# MULTIFUNCTION MICROPROCESSOR
# PROTECTION RELAY
# TYPE IM3G-V

# OPERATION MANUAL



| | | | | |
|---|---|---|---|---|
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# 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 AND OPERATION

Input currents are supplied to 3 current transformers and 3 potential transformers respectively measuring phase currents and phase-to-neutral voltages. Phase current input can be 1 or 5A (movable jumpers an relay’s card). Rated voltage input can be programmed from 100 to 125V (phase-to-phase) 50 or 60Hz.
Time-current curves, operation algorithms and performances are reported in relay catalogue and in this manual together with diagrams and dimension drawings.
Make electric connection in conformity with the diagram reported on relay's enclosure.
Check that input quantities are same as reported on the diagram and on the test certificate.
The auxiliary power is supplied by a built-in interchangeable module fully isolated an self protected

**2.2** 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 energizing the unit check that supply voltage is within the allowed limits.

**2.2** Measuring input

The relay computes the RMS value of current and voltage and the relevant phase displacement.

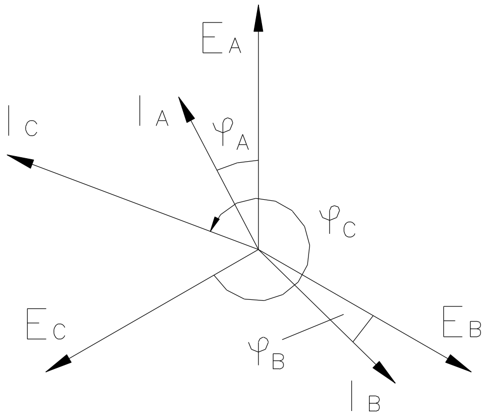
**2.2.1** Phase currents are supplied to three current transformers with 5A rated primary. By movable jumpers on the relay card, the secondary can be switched-on to two different taps to obtain a relay rated input current In = 5 or 1 Amp (different values can be provided on request).
The measuring dynamics of the C.Ts. runs from 0.001 through 50 times In.
For the phase current the measuring range of the A/D Converters runs from 0 to 13In automatically switched to two channels one measuring from 0 to 1.3In and the second from 0 to 13In. The theoretical accuracy of the measurement is 0.12%In from 0 to 1.3In and 1.2%In from 1.3 through 13In.
The actual absolute error on each measurement M can be:

- $\varepsilon_1 = \pm 0.02\ M \pm 0.002\ In$ from 0 to 1.3 In
- $\varepsilon_2 = \pm 0.02\ M \pm 0.02\ In$ from 1.3 to 13 In

**2.2.2** Phase-to-neutral voltages are supplied to three Potential transformers rated 220V. Relay's rated phase-to-phase input voltage (Uns) can be adjusted from 100 through 125V.
The ADC converter measuring range runs up to 2 x Uns.
The theoretical accuracy is 0.2%Uns.
The actual absolute error can be :

- $\varepsilon_v = \pm 0.02\ M \pm 0.003\ Uns$

**2.2.3** Phase displacement
The relay detects the displacement between the input voltage of phase C and each phase current IA, IB, IC. The displacement angle are therefore :




$\varphi_A = \varphi_{A\text{-}C} - 120°$ ; $\varphi_B = \varphi_{B\text{-}C} + 120°$ ; $\varphi_C = \varphi_{C\text{-}C}$

This means that the voltage system is considered to be balanced as it is normally, where as the currents can be however unbalanced. (see figure)
Angles are measured anticlockwise from 0° to 360° with accuracy ±2°.
Displacement is not measured if current or voltage are null.

## 2.3 Algorithms of the different functions

### 2.3.1 Setting range of the reference input quantities :

- System frequency : **Fn** = (50-60)Hz
- Rated primary current of phase C.Ts. : **In** = (0-9999)A, step 1A
- Rated secondary phase-to-phase voltage of P.Ts. : **Uns** = (100-125)V, step 1V
- Relay basic current (Generator's rated current) : **Ib** = (0.5-1.1)In, step 0.1In

### 2.3.2 **F49** - Thermal overload

The relay computes a thermal image of the machine based on the ratio I/[Ib] of the RMS of the current flowing in each phase to the rated full load current of the generator :

- Warming-up time constant : **Tc** = (2 - 400)m, step 1m
- Maximum continuous overload : **Ic** = 1.05Ib (≡110%Tn)
- Rated full load (I=Ib) temperature rise : **Tn**
- Overtemperature prealarm level : **Ta** = (50-110)% Tn, step 1%
- Current corresponding to machine's temperature before the overload : **Ip** (≡√Tp)
- Time to warm-up from Tp to trip temperature (110%Tn) in function of the current overload

$$t = [Tc]\ln\frac{(Tx / Tn) - (Tp / Tn)}{(Tx / Tn) - (Tb / Tn)} = [Tc]\ln\frac{(I / [Ib])^2 - (Ip / [Ib])^2}{(I / [Ib])^2 - (Ib / [Ib])^2}$$

(see curves TU0325 §20)

Cooling is computed with the same time constant (Tc) as heating.

### 2.3.3 **F50/51** - Dual level 3-phase overcurrent with or without voltage control

**F1 50/51** : Low set overcurrent

- Voltage control activated / non activated : I>/U = ON-OFF

- Pick-up (operation) level : **I>** = (1-2.5)Ib, step 0.01Ib
  Setting **I>** = Dis blocks function's operation

- Drop-out ratio ≥0.95

- Minimum operation time of instantaneous output 30ms

- Trip time delay in the definite time operation mode **F(I>) = D** :
  t = **tI>** = (0.05-30)s, step 0.01s

- Trip time delay in the inverse time operation mode **F(I>) = SI :**

$$t = \frac{0.033 \cdot tI>}{(I/I>)^{0.02} - 1} \quad ; \qquad (tI> = \text{trip time delay at } I/I> = 5)$$

(see curves TU0311 §18)

**F2 50/51** : High set overcurrent

- Voltage control activated / non activated : I>>/U = ON-OFF

- Pick-up (operation) level : **I>>** = (1-12)Ib, step 0.1Ib
  Setting **I>>** = Dis blocks function's operation

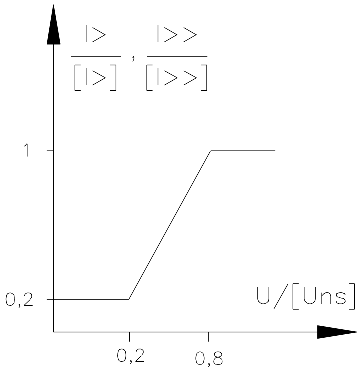
- Drop-out ratio ≥0.95

- Minimum operation time 30ms

- Independent trip time delay : t = **tI>>** = (0.05-3)s, step 0.01s

**2.3.4** Voltage controlled overcurrent

If the parameters I>/U and/or I>>/U are set to "ON" the voltage controls is active respectively for the level I> and/or I>>. The actual pick-up levels (I>,I>>) variate in respect to the programmed levels ([I>] , [I>>]) proportionally to variation of the voltage according to the curve herbelow




$$\frac{I>}{[I>]},\frac{I>>}{[I>>]}=\frac{\text{Actual pick-up level}}{\text{[Set pick-up level]}}$$

$$\frac{U}{[Uns]}=\frac{\text{Actual voltage}}{\text{[Rated input voltage]}}$$

The voltage ratio is measured on each phase $\left(\frac{Ex\cdot\sqrt{3}}{[Uns]}\right)$ and the smallest among the values is used in the algorithm. Practically in the zone between 0.2 and 0.8 Uns, the relay operates as underimpedance protection when $Zx=\frac{Ex}{Ix}<\frac{[Uns]}{\sqrt{3}[I>]},\frac{[Uns]}{\sqrt{3}[I>>]}$.

**2.3.5** **F46** - Current unbalance : Measurement of RMS Negative Sequence Current $I_2$

- **F1 46** : $I_2^2\ t = K$ (adiabatic heating)

- Generator's continuous $I_2$ rating : **1Is** = (0.05-0.5)Ib, step 0.01Ib

  Setting **1Is** = Dis blocks function's operation

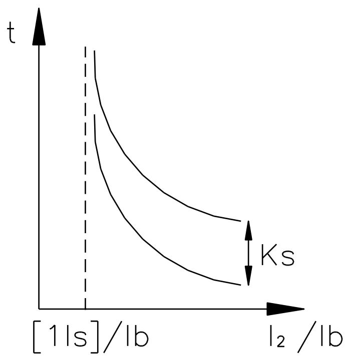
- Time multiplier : **Ks** = (5-80)s, step 1s ; **Ks** = Trip time when $I_2 = I_b$

- Trip time delay $t_h=\frac{Ks}{(I_2/I_b)^2}$ ; Heat accumulation only operates if $I_2 \geq [1Is]$

- Cooling time from trip level to the status corresponding to the operation at $I_2$=[1Is] :
  **tcs** = (10-1800)s, step 1s

  Cooling time $t_1=\frac{[tcs]}{Ks}\left(\frac{I_2}{I_b}\right)^2\cdot t$ ; $t_1$ = [tcs] when $\left(\frac{I_2}{I_b}\right)^2\cdot t = Ks$

  Cooling only takes places if $\frac{I_2}{I_b}<1Is$




(see curves TU0312 §19)

