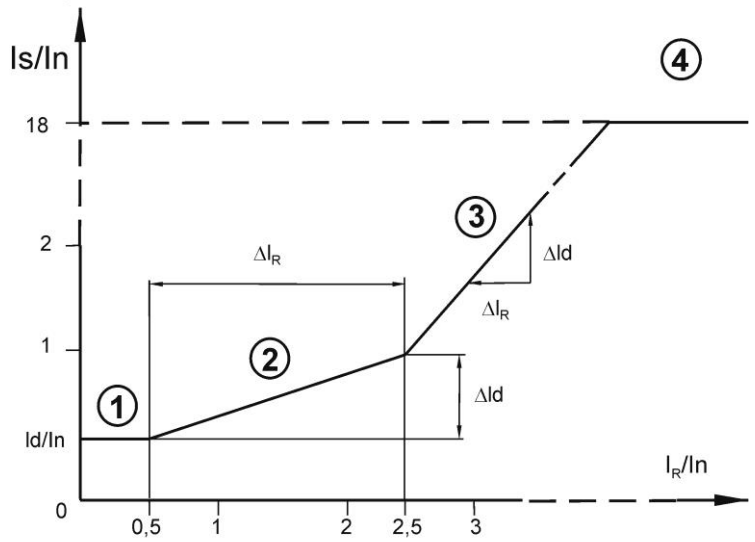
$$Ir(A) = \frac{|\bar{I}1A| + |\bar{I}2A| + |\bar{I}'3A|}{2} \qquad Ir(B) = \frac{|\bar{I}1B| + |\bar{I}2B| + |\bar{I}'3B|}{2} \qquad Ir(C) = \frac{|\bar{I}1C| + |\bar{I}2C| + |\bar{I}'3C|}{2}$$

The operation is based on the above measurements and on the following programmable levels :

- Basic minimum differential pick-up level : **d>** = (0.1 - 0.5)In, step 0.01
- Second harmonic restraint level : **2H** = (0.1 - 0.3)d, step 0.01
- Fifth harmonic restraint level : **5H** = (0.2 - 0.4)d, step 0.01
- Percent bias level : **R%** = (10 - 50)%, step 1%

To compensate differential current produced by errors of the CTs and/or to variation of the Power Transformator ratio (Voltage tap changers) the actual differential current minimum pick-up level " **Is "** is dynamically adjusted in function of the actual Through Current " **Ir "** depending on the set percent bias " **R% "** (Fig.1).

Fig.1



$$R\% = 100\,\frac{\Delta I_d}{\Delta I_R} = 100\,\frac{\Delta(I_1 - I_2)}{\Delta(I_1 + I_2):2}$$

① $\dfrac{Is}{In} = \dfrac{I_d}{In}$

② $\dfrac{Is}{In} = \dfrac{I_d}{In} + (\dfrac{I_R}{In} - 0{,}5)\cdot\dfrac{R\%}{100}$

③ $\dfrac{Is}{In} = \dfrac{I_d}{In} + \dfrac{2R\%}{100} + (\dfrac{I_R}{In} - 2{,}5)$

④ $\dfrac{Is}{In} \cong 18$

Is= Effective relay's operation differential current
Id= Relay's setting differential current = [d>]

The low set differential element operates instantaneously (less than 30ms) when the measured differential current " $\mathbf{I_{dx}}$ " of any phase is above the pick-up level **Is**, provided that the second and/or fifth harmonic components of the differential current of any phase are below the levels set for **" 2H "** and " **5H "**.

Trip conditions for 1F87T
$$\begin{cases} Idx \geq Is \\ d2x < [2H] \quad (x = A,B,C) \\ d5x < [5H] \end{cases}$$

Harmonic restraint is very important to avoid spurious tripping on Transformer energization, but if too sensitive, could block or delay relay's operation on real faults.

For this reason it is possible to decrease the harmonic restraint level (i.e. increase the harmonic restraint effect) only during a programmable time " **tH** " from Transformer's switch-on.

- Time " **tH** " is started on activation of relay's digital input B2 (activated by a cold N/O contact of the Main Transformer Primary's Circuit Breaker) : **tH** = (0.05 - 9.9)s, step 0.01s

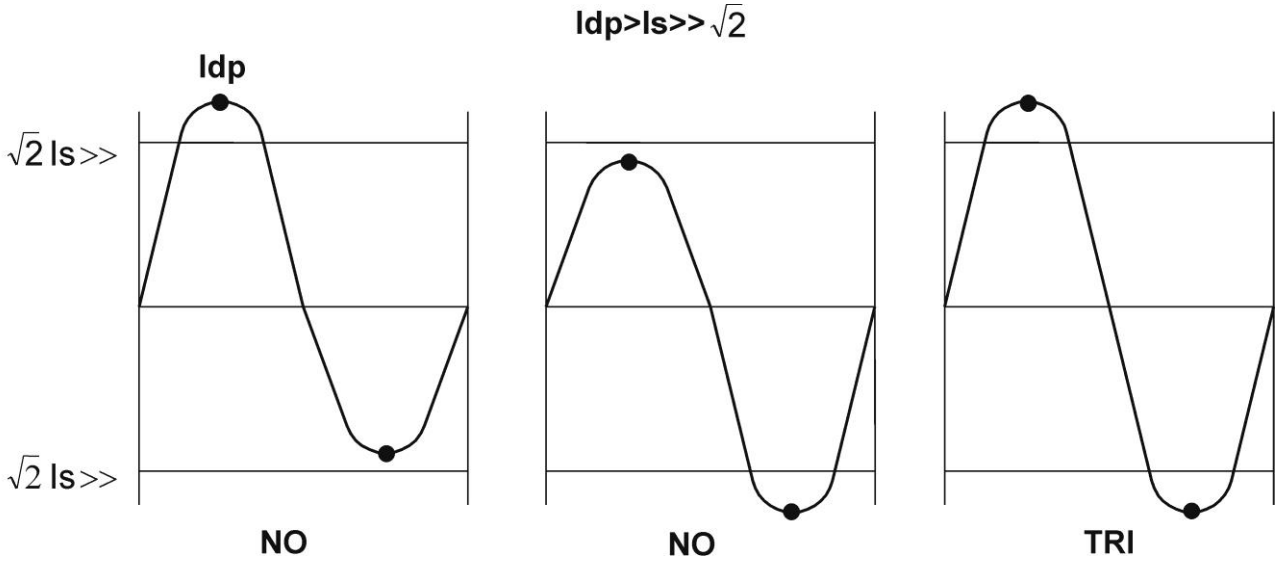
- Second harmonic restraint reduction during **tH** : **R2H** = (0.5 - 1)2H, step 0.01

- Fifth harmonic restraint reduction **tH** : **R5H** = (0.5 - 1)5H, step 0.01

Example : **R2H** = 0.7 → during " **tH** " the level is 2H = 0.7 [2H]

2.2.3 - High set differential level 2F87T

For each phase the relay measures the peak value of the positive and negative wave of the differential current. The relay operates instantaneously **if both** the values are above the minimum pick-up level.



