DIGITAL-MULTIFUNCTION
HIGH IMPEDANCE BIASED
DIFFERENTIAL RELAY

TYPE

M-HIB3

Microelettrica's Relay M-Line

Protection and control

"APPLICATION GUIDE"

INDEX

1. MHIB-3 High Impendance Biased Differential Relay

1.1 - Main characteristics

- Two Differential levels.
- Programmable percentage bias.
- Two Overcurrent levels.
- Harmonic restraint.
- Breaker Failure protection.
- Oscillographic recordings.
- Modbus Communication Protocol.

1.2 - Technical features

The M-HIB3 is a microprocessor relay with three high speed current measuring elements.
With the addition of proper external stabilizing resistors the relay is used as High Impedance Differential protection against phase and ground fault.

<u>The relay has the following features:</u>
- Low-set percentage biased differential element on each phase.
- Adjustable second harmonic restraint level.
- High-set differential element with DC offset restraint.
- 2 instantaneous and 2 definite time delay elements for through overcurrent protection.
- Breaker Failure protection.
- Real time measurements

- Maximum Demand and Inrush Recording
- Recording of last five events.
- Oscillographic recording of 3 input currents.

2. PROTECTIVE FUNCTIONS

2.1 - Differential Protection 1F87

The relay performs a percentage biased differential protection against faults inside the protected zone.
For each phase the relay measures :
- The value of the System Frequency component of the Vector Difference between side 1 and side 2 currents

Dx = $\left|\bar{I}_{1x} - \bar{I}_{2x}\right|$ x=A,B,C

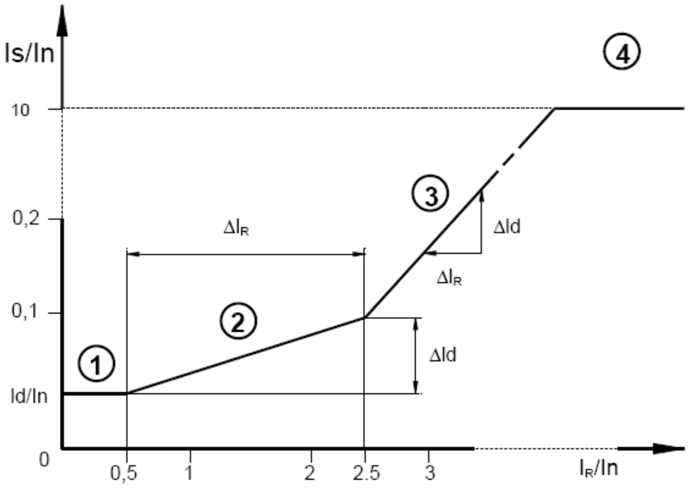
- The R.M.S. value of the zone "Through current" $Ir = \dfrac{\left|\bar{I}_1 - \bar{I}_2\right|}{2}$

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

- Basic minimum differential pick-up level : **d>** = (0.10 – 1.00)In, step 0.01In
- Percent bias in the zone 0.5 < $\frac{I_R}{I_n}$ < 2.5 :R% = (10-50)%, step 1%
- Percent bias in the zone $\frac{I_R}{I_n}$ > 2.5 :R%= (100)%, step 1%

To compensate differential current produced by errors of the CT 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 levels **" R% ".**

Fig.1



$$R\% = 100\,\frac{\Delta I_d}{\Delta I_R} \qquad I_R = \frac{I1+I2}{2}$$

① $\frac{Is}{In} = \frac{I_d}{In}$

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

③ $\frac{Is}{In} = \frac{I_d}{In} + \frac{(2.5-0,5)R\%}{100} + \left(\frac{I_R}{In} - 2.5\right)$