**F2 46** : Umbalance Alarm

- Alarm level : **2Is** = (0.03-1)Ib, step 0.01Ib

- Setting **2Is** = Dis blocks function's operation

- Independent trip time delay : **t2Is** = (1-100)s, step 1s

### 2.3.6 <u>F32 - Reverse active power</u>

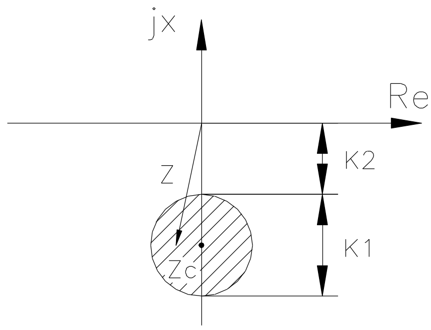
- Active current (I cos φ) setting range : **Ir** = (0.02-0.2)In, step 0.01In
  Setting **Ir** = Dis blocks function's operation
- Operation level : Ic cos (φc-180°) ≥ [Ir]
- Independent trip time delay : **tIr** = (0.1-60)s, step 0.1s
- Operation zone : 90°<φc<270°

### 2.3.7 <u>F37 - Underpower W<</u>

The element measures the 3-phase active power and trips when the power generated (forward) drops below the set level [W<]

- Pick-up (operation) level : W< = (0.05-1.00)Wb, step 0.05Wb
  Setting **W<** = Dis blocks function's operation
- Independent trip time delay : **tW<** = (0.1-60)s, step 0.1s

### 2.3.8 <u>F40 - Loss of excitation : capacitive underimpedance Zc<</u>




- For each phase the relay computes the impedance

$$Zc_x = \frac{E_x}{I_x \cos(\varphi_x - 90°)}$$

- Characteristics angle of the impedance $\alpha_Z$ = 270°

N.B. By definition the relation between current displacement φ and impedance displacement α is :

α = 360°- φ
Angles are counted anticlockwise from 0° (real axis = direction of phase-to-neutral voltage E) through 360°.
For example : the displacement of a totally capacitive current is φ = 90°;
the angle of a totally capacitive impedance is α = 270°.

- Operation zone is that included in the circle having (see figure) :

Center on the axle displaced by $\alpha_Z$ at distance $K2 + \frac{K1}{2}$ from the axles' origin and Diameter = K1

- Circle offset : **K2** = (5-50)%Zb, step 1%

- Circle diameter : **K1** = (50-300)%Zb, step 1%
  Setting **K1** = Dis blocks the function's operation

- rated generator's impedance : $Zb = \frac{[Uns]}{\sqrt{3}\,[Ib]}$

- Independent trip time delay : **tz** = (0.2-60)s, step 0.1s

- Integration time : **ti** = (0-10)s, step 0.1s
  In case of impedance oscillation,reset of the timer tz only takes place if Z remains outside the trip area for at least [ti].

- Undervoltage inhibition level : $Ex<0.3\frac{[Uns]}{\sqrt{3}}$

- Undercurrent inhibition level : Ix<0.2[Ib]

- Operation taxes place only if all the 3 impedances of phase A, B, C are within the trip zone

### 2.3.11 F27-59 : Dual level 3-phase over-under voltage

**F1 27-59** : First voltage element 1U

- Pick-up (operation) level of voltage difference : **1u** = (5-50)%Un, step 1%

- Independent trip time delay : **t1u** = (0.1-60)s, step 0.1s

- Operation mode : (Un **+/-** 1u)
  The function can be programmed to operate as :

- Overvoltage (Un **+** 1u) : operates when any phase voltage $E_x$ rises above the rated value $\frac{[Uns]}{\sqrt{3}}$
  by more than [1u]%. $$\frac{\sqrt{3}\cdot Ex}{[Uns]}\cdot 100 \geq (100+[1u])\%$$

- Undervoltage (Un **-** 1u) : operates when any phase voltage $E_x$ drops below the rated value $\frac{[Uns]}{\sqrt{3}}$
  by more than [1u]%. $$\frac{\sqrt{3}\cdot Ex}{[Uns]}\cdot 100 \leq (100-[1u])\%$$

- Voltage balance (Un **+/-** 1u) : operates when any phase voltage differs from the rated value more then [1u]%

$$\frac{\sqrt{3}\cdot Ex}{[Uns]}\cdot 100 \geq (100+[1u])\% \text{ or } \frac{\sqrt{3}\cdot Ex}{[Uns]}\cdot 100 \leq (100-[1u])\%$$

- Operation blocked : (Un = Dis)

**F2 27-59** : Second voltage element 2U

It operates same as the first element the programmable parameter are :

- Pick-up level : **2u** = (5-50)%Un, step 1%

- Independent trip time delay : **t2u** = (0.1-60)s, step 0.1s

- Operation mode : (Un **+/-** 2u)

**2.3.12 F81** : Dual level over/under frequency

**F1 81** : First frequency element 1f

- Pick-up (operation) level of frequency difference : **1f** = (0.05-9.99)Hz, step 0.01Hz

- Independent trip time delay : **t1f** = (0.1-60)s, step 0.1s

- Operation mode : (Fn **+/-** 1f)

The function can be programmed to operate as :

- Overfrequency (Fn **+** 1f) : operates when the frequency rises above the rated value [Fn] by more than 1f Hz. f ≥ (Fn+[1f])Hz

- Underfrequency (Fn - 1f) : operates when the frequency drops below the rated value [Fn] by more than [1f]Hz. f ≤ (Fn-[1f])Hz

- Frequency balance (Fn **+/-**1f) : operates when frequency differs from rated value by more than [1f]Hz. f ≥ (Fn+[1f])Hz or f ≤ (Fn-[1f])Hz

- Operation blocked : (Fn = Dis)

**F2 F81** : Second frequency element 2f

It operates same as the first element ; the programmable parameters are :

- Pick-up level : **2f** = (0.05-9.99)Hz, step 0.01Hz

- Independent trip time delay : **t2f** = (0.1-60)s, step 0.1s

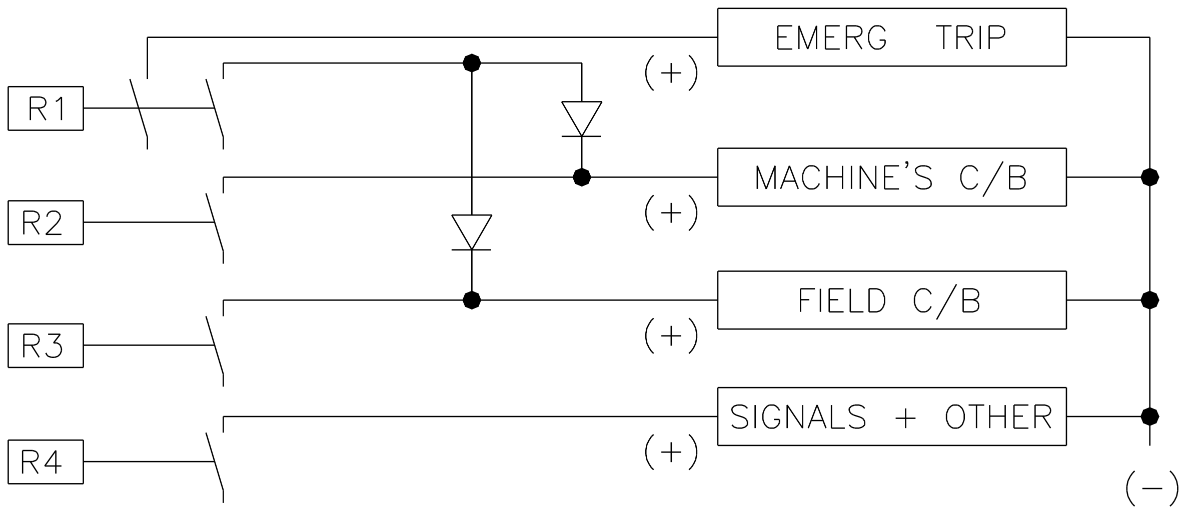
- Operation mode : (Fn **+/-** 2f)

## 2.4 Configuration of the output relay (see § 5)

The different functions of the relay can be programmed to operate any of the output relays as explained in § 5.
The functions are more than the available output relays but some of then can be grouped to operate the same relay according to the tripping system's.
For generator protection, the different functions normally operate the trippings shown in the tabel here below.

| PROTEC. FUNCTION | DEVICE OPERATED | | | | OUTPUT RELAY CONTROLLED | | | |
|---|---|---|---|---|---|---|---|---|
| | EMERG. TRIP | MACHINE C/B | FIELD C/B | SIGNALS OR OTHER | R1 | R2 | R3 | R4 |
| 27 = 1U | | | | (X) | | | | (X) |
| 32 = Ir> | | X | X | | | X | X | |
| 37 = W< | | | | (X) | | | | X |
| 40 = Zc< | | X | | | | X | | |
| 46-1 = 1Is | | X | | X | | X | | |
| 46-2 = 2Is | | (X) | | | | | | X |
| 49 = T> | | (X) | | X | | (X) | | X |
| 49A = Ta | | | | | | | | X |
| 50-1 = I> | | | | (X) | | | | (X) |
| 50-2 = I>> | | | | (X) | | | | (X) |
| 51-1 = tI> | X | X | X | | X | | | |
| 51-2 = tI>> | X | X | X | | X | | | |
| 59 = 2U | | X | X | | | X | X | |
| 81> = 1f | (X) | | | | (X) | | | (X) |
| 81< = 2f | | | (X) | | | | | (X) |