This practically avoids spurious tripping on unidirectional current component.

- Basic minimum differential pick-up level : **d>>** = (2 - 17)In, step 0.1

2.3 - Overcurrent Protection F51

The element detects the largest of the three phase-currents flowing in the winding 1 (input terminals 2 – 3 – 4 of module TX33 and terminals 25 – 26 – 27 of MD33-T)

The adjustable parameters are :

- Minimum pick-up level : **I>** = (0.5 - 20)1In, step 0.1
  (1In = Rated current of CT feeding input terminals 25-26-27)
- Instantaneous element : t ≤ 30ms
- Time delayed element : **tI>** = (0.05 - 9.99)s, step 0,01

2.4 - 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 input B1 can be programmed to block (when activated) any of the relay functions by programming the variable B

- B = d>, d>>, I>

any combination is possible :

B =	d>	-	-
B =	-	d>>	-
B =	-	-	I>
B =	d>	d>>	-
B =	d>	-	I>
B =	d>	d>>	I>
B =	-	d>>	I>

2.5 - Characteristics required for C.Ts.

Relay burden on inputs at rated current

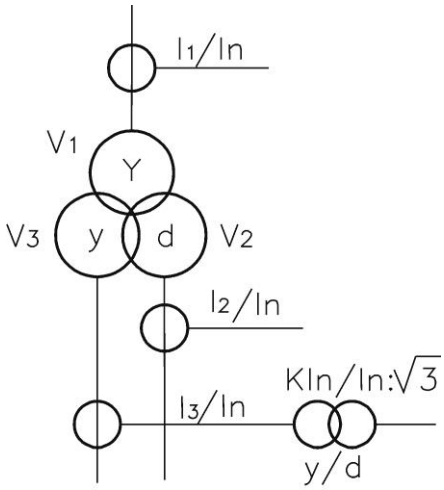
Phase inputs : **PB = 0.03VA** for C.T. 1A; **PB = 0.5VA** for C.T. 5A

C.T.'s requirements for phase differential protection

- Class 5P10 (or better)
- Minimum burden $10xPB+(R_{CT}+R_L)$, where:
  R_{CT} = Resistance of C.T.'s secondary winding
  R_L = Resistance of the loop lead between C.T. and relay

2.6 - Characteristics required for the adapting transformer TAD

One set of three adapting transformers is only needed for the CTs of the wye connected secondary winding of the Power Transformer to match the ratio and the Vector Group of the Delta connected winding of the Power Transformer.



Ratio $K \bullet In/In : \sqrt{3}$: where

In = Rated CT secondary current

I_2, I_3 = Rated CT primary currents

$$K = \frac{I_2 \bullet V_2}{I_3 \bullet V_3}$$

Connection : Y/d according to Power transformer Group

Burden : ≥10VA cl 5P10

Self-consumption : ≤3VA

Adapting transformers must be mounted as close as possible to the relay.

2.7 - CLOCK AND CALENDAR

The unit features a built in clock calendar with Years, Months, Days, Hours, Minutes, Seconds, Tenths of seconds and Hundredths of seconds.

2.7.1 - 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 10th, 98, then the clock is set to 20:00:00 January the 10th, 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 10th 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.

2.7.2 - 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.

2.7.3 - 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.

2.7.4 - 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.

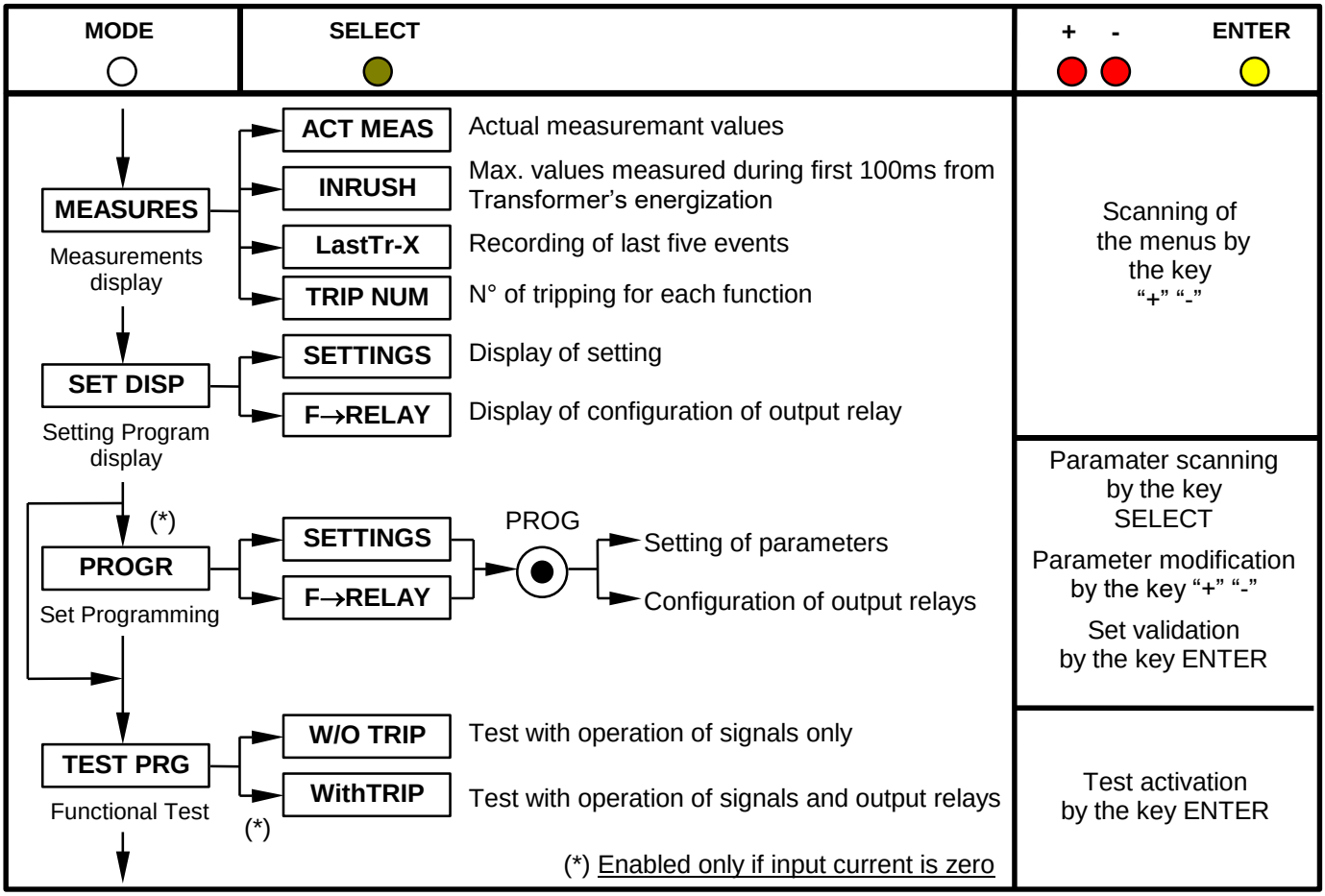
2.7.5 - Time tolerance.