④ $\frac{Is}{In} \cong 10$

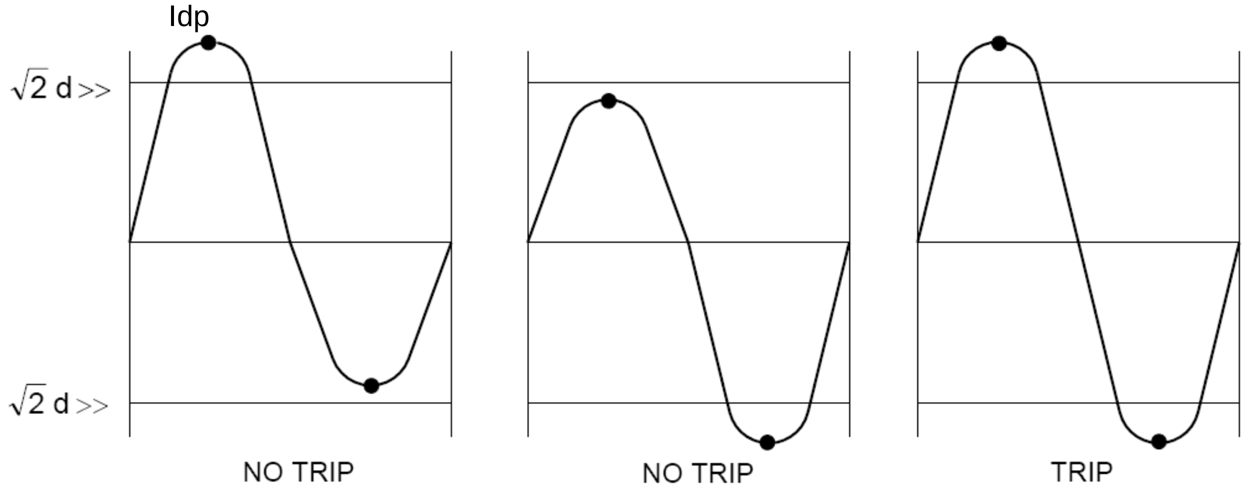
Is= Effective relay operation differential current
Id= Relay setting differential current
I_R= Relay through current

The low set differential element operates instantaneously (less than 30ms) when the measured differential current **Idx** of any phase exceeds the pick-up level **2xIs**.

2.2 - High set differential level 2F87

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

Idp > [d>>] √2



This practically avoids spurious tripping on unidirectional current component typicall of the saturation of the CTs.

Basic minimum differential pick-up level : **d>>** = (0.5 – 9.0 - Dis)In, step 0.1In

3. PLUSES

3.1 - Oscillography Records

The relay continuously records in a buffer the samples of the three input phase currents. The buffer contains samples for approximately 16 periods.
Recording is stopped after approximately 8 periods after a trigger signal and the content of the buffer is stored into memory.
Therefore in the memory are stored the wave forms for 8 cycles before and 8 cycles after the trigger instant.
The trigger can be operated either internally on tripping of any function programmed d>, d>>, I>, I>> or externally by activation of the digital input B3.
Selection between the two modes is made by programming the variable **TRG** = EXT, d>, d>>, I>, I>>.
The last oscillography record of the three input currents is stored; a second record replaces the first one.

3.2 - Serial Communication

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

3.3 - Test

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

- Diagnostic and functional test, with checking of program routines and memory's content, run every time the aux. power is switched-on: the display shows the type of relay and its version number and then switches over to the default display.
- Dynamic functional test run during normal operation every 15 min. (relay's operation is suspended for less than ≤4 ms).
- Complete test activated by the keyboard or via the communication bus either with or without tripping of the output relays.
- If any internal fault is detected, the display shows a fault message, the Led "PROG/IRF" illuminates and the relay R5 is deenergized.

4. DIMENSIONING OF ACCESSORIAL DEVICES

4.1 - CTs

- All the CTs must have same ratio.
- Current transformers must meet the requirements hereunder specified for stability on through Fault:

  - $V_k \geq 2V_S$
  - $V_S < I_S(R_R + R_S) \Rightarrow I_F(R_C + R_2) < I_S(R_R + R_S) \Rightarrow \frac{I_F}{I_S} < \frac{R_R + R_S}{R_C + R_2} \Rightarrow R_S > \frac{I_F}{I_S}(R_C + R_2) - R_R$

Where:

- $\mathbf{R_R}$ = Relay Burden = $\begin{cases} 0.02\ \Omega \text{ for In} = 1A \\ 0.01\ \Omega \text{ for In} = 5A \end{cases}$

- $\mathbf{R_C}$ = Resistance of the Cable loop between C.T. and relay
- $\mathbf{R_2}$ = Resistance of C.T's secondary winding
- $\mathbf{I_F}$ = Maximum external short-circuit current
- $\mathbf{I_S}$ = Relay trip level
- $\mathbf{V_k}$ = C.T's Knee point voltage
- $\mathbf{V_S}$ = Stability voltage = I_F (R_C + R_2)
- $\mathbf{R_S}$ = Stabilizing resistor

(Class X CTs with 1A secondary are recommended).

The calculation has been made accordingly to the requirements for protective current transformers for transient performance as specified in IEC 60044-6 §3.15-3.20.

4.2 - Relay Sensitivity

The minimum primary setting value for the differential protection relay is affected by the magnetising current of the CTs and the current in the surge arrester.