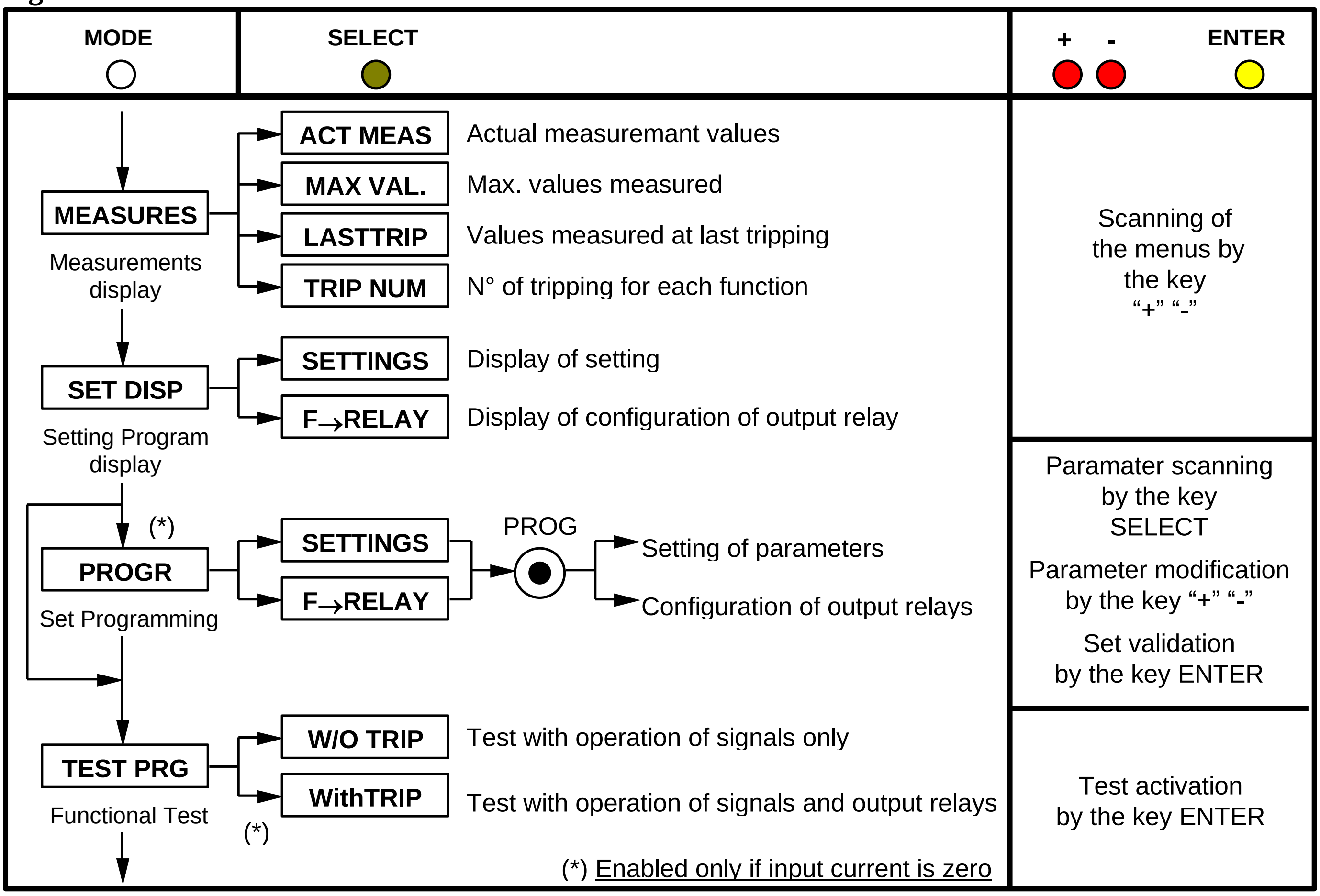
(X) = if required ; X = needed

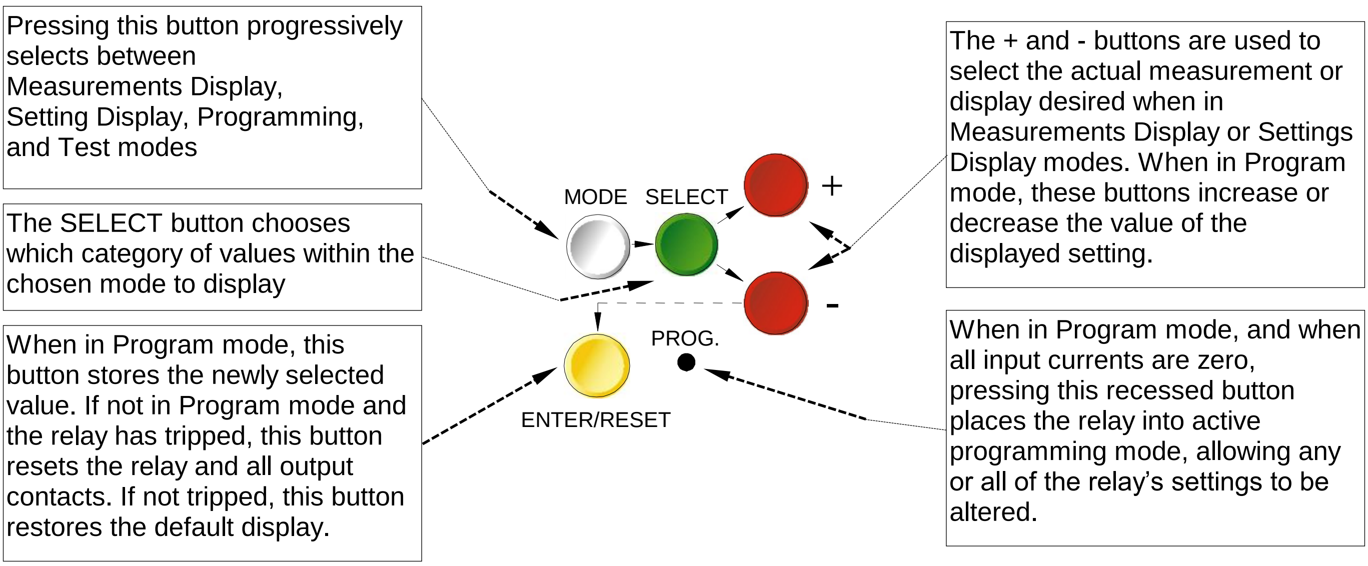


## 3. CONTROLS AND MEASUREMENTS

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

**Fig.1**



## 4.SIGNALIZATIONS

Eight signal leds (normally off) are provided:

a) Red LED **I>->>** : - Flashing when measured current exceeds the set trip level [I>],[I>>]
- Illuminated on trip after expiry of the set trip time delay [tI>],[tI>>].

b) Red LED **$I_2$>** : - Same as above related to [1Is], [2Is].

c) Red LED **T>** : - Flashing when the thermal image’s temperature exceeds the prealarm temperature [Ta].
- Illuminated when temperature exceeds the trip level.

d) Red LED **U,f** : - Flashing during the trip time delay of any over/under voltage elements 1U,2U or over/under frequency elements 1f,2f.
- Illuminated on trip at the end of time delay.

e) Red LED **Z<** : - Flashing during the trip time delay of the function $Z_c$<.
- Illuminated on trip at the end of time delay

f) Yellow LED **PROG/IRF** : - Flashing during the programming of the parameters.
- Illuminated in case of Internal Relay Fault.

g) Red LED **W** : - Flashing during the trip time delay of the functions W< or Ir>.
- Illuminated at the end of the time delay of either W< or Ir>.

h) Yellow LED **BI/BF** : - Lit-on when the Breaker Failure functions operated
- Flashing when a blocking signal is present at the relevant input terminals.

**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 via serial bus command 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 (energised on trip): these output relays are user programmable and any of them can be associated to one of the IM3G-V's functions.
One relay eventually associated to the instantaneous element of one of the functions, after pick-up normally drops-out as soon as the tripping cause disappears (current below the set trip level).
If the current remains above the trip level longer than the time delay programmed for the relevant function, the drop-out of the instantaneous relay is anyhow forced after an adjustable waiting time [tBF].(Diasactivation of the blocking output eventually used to block a relay upstream in the distribution system).
Moreover any of the relays R1,R2,R3,R4, can be programmed to be energised at the end of the delay tBF(Breaker Failure function)
Reset of the output relays associated to any time delayed function can be programmed to take place “Automatically” (tFRes= A) as soon as the tripping cause has disappeared, or “Manually” (tFRes= M) only by operating the ENTER/RESET key on relay’s front or via the serial bus.
It has to be remarked that the programming structure does not allow to associate the same relay at the same time 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 energised, is not programmable and it is deenergized on:
- internal fault
- power supply failure
- during the programming

## 6. SERIAL COMMUNICATION (Optional: see relevant instruction manual)

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).
Via the communication bus all settings and commands available on relay's keyboard can be operated from the computer and viceversa all information available at relay's level can be received at computer's level.
The transmission standard is RS485 (converter 485/232 available).
Each relay is identified by its programmable address code (NodeAd) and can be called from the P.C. fitted with a WINDOWS (version 3.1 or later) program driven by the application program supplied by Microelettrica Scientifica.

## 7. DIGITAL INPUTS

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

- **2** (terminals 1 - 2) : it blocks the operation of the relays associated to the time delayed elements of the overcurrent functions (I>) or (I>>) or (I>+I>>).

- **3** (terminals 1 - 3) : it blocks the operation of the relays associated to time delayed elements relevant of the functions Under Impedance of Reverse Power : (Z<) or (Ir) or (Z<+Ir)

- **4** (terminals 1-14) : It blocks the operation of the relays associated to one or more of the functions 1U, 2U, 1f, 2f in any possible combination

When a function is blocked the pick-up of its output is inhibited. For input -2- programming allows to have the inhibition either permanent as long as the blocking input is active ($t_2$=OFF) or automatically removed after the expiry of the set trip time delay of the function involved plus additional time 2tBF ($t_2$=2tBF). By proper interconnection of the blocking inputs and blocking outputs of different relays it is possible to configurate very efficient arrangements of logic fault discrimination as well as to feature a safe and quick breaker back-up protection.

## 8. 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 10 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.

## 9. 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:

- **MEASURE** = 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 PROG : enables access to the programming.