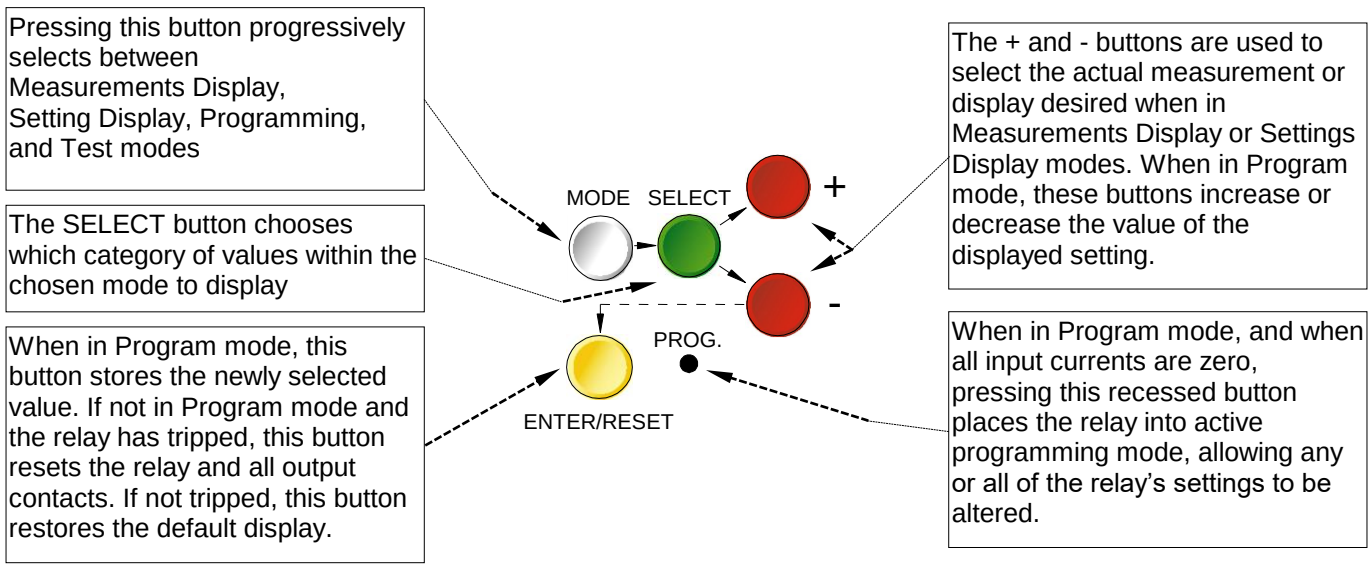
During power on, time tolerance depends on the on board crystal (+/-50ppm typ, +/-100ppm max. over full temperature range).
During power off, time tolerance depends on the RTC's oscillator (+65 /–270 ppm max over full temperature range).

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)

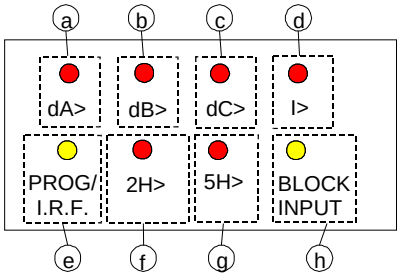
FIG.1





4. SIGNALIZATIONS

Eight signal leds (normally off) provide the following information:



a)	Red LED	**dA>**	❑ Illuminated on tripping of differential elements phase A (d> and/or d>>)
b)	Red LED	**dB>**	❑ Illuminated on tripping of differential elements phase B (d> and/or d>>)
c)	Red LED	**dC>**	❑ Illuminated on tripping of differential elements phase C (d> and/or d>>)
d)	Red LED	**I>**	❑ Flashing when I1>[I>] ❑ Illuminated on tripping of the time delayed overcurrent element (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	**2H>**	❑ Illuminated when 2nd harmonic component of differential current in any phase exceeds the set level [2H]
g)	Red LED	**5H>**	❑ Illuminated when 5th harmonic component of differential current in any phase exceeds the set level [5H]
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)

a) - 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 MD33's functions.
For function **I>** both instantaneous and time delayed elements are provided.
Any relay associated to of any function picks-up as soon as the measured input value gets into the operation zone.
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
It has to be remarked that the programming structure does not allow to associate the same relay both to instantaneous and delayed elements. Therefore any relay already associated to any time delayed element cannot be associated to any instantaneous element and viceversa.

b) - The relay **R5**, normally energized, 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 a fiber optic bus for interfacing with a Personal Computer (type IBM or compatible).
All the functionalities that can be operated locally (for example reading of input measurement and changing of relay's settings) are also possible via the serial communication interface.
Furthermore the serial port allows the user to read event recording and stored 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, allowing 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 (only functions 3, 4 and 16 are implemented).
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/NT4 SP3 (or later) is available.
Please refer to the MSCOM instruction manual for more information Microelettrica Scientifica.

7. OSCILLOGRAPHY RECORDS

The relay continuously records in a buffer the samples of the six input phase currents and the residual zero sequence current.
The buffer contains samples for approximately 12 periods.
Recording is stopped after approximately 6 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 6 cycles before and 6 cycles after the trigger instant.
The trigger can be operated either internally on tripping of any function d>, d>>, I>, or externally by activation of the digital input B3.
Selection between the two modes is made by programming the variable **TRG** = d>, d>>, I>, EXT
The last two oscillography records are stored; a third trigger replaces the first of the two records.

8. DIGITAL INPUTS

Three inputs active when the relevant terminals are shorted are provided:

- **B1** (terminals 1 - 2) : For function blocking
- **B2** (terminals 1 - 3) : To activate harmonic restraint variation at inrush
- **B3** (terminals 1 - 14) : External trigger for oscillography records

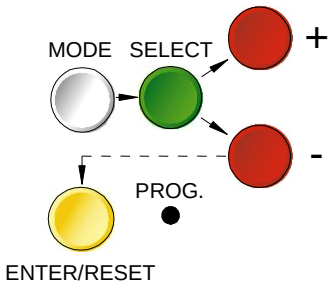
9. TEST

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.
- Dynamic functional test run during normal operation every 15 min. (relay's operation is suspended for less than ≤4 ms). If any internal fault is detected, the display shows a fault message, the Led "PROG/IRF" illuminates and the relay R5 is deenergized.
- Complete test activated by the keyboard or via the communication bus either with or without tripping of the output relays.