## 10. 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 "-" .

**ACT.MEAS** = Actual values as measured during the normal operation. The values displayed are continuously refreshed.

| Display | Description |
|---|---|
| **T**xxxx**%Tn** | Actual thermal status as % of the steady full load status Tn : (0-999)% |
| **IA**xxxxx**A** | R.M.S. value of the current of phase A displayed as primary Amps. : (0 - 99999) |
| **IB**xxxxx**A** | As above, phase B |
| **IC**xxxxx**A** | As above, phase C |
| **EA**xxx**%En** | R.M.S. of phase voltage A as % of the rated voltage : (0-999)% |
| **EB**xxx**%En** | As above, phase B |
| **EC**xxx**%En** | As above, phase C |
| **φa**xxxxx° | Phase displacement of IA on EA : (0-360° anticlockwise) |
| **φb**xxxxx° | Phase displacement of IB on EB : (0-360° anticlockwise) |
| **φc**xxxxx° | Phase displacement of IC on EC : (0-360° anticlockwise) |
| **W**xxxx**%Wb** | Three phase active power as % of generator's rated power: (0-999)% (Wb=√3•Un•Ib) |
| **f**xxxxx**Hz** | System frequency : (40,00-70,00)Hz |
| **I2**xxxx**%Ib** | R.M.S. Negative sequence current as % of generator's rated current Ib |

**MAX VAL** = Maximum demand values recorded starting from 100ms after closing of main Circuit Breaker (updated any time the C/B closes)

| Display | Description |
|---|---|
| **T**xxxx**%Tn** | Thermal image status as % of full load temperature |
| **IA**xx.x**In** | Phase A current displayed as p.u. of C.Ts rated current |
| **IB**xx.x**In** | As above, phase B |
| **IC**xx.x**In** | As above, phase C |
| **I2**xxxx**%Ib** | Negative sequence current as % of generator's rated current |
| **Ir**xxxx**%Ib** | As above reverse current . (Ir=[(I•cosφ)/Ib] •100) |
| **W**xxxx**%Wb** | Active power as % of generator's rated power |

**LASTTRIP** = Display of the function which caused the tripping of the relay plus values of the parameters at the moment of tripping.

| Display | Description |
|---|---|
| **F:**xxxxxx | Function which produced the last event being displayed : **I>, I>>, Io>, 1Is, 2Is, Ir>, Z<** |
| **T**xxxx**%Tn** | Temperature of thermal image. |
| **IA**xx.x**In** | Current phase A. |
| **IB**xx.x**In** | Current phase B. |
| **IC**xx.x**In** | Current phase C. |
| **EA**xxx**%En** | Voltage phase A |
| **EB**xxx**%En** | Voltage phase B |
| **EC**xxx**%En** | Voltage phase C |
| **φa**xxxxx° | Phase displacement of current phase A |
| **φb**xxxxx° | Phase displacement of current phase B |
| **φc**xxxxx° | Phase displacement of current phase C |
| **W**xxxx**%Wb** | Three phase active power |
| **f**xxxxx**Hz** | Frequency |
| **I2**xxxx**%Ib** | Negative sequence current |

**TRIP NUM** = Counters of the number of operations for each of the relay functions.
The memory is non-volatile and can be cancelled only with a secret procedure.

| Display | Description |
|---|---|
| **T>**xxxxxx | Thermal overload |
| **I>**xxxxxx | Time delayed element of 1st O/C level [tI>]. |
| **I>>**xxxxx | As above, 2nd O/C level [tI>>]. |
| **1Is**xxxxx | As above, 1st negative sequence O/C element |
| **2Is**xxxxx | As above, 2nd negative sequence O/C element |
| **Ir>**xxxxx | As above, reverse current |
| **1U**xxxxx | As above, element 1U |
| **2U**xxxxx | As above, element 2U |
| **1f**xxxxx | As above, element 1f |
| **2f**xxxxx | As above, element 2f |
| **Z<**xxxxx | As above, loss of field element |
| **W<**xxxxx | As above, under power element |

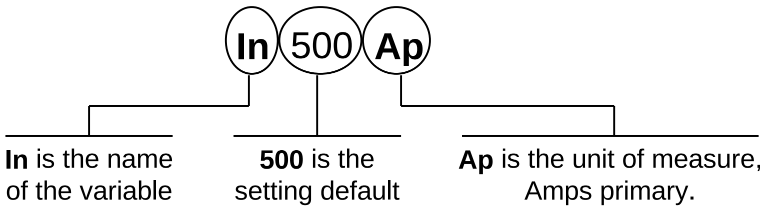
## 11. READING OF PROGRAMMED SETTINGS AND RELAY'S CONFIGURATION

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

## 12. PROGRAMMING

The relay is supplied with the standard default programming used for factory test. [ Values here below reported **( ----- )** ].
All parameters can be modified as needed in the mode PROG and displayed in the mode SET DISP
**Programming is enabled only if no input current is detected (main switch open).**
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.

### 12. 1 - PROGRAMMING OF FUNCTIONS SETTINGS




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

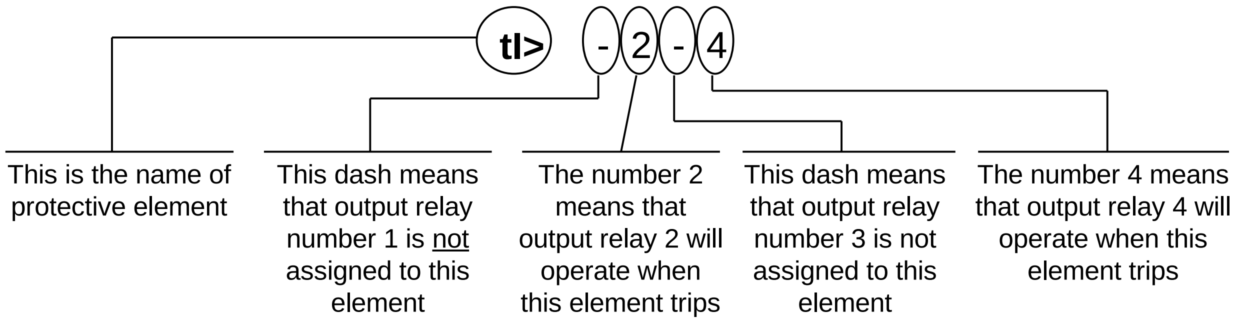
| Display | Description | Setting Range | Step |
|---|---|---|---|
| **NodAd** 1 | Identification number for connection on serial communication bus | (1 - 250) | 1 |
| **Fn** 50 **Hz** | Mains frequency | 50 - 60 Hz | - |
| **In** 500**Ap** | Rated primary current of the phase C.Ts. | (0 - 9999)A | 1A |
| **UnS** 100**V** | Rated secondary voltage of Vts (phase to phase) | (100-125)V | 1V |
| **Ib** .5**In** | Generator’s rated current as p.u. of C.Ts rated current | (0.5-1.1)In | 0.1In |
| **F(I>)** D | Operation characteristic of the low-set overcurrent element<br>D = Independent definite time.<br>SI = Dependent normal inverse time | (D - SI) | - |
| **U/I>** ON | Voltage control on level I> | (ON - OFF) | - |
| **I>** 1.0**Ib** | Trip level of low-set overcurrent element (p.u. of Ib) | (1-2.5-Dis) | 0.01Ib |
| **tI>** .05**s** | Trip time delay of the low-set overcurrent element<br>In the inverse time operation [tI>] is the trip time delay at I = 5x[I>]. | (0.05 - 30) | 0.01s |
| **U/I>>** ON | Voltage control on level I>> | (ON - OFF) | - |

| Display | Description | Setting Range | Step |
|---|---|---|---|
| **I>>** 3**Ib** | Trip level of high-set overcurrent element (p.u. of Ib) | (1 - 9.9 - Dis) | 0.1Ib |
| **tI>>** .05**s** | Trip time delay of the high-set overcurrent element | (0.05 - 3)s | 0.01s |
| **1Is** .05**Ib** | Generator's max. continuos negative sequence current rating (p.u. of Ib) | (0.05-0.5-Dis) | 0.01Ib |
| **Ks** 5**s** | Time multiplier of the $I^2t$ time-current curve | (5 - 80)s | 1s |
| **tcs** 10**s** | Cooling time from trip level to the state corresponding to $I_2$=1Is | (10-1800)s | 1s |
| **2Is** .03**Ib** | Negative sequence current alarm level | (0.03-0.5-Dis) | 0.01Ib |
| **t2Is** 1**s** | Independent trip time delay of alarm element | (1-100)s | 1s |
| **Ir>**.02**Ib** | Trip level of the reverse power element (Active component of current as p.u. of In) | (0.02-0.2-Dis) | 0.01Ib |
| **tIr>** .1**s** | Independent trip time delay of reverse power element | (0.1-60)s | 0.01s |
| **K**1300**%Zb** | Diameter of the circle including the underimpedance tripping zone | (50-300-Dis)% | 1% |
| **K**2 50**%Zb** | Offset of the circle (% of Zb=Vn/(√3 Ib)<br>**Underimpedance trip is inhibited on undervoltage U<0,3Un and undercurrent I<0,2Ib** | (5 - 50)% | 1% |
| **tz** .2**s** | Trip time delay of the underimpedance element | (0.2-60)s | 0.1s |
| **ti** .0**s** | Integration time of underimpedance element.<br>To avoid non operation in case of impedance swinging the reset of the trip time delay (tz) only takes place if the measured impedance remains outside the tripping zone for at least ti<br>**N.B. (ti)must be always shorter than (tz)** | (0-10)s | 0.1s |
| **Un** +/- **1u** | Operation mode of first voltage element<br>+ = overvoltage<br>- = undervoltage<br>+/- = over/under voltage<br>Dis = disactivated | +<br>-<br>+/-<br>Dis | - |
| **1u** 15%**Un** | Pick-up level of the first voltage element | (1-50)% | 1% |
| **t1u** 1.00**s** | Trip time delay of the first voltage element | (0.10-60)s | 0.1s |
| **Un** + **2u** | Operation mode of second voltage element<br>+ = overvoltage<br>- = undervoltage<br>+/- = over/under voltage<br>Dis = disactivated | +<br>-<br>+/-<br>Dis | - |
| **2u** 10%**Un** | Pick-up level of the second voltage element | (1-50)% | 1% |
| **t2u** 3**s** | Trip time delay of the second voltage element | (0.10-60)s | 0.1s |