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 indirect 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	=	Reading of all the parameters measured and of those recorded in the 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 relay 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
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 "-" .

10.1 - ACT.MEAS

Actual values as measured during the normal operation.
The values displayed are continuously updated.

Display	Description
xxXXXxx	Date : Day, Month, Year
xx:xx:xx	Hour : Hours, Minutes, Seconds
dAxx.x**On**	R.M.S. value of differential current of phase A : (0 - 99.99) per unit of rated phase input current
dBxx.x**On**	As above phase B
dCxx.x**On**	As above phase C
1Axxxxx**A**	R.M.S. value of phase A current at relay input 25-28: (0-99999) CT's primary Amp
1Bxxxxx**A**	R.M.S. value of phase B current at relay input 26-28: (0-99999) CT's primary Amp
1Cxxxxx**A**	R.M.S. value of phase C current at relay input 27-28: (0-99999) CT's primary Amp
2Axxxxx**A**	R.M.S. value of phase A current at relay input 29-32: (0-99999) CT's primary Amp
2Bxxxxx**A**	R.M.S. value of phase B current at relay input 30-32: (0-99999) CT's primary Amp
2Cxxxxx**A**	R.M.S. value of phase C current at relay input 31-32: (0-99999) CT's primary Amp
d2Ax.xx**d**	2nd Harmonic component of differential current of phase A : (0-1.00) per unit of differential current phase A
d5Ax.xx**d**	5th Harmonic component differential current of phase A : (0-1.00) per unit of differential current phase A
d2Bx.xx**d**	2nd Harmonic component of differential current of phase B : (0-1.00) per unit of differential current phase B
d5Bx.xx**d**	5th Harmonic component differential current of phase B : (0-1.00) per unit of differential current phase B
d2Cx.xx**d**	2nd Harmonic component of differential current of phase C : (0-1.00) per unit of differential current phase C
d5Cx.xx**d**	5th Harmonic component differential current of phase C : (0-1.00) per unit of differential current phase C
IRxx.x**n**	R.M.S. value of restraint current

10.2 - INRUSH

Highest inrush values recorded within the first 100ms from Breaker closing, (updated any time the breaker closes).

Display	Description
dAxx.x**On**	Differential current of phase A : (0-99.99) per unit of rated phase input current
dBxx.x**On**	As above phase B
dCxx.x**On**	As above phase C
1Axx.x**On**	Current of phase A at relay input 25-28 : (0-9.99) p.u. of phase input current
1Bxx.x**On**	Current of phase B at relay input 26-28 : (0-9.99) p.u. of phase input current
1Cxx.x**On**	Current of phase C at relay input 27-28 : (0-9.99) p.u. of phase input current
2Axx.x**On**	Current of phase A at relay input 29-32 : (0-9.99) p.u. of phase input current
2Bxx.x**On**	Current of phase B at relay input 30-32 : (0-9.99) p.u. of phase input current
2Cxx.x**On**	Current of phase C at relay input 31-32 : (0-9.99) p.u. of phase input current
d2Ax.xx**d**	2nd Harmonic component of differential current of phase A : (0-1.00) per unit of differential current phase A
d5Ax.xx**d**	5th Harmonic component differential current of phase A : (0-1.00) per unit of differential current phase A
d2Bx.xx**d**	2nd Harmonic component of differential current of phase B : (0-1.00) per unit of differential current phase B
d5Bx.xx**d**	5th Harmonic component differential current of phase B : (0-1.00) per unit of differential current phase B
d2Cx.xx**d**	2nd Harmonic component of differential current of phase C : (0-1.00) per unit of differential current phase C
d5Cx.xx**d**	5th Harmonic component differential current of phase C : (0-1.00) per unit of differential current phase C

10.3 - LASTTRIP

Display of the function which caused the tripping of the relay plus values of the parameters at the moment of tripping. The memory buffer is refreshed at each new relay tripping.

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: **dA>,dB>,dC>,dA>>,dB>>,dC>>,I>**
dAxx.x**On**	Differential current phase A
dBxx.x**On**	Differential current phase B
dCxx.x**On**	Differential current phase C
1Axx.x**On**	Current of phase A at relay input 25-28 : (0-99.9) p.u. of phase input current
1Bxx.x**On**	Current of phase B at relay input 26-28 : (0-99.9) p.u. of phase input current
1Cxx.x**On**	Current of phase C at relay input 27-28 : (0-99.9) p.u. of phase input current
2Axx.x**On**	Current of phase A at relay input 29-32 : (0-99.9) p.u. of phase input current
2Bxx.x**On**	Current of phase B at relay input 30-32 : (0-99.9) p.u. of phase input current
2Cxx.x**On**	Current of phase C at relay input 31-32 : (0-99.9) p.u. of phase input current
d2Ax.xx**d**	2nd Harmonic component of differential current of phase A : (0-1.00) per unit of differential current phase A
d5Ax.xx**d**	5th Harmonic component differential current of phase A : (0-1.00) per unit of differential current phase A
d2Bx.xx**d**	2nd Harmonic component of differential current of phase B : (0-1.00) per unit of differential current phase B
d5Bx.xx**d**	5th Harmonic component differential current of phase B : (0-1.00) per unit of differential current phase B
d2Cx.xx**d**	2nd Harmonic component of differential current of phase C : (0-1.00) per unit of differential current phase C
d5Cx.xx**d**	5th Harmonic component differential current of phase C : (0-1.00) per unit of differential current phase C

10.4 - 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
dA> xxxx	Low set differential element phase A
dB> xxxx	Low set differential element phase B
dC> xxxx	Low set differential element phase C
dA>>xxxx	High set differential element phase A
dB>>xxxx	High set differential element phase B
dC>>xxxx	High set differential element phase C
I>xxxx	Overcurrent element