| Display | Description | Setting Range | Step |
|---|---|---|---|
| **Fn** +/- **1f** | Operation mode of first frequency element<br>+ = overfrequency<br>- = underfrequency<br>+/- = over/under frequency<br>Dis = disactivated | +<br>-<br>+/-<br>Dis | - |
| **1f** 0,5**Hz** | Pick-up level of the first frequency element | (0.05-9.99)Hz | 0.01Hz |
| **t1f** 3**s** | Trip time delay of the first frequency element | (0.1-60)s | 0.1s |
| **Fn** + **2f** | Operation mode of second frequency element<br>+ = overfrequency<br>- = underfrequency<br>+/- = over/under frequency<br>Dis = disactivated | +<br>-<br>+/-<br>Dis | - |
| **2f** 1**Hz** | Pick-up level of the second frequency element | (0.05-9.99)Hz | 0.01Hz |
| **t2f** 0,5**s** | Trip time delay of the second frequency element | (0.1-60)s | 0,1s |
| **Tc** 60**m** | Thermal time constant of the alternator | (1-400)m | 1m |
| **Ta/n**100**%** | Prealarm level of the thermal image | (50 - 110)%Tn | 1% |
| **W**<0.05**Wb** | Pick-up level of the active underpower element | (0.05-1.00)Wb | 0.05Wb |
| **tW**<0.1**s** | Trip time delay | (0.1-60)s | 0.1s |
| **tBF** .05**s** | Max. reset time delay of the instantaneous elements after tripping of the time delayed elements and time delay for activation of the output relay associated to the Breaker Failure function | (0.05-0.5)s | 0.01s |

**The setting Dis indicates that the function is disactivated.**

**12.2** - 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 digits 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.

| Display | Description |
|---|---|
| **I>** ---- | Instantaneous element of low-set overcurrent operates relays R1,R2,R3,R4 (only one or more, whatever combination) |
| **tI>** 1--- | As above, time delayed element |
| **I>>** ---- | Instantaneous element of high-set overcurrent operates relay R1,R2,R3,R4 |
| **tI>>** 1--- | As above, time delayed element |
| **1Is** -2-- | First unbalance element (time delayed) operates relay R1,R2,R3,R4 |
| **2Is** ---4 | As above, second unbalance element |
| **tIr>** -23- | Reverse power time delayed element operates relay R1,R2,R3,R4 |
| **Z<** -2-- | Underimpedance time delayed element operates relay R1,R2,R3,R4 |
| **tW<** ---4 | Underpower time delayed element operates relay R1,R2,R3,R4 |
| **1U** ---4 | Time delayed element 1U operates relay R1,R2,R3,R4 |
| **2U** -23- | Time delayed element 2U operates relay R1,R2,R3,R4 |
| **1f** ---4 | Time delayed element 1f operates relay R1,R2,R3,R4 |
| **2f** ---4 | Time delayed element 1f operates relay R1,R2,R3,R4 |
| **T>** -2-- | Overtemperature element operates relay R1,R2,R3,R4 |
| **Ta/n** ---4 | Thermal prealarm operates relay R1,R2,R3,R4 |
| **tBF** ---- | Breaker Failure function operates relay R1,R2,R3,R4 |
| **tFRes:** A | The reset after tripping of the relays associated to the time delayed elements can take place: **(A)** automatically when current drops below the trip level. **(M)** manually by the operation of the "ENTER/RESET" key. |
| **2=** I>> | The input (2) for blocking the time delayed elements relevant to phase and ground faults operate on (I>) or (I>>) or (I>+I>>) |
| **t2=** OFF | The operation of the blocking input (2) can be programmed so that it lasts as long the blocking input signal is present ($t_2$=OFF) or so that, even with the blocking input still present, it only lasts for the set trip time delay of the function plus an additional time 2xtBF ($t_2$=2xtBF). |
| **3=** --Ir | The blocking input (3) operate on function (Z<) or (Ir>) or (Z<+Ir>) |
| **4=**1--2-- | The blocking input (4) (terminals 1-14) blocks the operation of one or more of the function 1U, 2U, 1f, 2f in any possible combination. |

## 13. MANUAL AND AUTOMATIC TEST OPERATION

- 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 (Txxxx%Tn).
  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.

- 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 $\leq$ 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.

- Further operation of key SELECT instead of the TEST programs gives the indication of the version and production date of the firmware.

**CAUTION**

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.

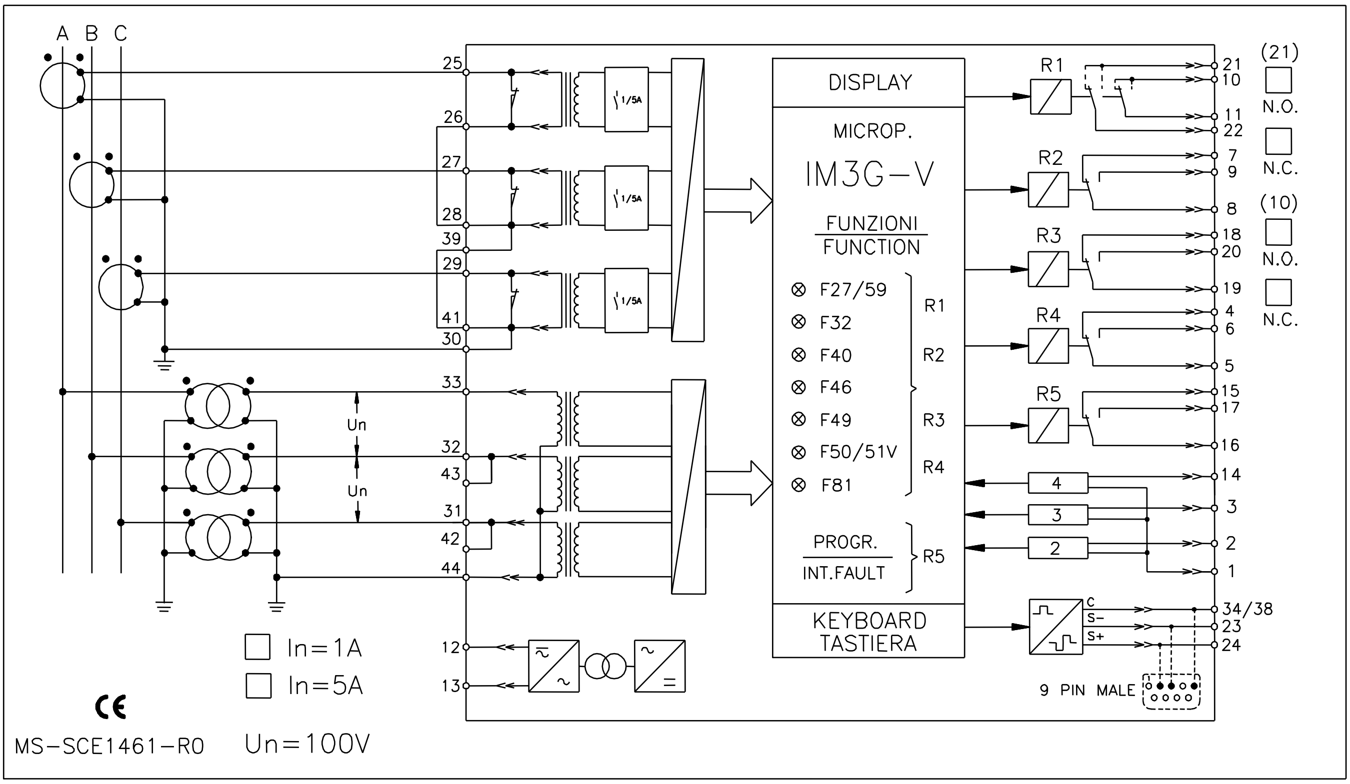
## 14. MAINTENANCE

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.

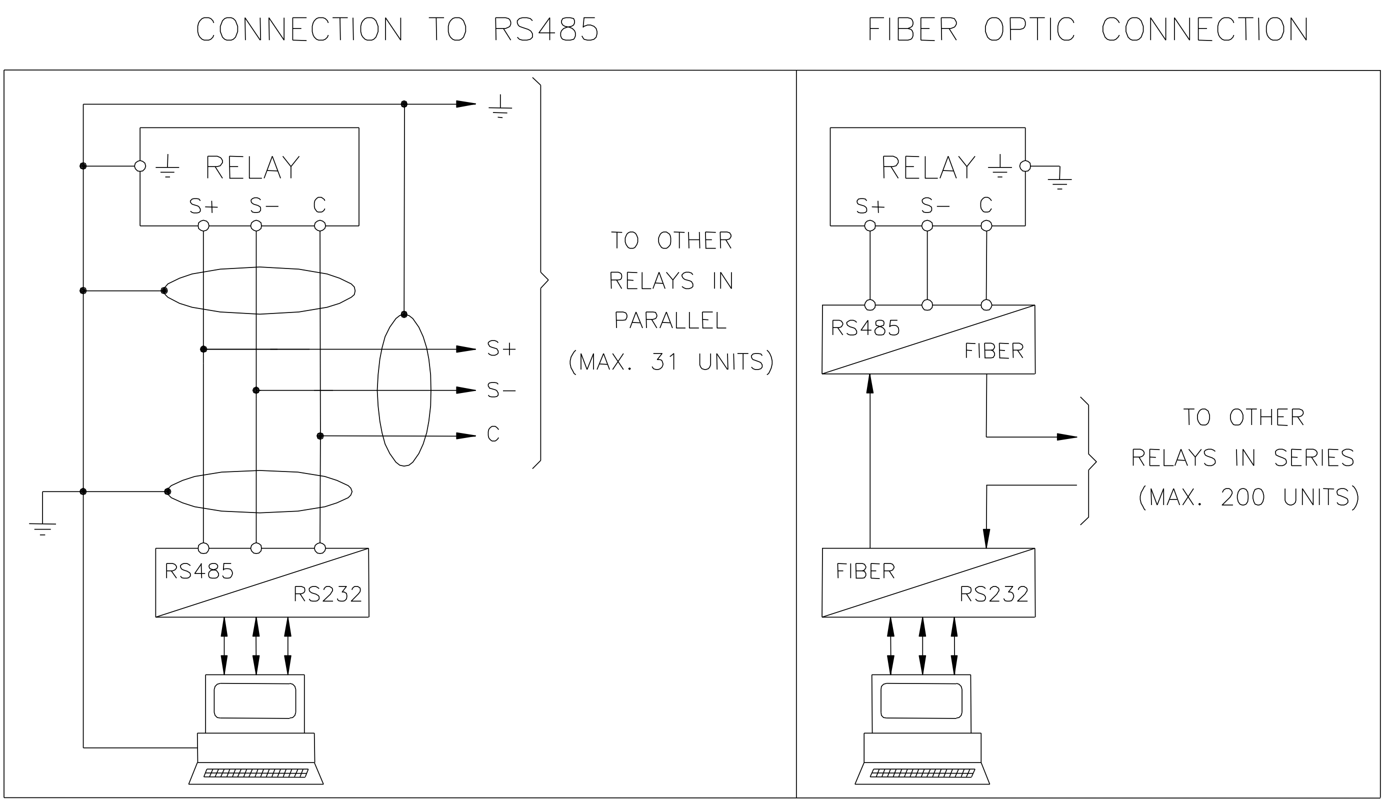
## 15. ELECTRICAL CHARACTERISTICS

| | |
|---|---|
| Reference standards | IEC 255, 801; CEI 41-1; IEEE C37; CE |
| Dielectric test voltage | 2000 V, 50 Hz, 1 min. |
| Impulse test voltage | 5kV (MC), 2 kV (MD) - 1,2/50μμs |
| Immunity to high frequency burst | 1 kV (MC), 0,5 kV (MD) - 0,1 MHz<br>2,5 kV (MC), 1 kV (MD) - 1 MHz |
| Immunity to electrostatic discharge | 15 kV |
| Immunity to sinusoidal wave burst | 100 V - (0,01-1) MHz |
| Immunity to radiated E.M. field | 10 V/m - (20-1000) MHz |
| Immunity to high energy burst | 4 kV (MC), 2 kV (MD) - (IEC 805-5) |
| Immunity to 50-60 Hz magnetic field | 1000 A/m |
| Immunity to impulse magnetic field | 1000 A/m - 8/20μs |
| Immunity to magnetic burst | 100A/m - (0,1-1) MHz |
| Resistance to vibration and shocks | 10-500 Hz - 1 g - 0,075 mm |
| Rated current | In = 1 or 5 A<br>On = 1 or 5 A |
| Current overload | 200 a for 1 sec; 10 A continuos |
| Burden on current inputs | 0,2 VA/phase at In; 0,06 VA at On |
| Rated voltage | Un=100V (different on request) |
| Voltage overload | 2 Un continuous |
| Burden on voltage inputs | 0,2 VA at Un |
| Average power supply consumption | 8,5 VA |
| Output relays | rating 5 A; Vn = 380 V<br>A.C. resistive switching = 1100 W<br>(380 V max)<br>make = 30 A (peak) 0,5 sec.<br>break = 0,3 A, 110 Vcc,<br>L/R = 40 ms (100.000 op.) |
| Operation ambient temperature | -20°C / +60°C |
| Storage temperature | -30°C / +80°C |

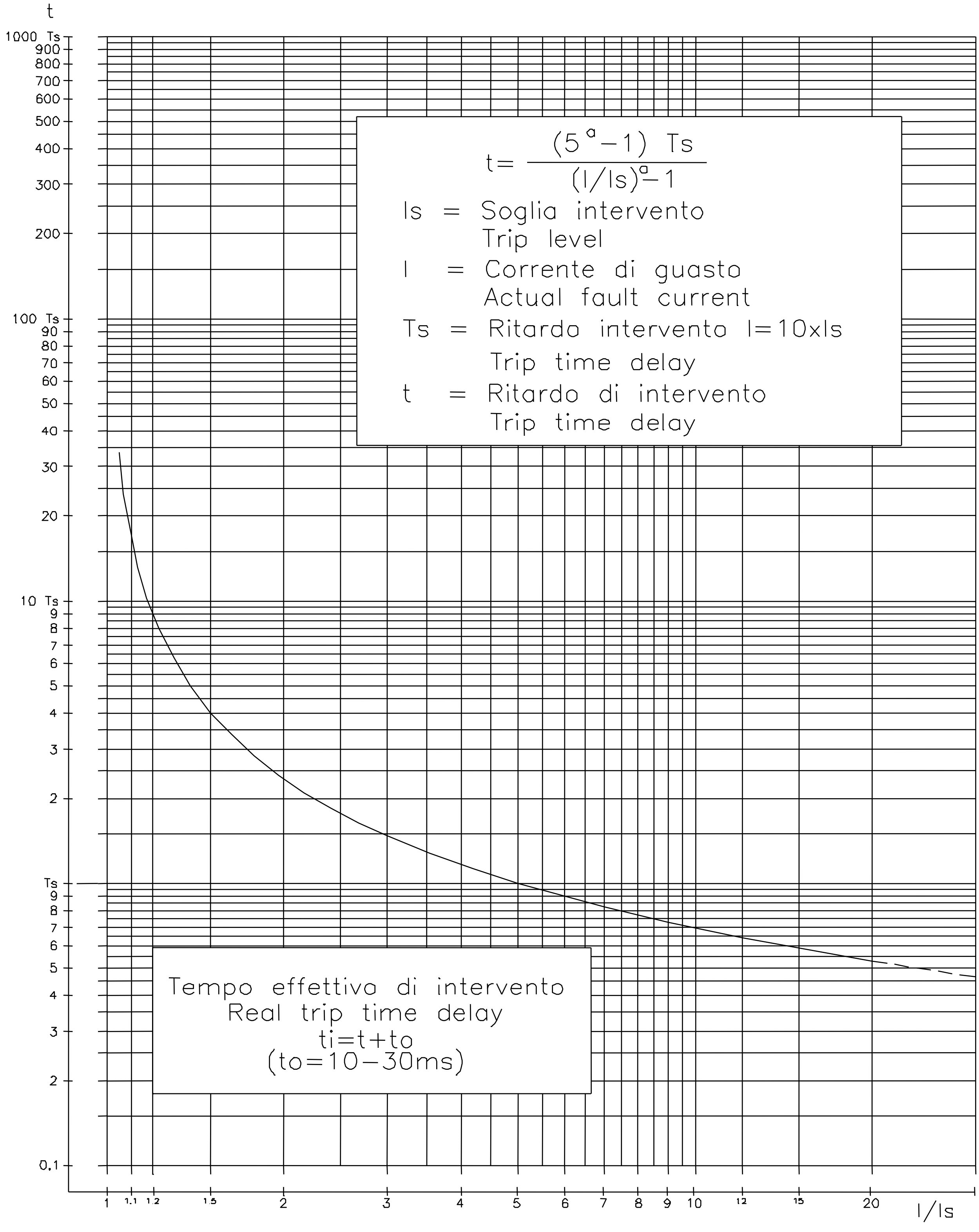
## 16. CONNECTION DIAGRAM (SCE1461 Rev.0)