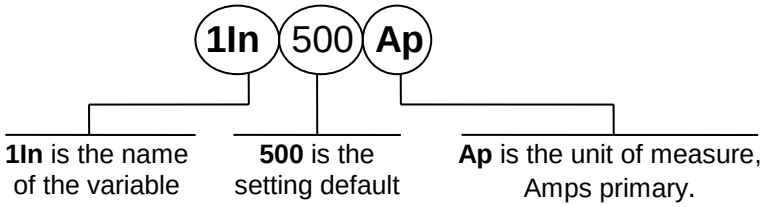
12. READING OF PROGRAMMED SETTINGS AND RELAY'S CONFIGURATION

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 which can be disclosed on request only.
As soon as programming is enabled, the Led PRG/IRF flashes and the reclosing lock-out 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
1In 500**A**	Rated primary current of Cts on Transformer's side 1	1 - 9999	1	A
2In 500**A**	Rated primary current of Cts on Transformer's side 2	1 - 9999	1	A
1V 1.00**kV**	Rated voltage of Transformer's side 1 (phase to phase voltage)	0.20 - 380	0.01	kV
2V 1.00**kV**	Rated voltage of Transformer's side 2 (phase to phase voltage)	0.20 - 380	0.01	kV
α Yd1	Transformer connection and vector group	Yd1…….	see § 2.2.1	
d> 0.15**n**	Basic minimum pick-up level of low set phase differential element	0.10-0.50-Dis	0.01	In
d>>10.0**n**	Basic minimum pick-up level of high set phase differential element	2.0-17.0-Dis	0.01	In
R 20**%**	Bias percentage	10-50	1	%
2H 0.15**d**	2nd harmonic restraint level (p.u. of measured differential current)	0.10-0.30-Dis	0.01	d
5H 0.30**d**	5th harmonic restraint level (p.u. of measured differential current)	0.20-0.40-Dis	0.01	d
R2H 1.00	Reduced 2nd harmonic restraint level during the time tH from Transformator switch-on	0.50-1.00	0.01	p.u. 2H
R5H 1.00	Reduced 5th harmonic restraint level during the time tH from Transformator switch-on	0.50-1.00	0.01	p.u. 5H
tH 0.50**s**	Time during which harmonic restraint level's reduction is active	0.01-90.00	0.01	s
I> 0.10**In**	Minimum pick-up level of overcurrent element	0.5-20-Dis	0.1	1In
tI> 0.50**s**	Time delay of overcurrent element	0.05-9.99	0.01	s
BI>: OFF	Overcurrent element can be blocked during tH (BI>=ON) or active (BI>=OFF)	ON-OFF	-	-
B1	Digital input B1 blocks the function selected (dL=d> - dH=d>>)	dL - dH – I>	Any combination	
Trg: d>	Trigger for oscillography records is Internal or External via digital input B3	d> - d>> I> - EXT		-
Tsyn Dis **m**	Synchronisation Time Expected time interval between sync. pulses.	5 - 60 - Dis	5-10 15-30 60-Dis	m
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---	Low set differential element	operates relay R1, R2, R3, R4 as programmed (one or more)
d>>	-2--	High set differential element	operates relay R1, R2, R3, R4 as programmed
I>	--3-	Instantaneous overcurrent element	operates relay R1, R2, R3, R4 as programmed
tI>	---4	Time delayed overcurrent element	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 (dAxx.xxn).
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 – RINA – UL and CSA approval File : E202083
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			

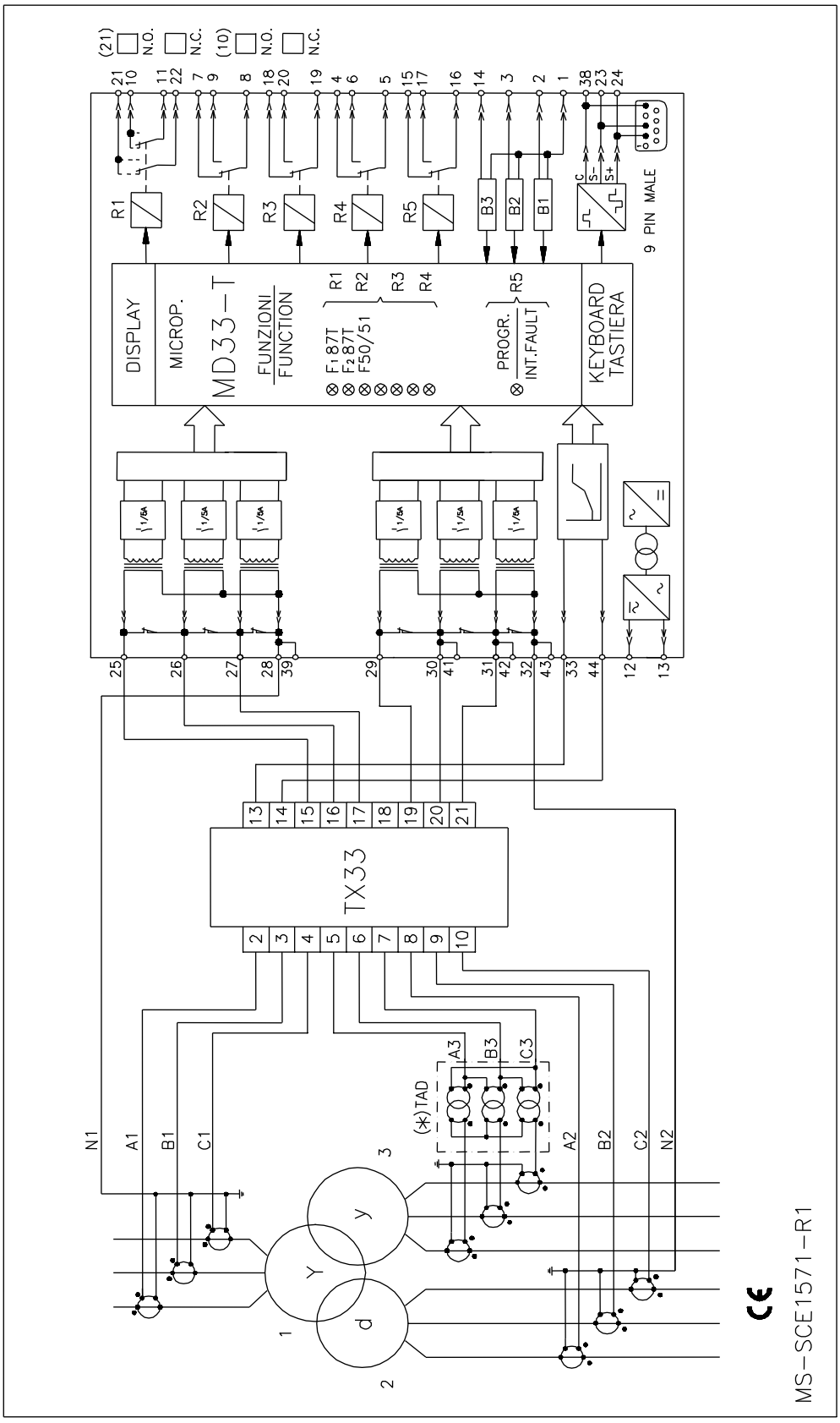
CHARACTERISTICS

❑	Accuracy at reference value of influencing factors	2% In for measure 2% +/- 10ms for times
❑	Rated Current	In = 1 or 5A
❑	Current overload	200 A for 1 sec; 10A continuous
❑	Burden on current inputs	Phase : 0.03VA at In = 1A; 0.5VA at In = 5A
❑	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.)