## 17. WIRING THE SERIAL COMMUNICATION BUS (SCE1309 Rev.0)



## 18. TIME CURRENT CURVES F51 (TU0311 Rev.0)

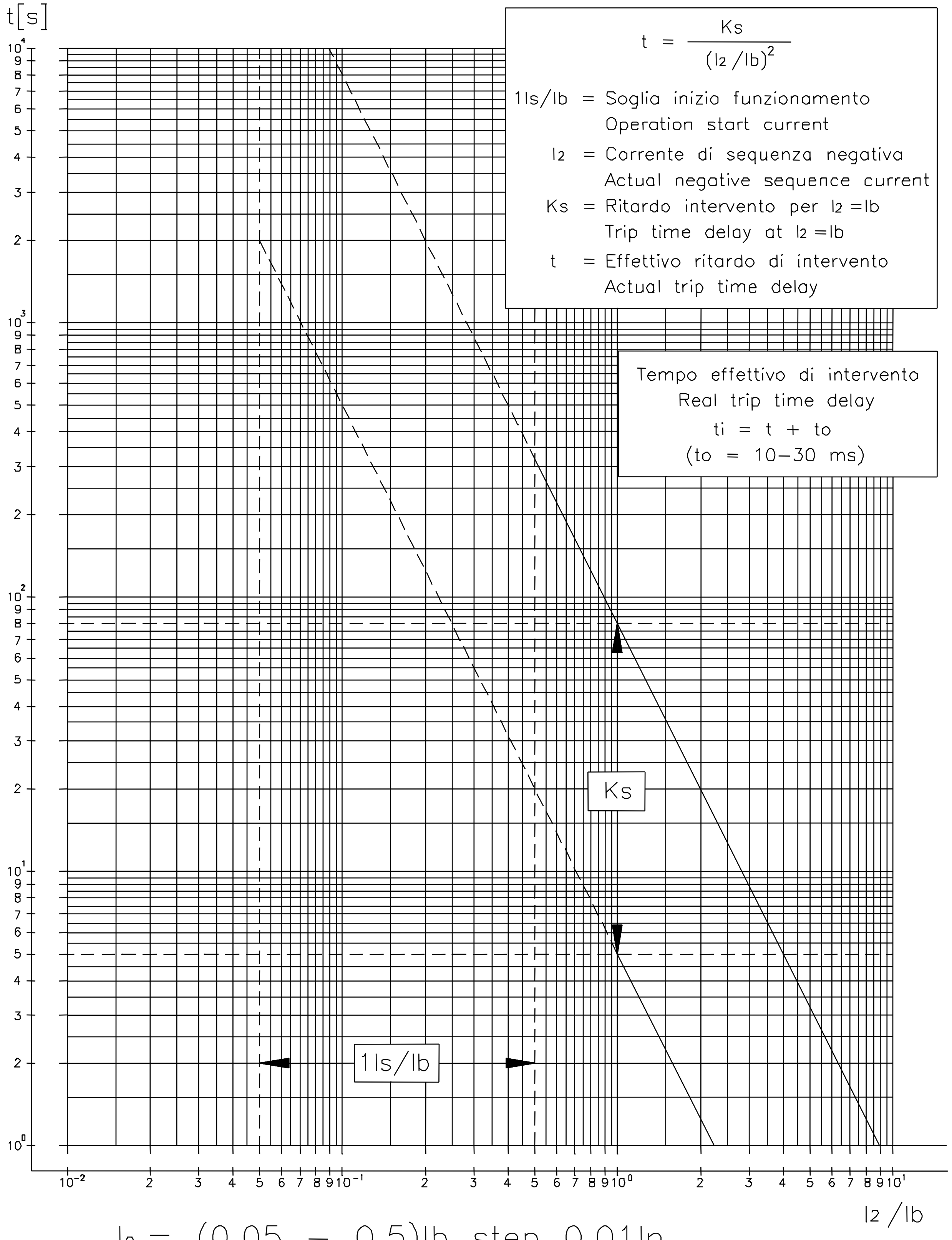



Tempo normalmente inverso
Normal inverse time

a=0.02

F51 [ Is = I> = (1 − 2,5)Ib
Ts = tI> = (0.05−30)s

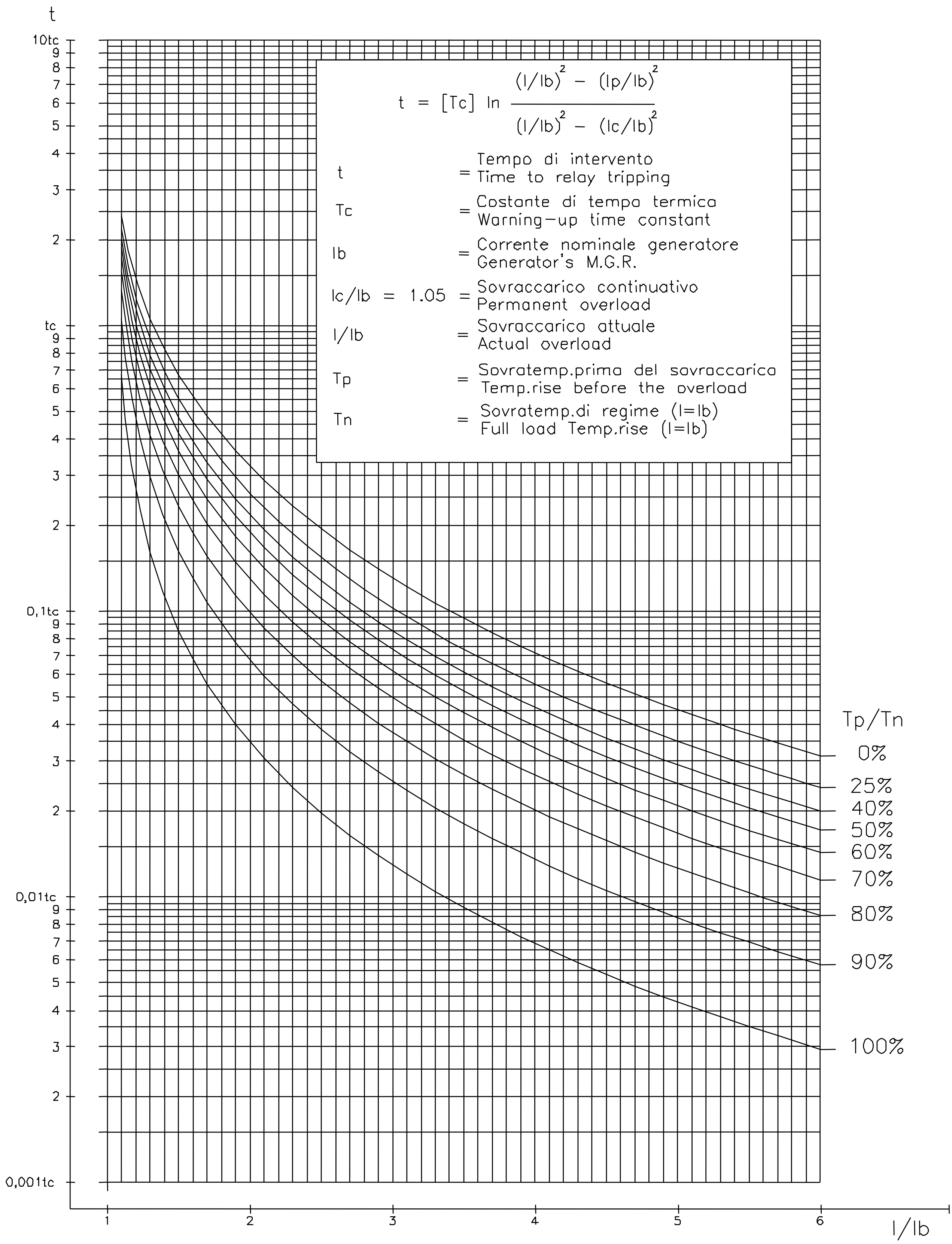
## 19. $I^2t$ = CONSTANT ELEMENT F46 (TU0312 Rev.0)




$I_2$ = (0.05 – 0.5)Ib step 0.01In

Ks = (5 – 80)sec. @ $I_2$ = Ib step 1sec.

## 20. THERMAL IMAGE CURVES (TU0325 Rev.0)



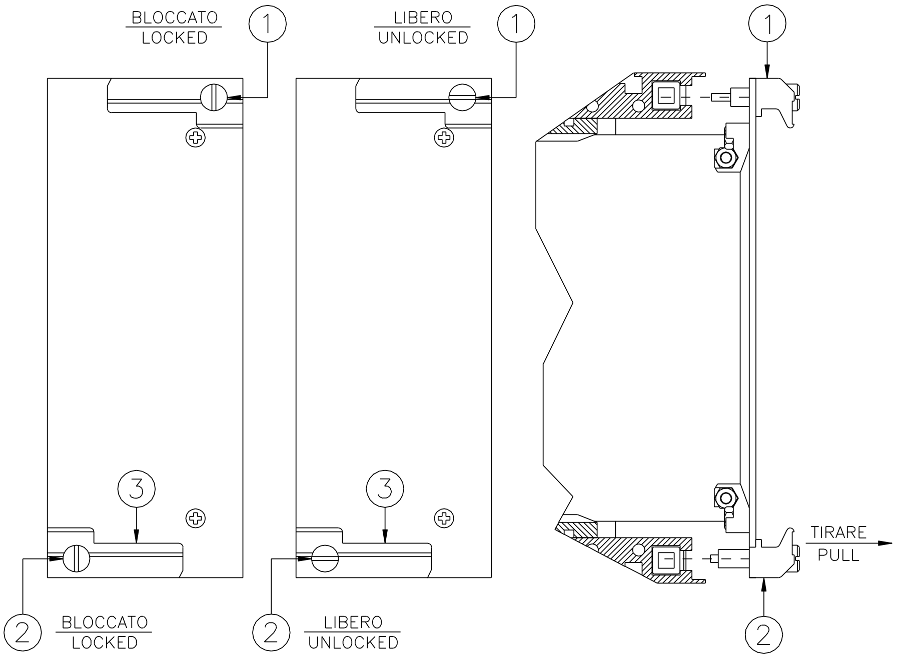
## 21. DIRECTION FOR PCB'S DRAW-OUT AND PLUG-IN

### DRAW-OUT

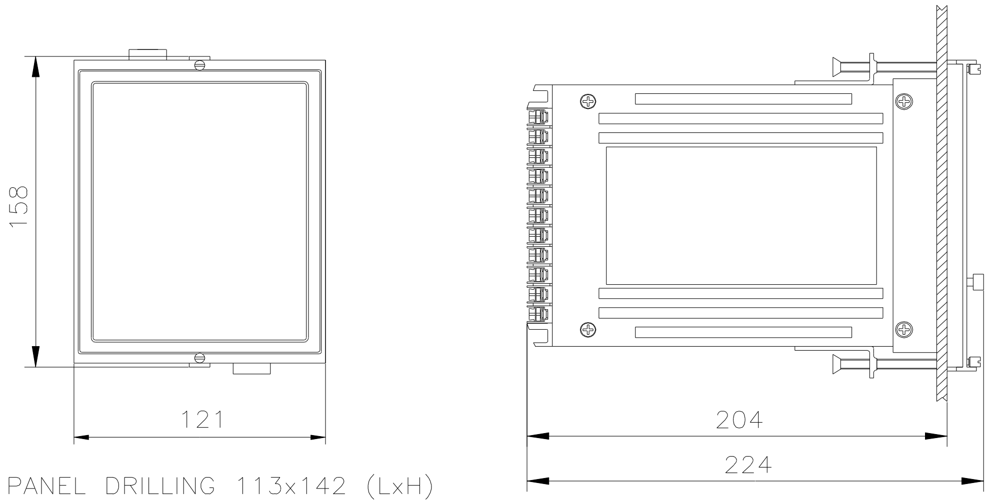
Rotate clockwise the screws ① and ② in the horizontal position of the screws-driver mark.
Draw-out the PCB by pulling on the handle ③