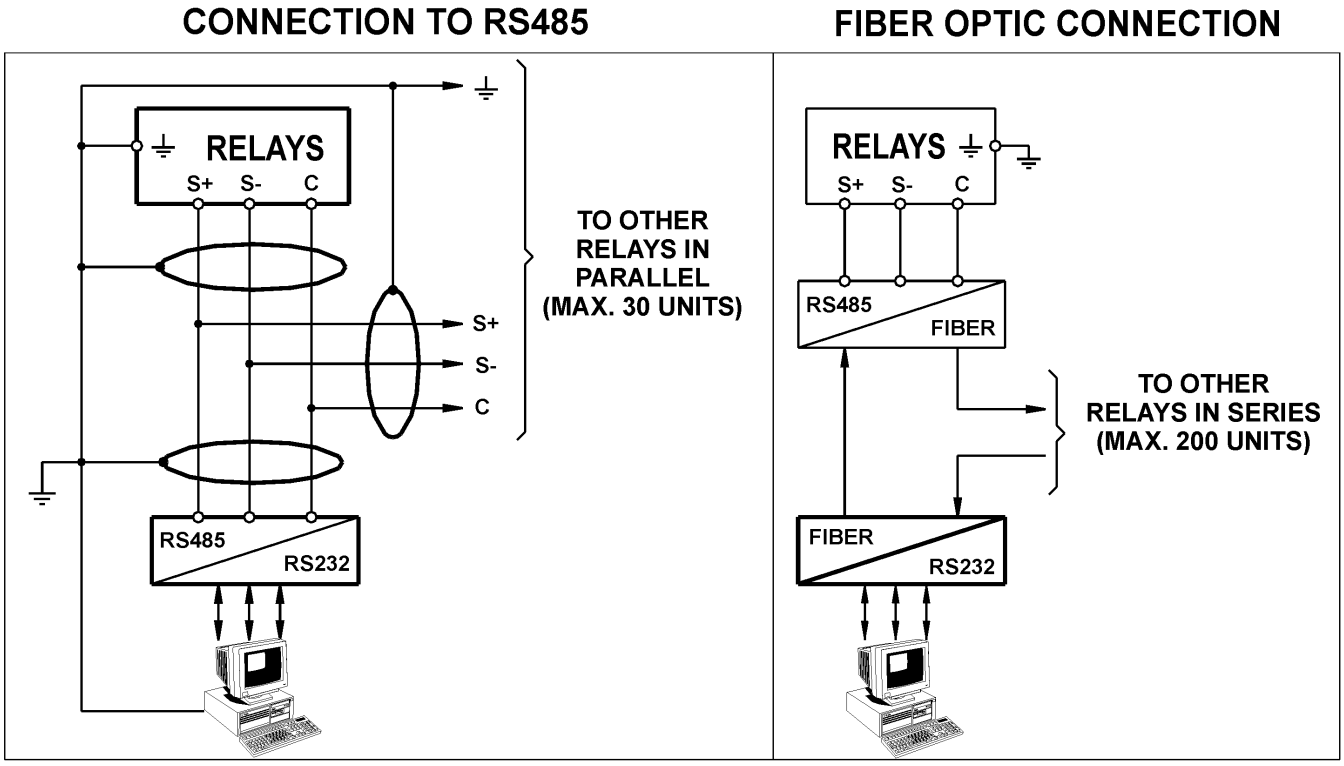
Microelettrica Scientifica S.p.A. - 20089 Rozzano (MI) - Italy - Via Alberelle, 56/68
Tel. (##39) 02 575731 - Fax (##39) 02 57510940
http://www.microelettrica.com **e-mail :** ute@microelettrica.com

The performances and the characteristics reported in this manual are not binding and can modified at any moment without notice

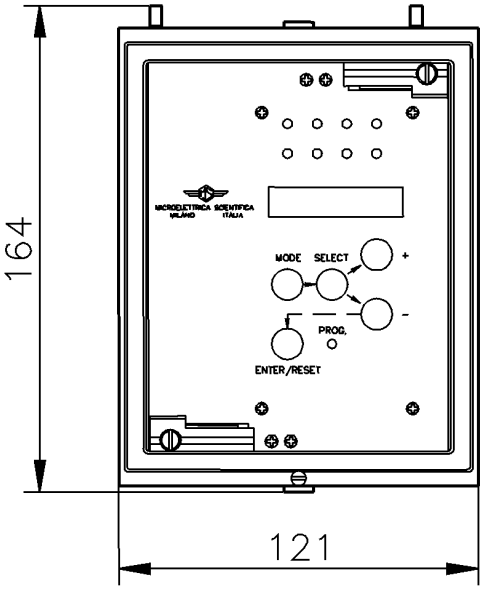
18. CONNECTION DIAGRAM (SCE1571 Rev.1)



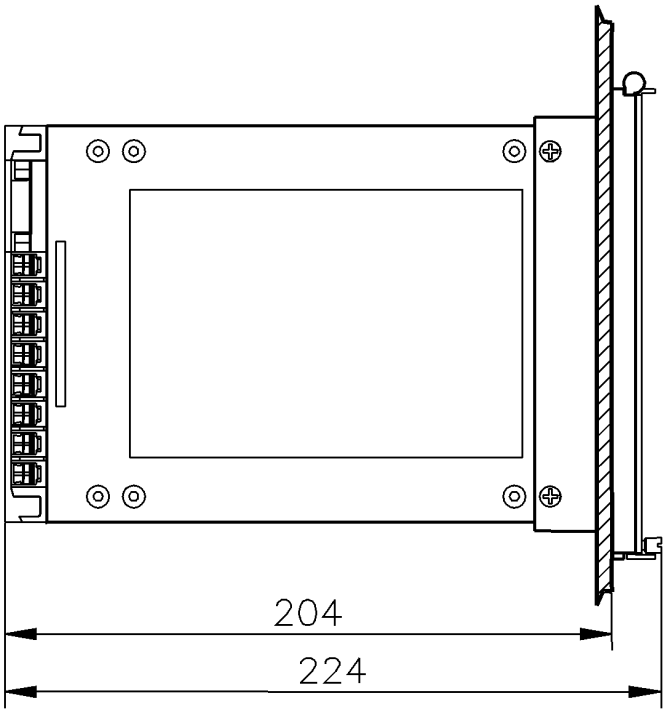
19. WIRING THE SERIAL COMMUNICATION BUS (SCE1309 Rev.0)

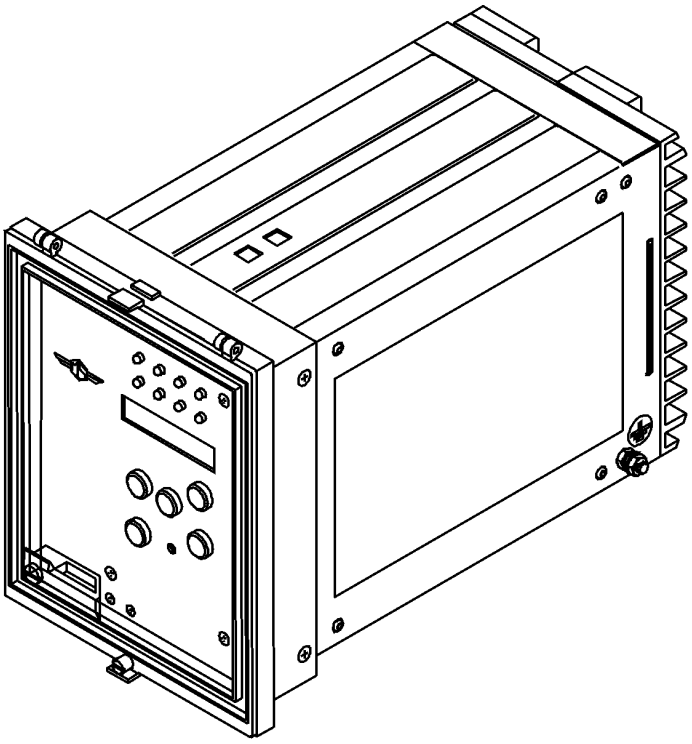


20. OVERALL DIMENSIONS

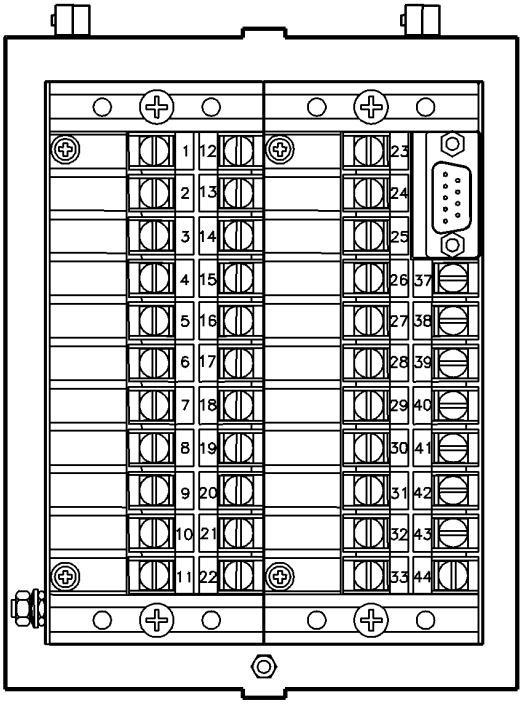


PANEL CŪT OUT 113x142 (LxH)





View of Rear Terminal Connection



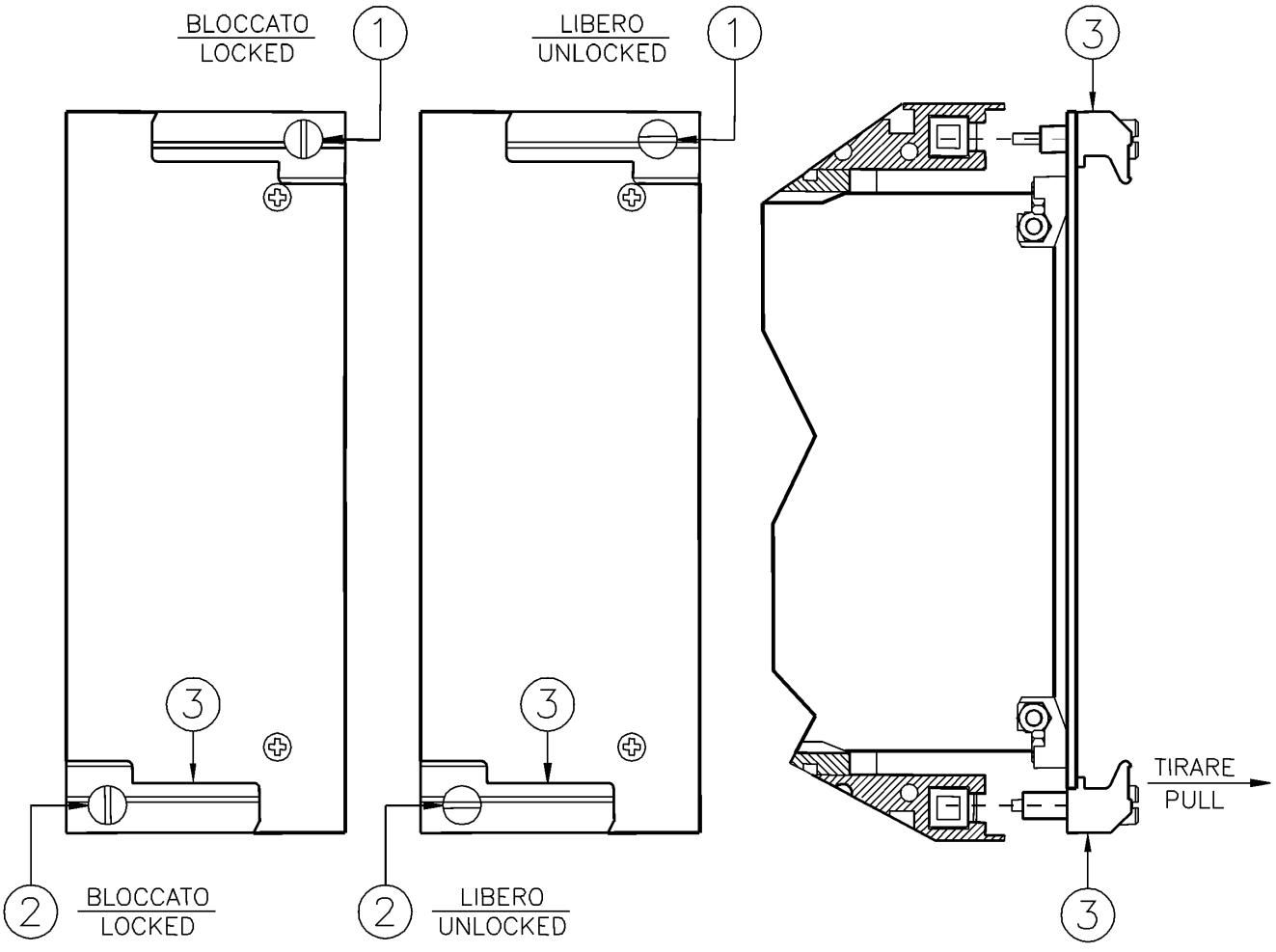
21. DIRECTION FOR PCB'S DRAW-OUT AND PLUG-IN