### PLUG-IN

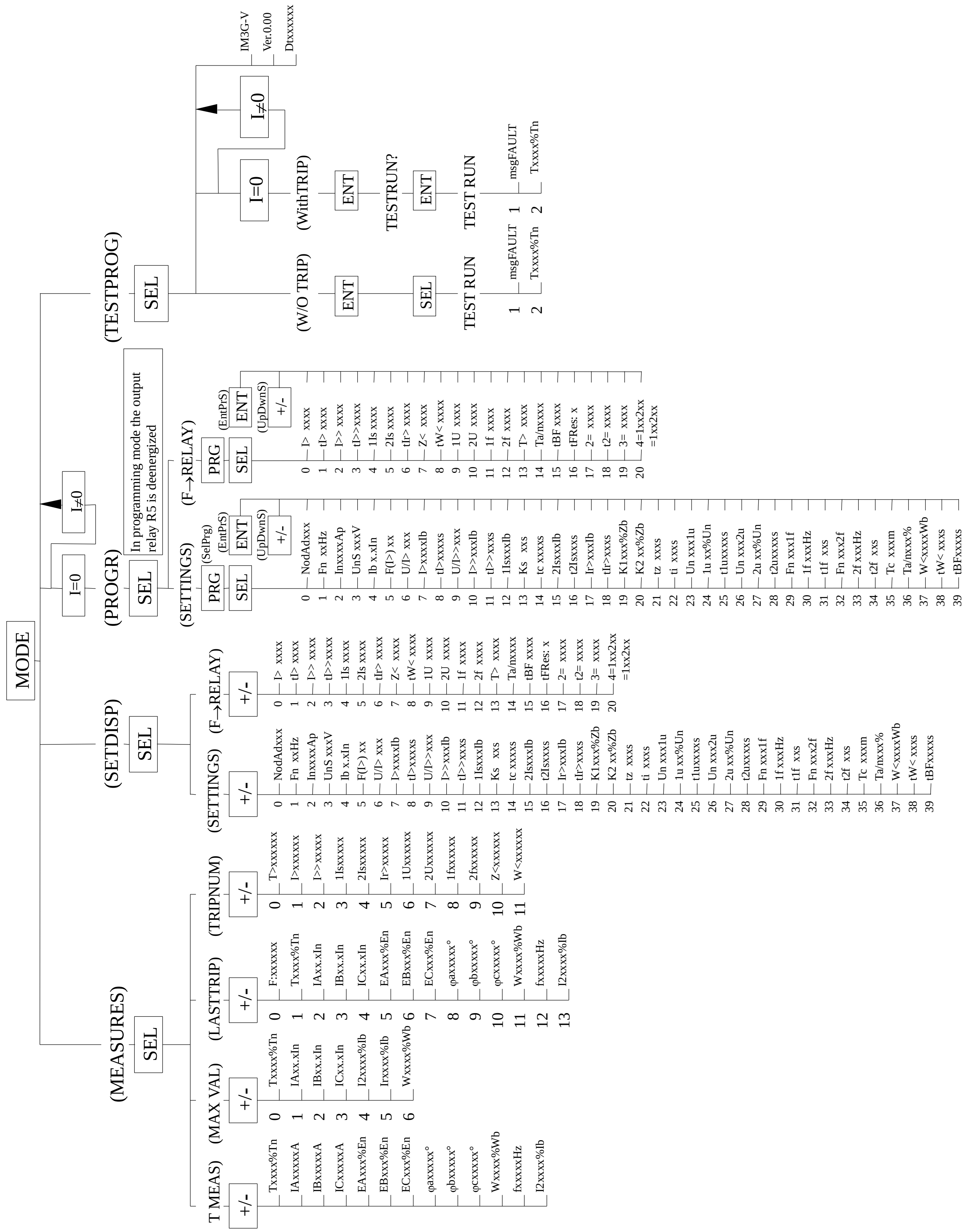
Rotate clockwise the screws ① and ②in the horizontal position of the screws-driver mark.
Slide-in the card on the rails provided inside the enclosure.
Plug-in the card completely and by pressing the handle to the closed position.
Rotate anticlockwise the screws ① and ② with the mark in the vertical position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




## 22. OVERALL DIMENSIONS



## 23. KEYBOARD OPERATIONAL DIAGRAM (D46851 Rev.0)



## 24. PROGRAMMING'S FORM

| **DatE :** | | | **Number Relay:** | | |
|---|---|---|---|---|---|
| RELAY PROGRAMMING | | | | | |
| **Default Setting** | | | **Actual Setting** | | |
| **Variable** | **Value** | **Measurement Unit** | **Variable** | **Value** | **Measurement Unit** |
| **NodAd** | 1 | ------------ | **NodAd** | | ------------ |
| **Fn** | 50 | **Hz** | **Fn** | | **Hz** |
| **In** | 500 | **Ap** | **In** | | **Ap** |
| **UnS** | 100 | **V** | **UnS** | | **V** |
| **Ib** | .5 | **In** | **Ib** | | **In** |
| **F(I>)** | D | ------------ | **F(I>)** | | ------------ |
| **U/I>** | ON | ------------ | **U/I>** | | ------------ |
| **I>** | 1.0 | **Ib** | **I>** | | **Ib** |
| **tI>** | .05 | **s** | **tI>** | | **s** |
| **U/I>>** | ON | ------------ | **U/I>>** | | ------------ |
| **I>>** | 3 | **Ib** | **I>>** | | **Ib** |
| **tI>>** | .05 | **s** | **tI>>** | | **s** |
| **1Is** | .05 | **Ib** | **1Is** | | **Ib** |
| **Ks** | 5 | **s** | **Ks** | | **s** |
| **tcs** | 10 | **s** | **tcs** | | **s** |
| **2Is** | .03 | **Ib** | **2Is** | | **Ib** |
| **t2Is** | 1 | **s** | **t2Is** | | **s** |
| **Ir>** | .02 | **Ib** | **Ir>** | | **Ib** |
| **tIr>** | .1 | **s** | **tIr>** | | **s** |
| **K1** | 300 | **%Zb** | **K1** | | **%Zb** |
| **K2** | 50 | **%Zb** | **K2** | | **%Zb** |
| **tz** | .2 | **s** | **tz** | | **s** |
| **ti** | .0 | **s** | **ti** | | **s** |
| **Un** | +/- | **1u** | **Un** | | **1u** |
| **1u** | 15 | **%Un** | **1u** | | **%Un** |
| **t1u** | 1.00 | **s** | **t1u** | | **s** |
| **Un** | + | **2u** | **Un** | | **2u** |
| **2u** | 10 | **%Un** | **2u** | | **%Un** |
| **t2u** | 3 | **s** | **t2u** | | **s** |
| **Fn** | +/- | **1f** | **Fn** | | **1f** |
| **1f** | 0,5 | **Hz** | **1f** | | **Hz** |
| **t1f** | 3 | **s** | **t1f** | | **s** |
| **Fn** | + | **2f** | **Fn** | | **2f** |
| **2f** | 1 | **Hz** | **2f** | | **Hz** |
| **t2f** | 0,5 | **s** | **t2f** | | **s** |
| **Tc** | 60 | **m** | **Tc** | | **m** |
| **Ta/n** | 100 | **%** | **Ta/n** | | **%** |
| **W<** | 0.05 | **Wb** | **W<** | | **Wb** |
| **tW<** | 0.1 | **s** | **tW<** | | **s** |
| **tBF** | .05 | **s** | **tBF** | | **s** |

| CONFIGURATION OF OUTPUT RELAYS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Default Setting** | | | | | **Actual Setting** | | | | |
| **Protective Elem.** | **Output Relays** | | | | **Protective Elem.** | **Output Relays** | | | |
| **I>** | - | - | - | - | **I>** | | | | |
| **tI>** | 1 | - | - | - | **tI>** | | | | |
| **I>>** | - | - | - | - | **I>>** | | | | |
| **tI>>** | 1 | - | - | - | **tI>>** | | | | |
| **1Is** | - | 2 | - | - | **1Is** | | | | |
| **2Is** | - | - | - | 4 | **2Is** | | | | |
| **tIr>** | - | 2 | 3 | - | **tIr>** | | | | |
| **Z<** | - | 2 | - | - | **Z<** | | | | |
| **tW<** | - | - | - | 4 | **tW<** | | | | |
| **1U** | - | - | - | 4 | **1U** | | | | |
| **2U** | - | 2 | 3 | - | **2U** | | | | |
| **1f** | - | - | - | 4 | **1f** | | | | |
| **2f** | - | - | - | 4 | **2f** | | | | |
| **T>** | - | 2 | - | - | **T>** | | | | |
| **Ta/n** | - | - | - | 4 | **Ta/n** | | | | |
| **tBF** | - | - | - | - | **tBF** | | | | |
| **tFRes:** | A | | | | **tFRes:** | | | | |
| **2=** | I>> | | | | **2=** | | | | |
| **t2=** | OFF | | | | **t2=** | | | | |
| **3=** | --Ir | | | | **3=** | | | | |
| **4=** | 1--2-- | | | | **4=** | | | | |