21.1 - Draw-out

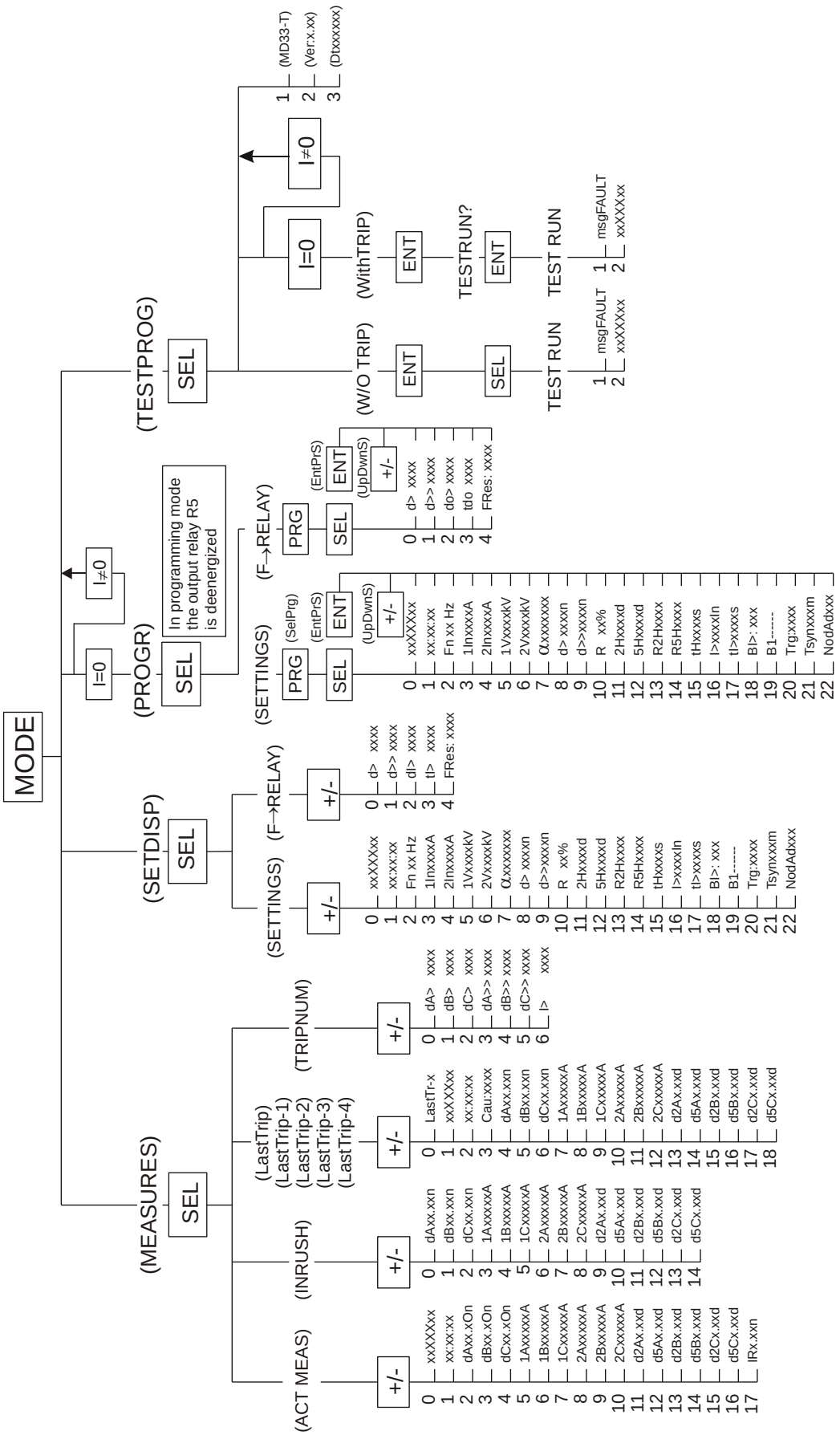
Rotate clockwise the screws ① and ② in the horizontal position of the screws-driver mark.
Draw-out the PCB by pulling on the handle ③

21.2 - 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).



22. KEYBOARD OPERATIONAL DIAGRAM



23. SETTING'S FORM

Relay Type	**MD33-T**	**Station :**	**Circuit :**
Date :	**/ /**	**FW Version:**	**Relay Serial Number :**
Power Supply	☐ 24V(-20%) / 110V(+15%) a.c.	24V(-20%) / 125V(+20%) d.c.	**Rated Current :** ☐ **1A** ☐ **5A**
	☐ 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	Reset
xxxxxxx	Current date	DDMMMYY	**-**	random			
xx:xx:xx	Current time	HH:MM:SS	**-**	random			
Fn	System frequency	50 - 60	**Hz**	50			
1In	Rated primary current of Cts on Transformer's side 1	1 - 9999	**A**	500			
2In	Rated primary current of Cts on Transformer's side 2	1 - 9999	**A**	500			
1V	Rated voltage of Transformer's side 1	0.20 - 380	**kV**	1.00			
2V	Rated voltage of Transformer's side 2	0.20 - 380	**kV**	1.00			
α	Transformer connection and vector group	Yd1…….	-	Yd1			
d>	Basic min. pick-up level of low set phase diff. element	0.10-0.50-Dis	**n**	0.15			
d>>	Basic min. pick-up level of high set phase diff. element	2.0-17.0-Dis	**n**	10.0			
R	Bias percentage	10-50	**%**	20			
2H	2nd harmonic restraint level	0.10-0.30-Dis	**d**	0.15			
5H	5th harmonic restraint level	0.20-0.40-Dis	**d**	0.30			
R2H	Reduced 2nd harmonic restraint level	0.50-1.00	-	1.00			
R5H	Reduced 5th harmonic restraint level	0.50-1.00	-	1.00			
tH	Time during which harmonic restraint level's	0.01-90.00	**s**	0.50			
I>	Minimum pick-up level of overcurrent element	0.5-20-Dis	**In**	0.10			
tI>	Time delay of overcurrent element	0.05-9.99	**s**	0.50			
BI>:	Overcurrent element can be blocked during tH	ON-OFF	-	OFF			
B1	Digital input B1 blocks the function selected	dL - dH – I>	-	-			
Trg:	Trigger for oscillography records	d> - d>> I> - EXT	-	d>			
Tsyn	Synchronisation Time	5 - 60 - Dis	**m**	Dis			

CONFIGURATION OF OUTPUT RELAYS

Default Setting						Actual Setting					
Protect. Element	**Output Relays**				**Description**	**Protect. Element**	**Output Relays**				
d>	1	-	-	-	Low set differential element	**d>**					
d>>	-	2	-	-	High set differential element	**d>>**					
I>	-	-	3	-	Instantaneous overcurrent element	**I>**					
tI>	-	-	-	4	Time delayed overcurrent element	**tI>**					
FRes:	Aut.				Reset of output relays after tripping is: **Aut.** = Automatic **Man.** = Manually	**FRes:**					

Commissioning Engineer : _____ **Date :** _____

Customer Witness : _____ **Date :** _____