- Id= n(q x Im+[d>])

4.3 - Stabilising Resitor

The correct value of the stabilising resistor will be choosen so that:

- (R2 + Rc) / [d>] x I_F < Rs < Vk / (2 x I_F)

4.4 - Surge arrester

In case, in the event of an internal fault, the voltage at relay inputs exceeds 2kV the use of a surge limiter device is required.
The calculation of the voltage at relay inputs will be done according the following formula:

- V = 2√2 x Vk x { IF-2 x (R2 + Rc + Rs) - Vk }

5. PRACTICAL EXAMPLES

R_c	Resistance of cable loop between CT and relay	**0,333 Ohm**
R_2	Resistance of CT secondary winding	**0,54 Ohm**
Id	Minimum primary current threshold (detectable by relay)	**569,6A**
I_F	Maximum through fault current (1:primary, 2:secondary)	**35300/110.31A**
Im	CT magnetizing current	**0,07A**
In	CT secondary current	**5A**
[d>]	Relay trip level (30% : 5 x 0.3 = 1.5)	**1,5A**
Vk	CT knee point voltage	**390V**
Vs	Stability voltage {IF-2 x (Rc + R_2)}	**96,3V**
R_R	Relay burden (resistance)	**0,01Ohm**
R_S	Stabilizing resistor	**100 Ohm**
q	nos. of parallel-connected current transformer	

CT type and ratio : 1600/5

$R_2$1 = 0.54 = CT1 secondary resistance (Ohm)
$R_2$2 = 0.54 = CT2 secondary resistance (Ohm)
R_2 = 1.08 = Max (R1,R2)
Vk1 = 390V = CT1 Knee point voltage
Vk2 = 390V = CT2 Knee point voltage

Rc1	= 0,167 = resistance on CT1 side	**5.5mm2 max. length 50m**
Rc2	= 0,167 = resistance on CT2 side	**5.5mm2 max. length 50m**
Rc	= 0,333 = Max (Rc-1, Rc-2)	**(5.5mm2, R=3.33 Ohm/Km)**
n =	1600/5 = 320= CT Ratio	
I_F1 =	35300A (primary)	
I_F2 =	35300 / 320 = 110.31A (secondary)	

Vk > 2Vs { Vs = IF-2 x (R2 + Rc) }
Vk = 2 x { 110.31 x (0.54 + 0.333) } = 192.6 V

Design rating of CT1 & CT2 Vk : 390V >> 192.6V
(R_2 + Rc) / Is x IF-2 < Rs ≦ Vk / (2 x Is)
{ (0.54 + 0.333) / 1.5 x 110.31 } < Rs ≦ { 390 / (2 x 1.5) } => 64.2 < Rs ≦ 130 Ohm

Set Rs = **100** Ohm

V = 2 √2 x Vk x { IF-2 x (R2 + Rc + Rs) - Vk }
V = 2 √2 x 390 x { 110.31 x (0.54 + 0.333 + 100) - 390 } = 5788 V
5788 >> 3 KV, therefore, surge limiter installation is required.

Id = 320 (4 x 0.07 + 1.5) = 569.6A
n : CT ratio (1600/5 = 320)

Rc	Resistance of cable loop between CT and relay	**Ohm**
R_2	Resistance of CT secondary winding	**1,20 Ohm**
Id	Minimum primary current threshold (detectable by relay)	
I_F	Maximum through fault current (1:primary, 2:secondary)	
Im	CT magnetizing current	**0,07A**
In	CT secondary current	**5A**
[d>]	Relay trip level (30% : 5 x 0.3 = 1.5)	**1,5A**
Vk	CT knee point voltage	**800V**
Vs	Stability voltage {IF-2 x (Rc + R2)}	
R_R	Relay burden (resistance)	**0,01Ohm**
Rs	Stabilizing resistor	
q	nos. of parallel-connected current transformer	

<u>CT type and ratio : 1600/5</u>

$R_2$1	= 1.20 =	CT1 secondary resistance (Ohm)
$R_2$2	= 1.20 =	CT2 secondary resistance (Ohm)
R_2	= 2.40 =	Max (R1,R2)
Vk1	= 800V =	CT1 Knee point voltage
Vk2	= 800V =	CT2 Knee point voltage

Rc1	= 0,167 = resistance on CT1 side	**5.5mm2 max. length 50m**
Rc2	= 0,167 = resistance on CT2 side	**5.5mm2 max. length 50m**
Rc	= 0,333 = Max (Rc-1, Rc-2)	**(5.5mm2, R=3.33 Ohm/Km)**
n =	2000/5 = 400=CT Ratio	
I_F1 =	35300A (primary)	
I_F2 =	35300 / 400 = 88.25A (secondary)	

Vk > 2Vs { Vs = IF-2 x (R2 + Rc) }
Vk = 2 x { 88.25 x (1.20 + 0.333) } = 270.57 V

Design rating of CT1 & CT2 Vk : 390V >> 192.6V
(R2 + Rc) / Is x IF-2 < Rs $\leqq$ Vk / (2 x Is)
{ (1.20 + 0.333) / 1.5 x 88.25 } < Rs $\leqq$ { 800 / (2 x 1.5) } => 91.19 < Rs $\leqq$ 166.67 Ohm

Set Rs = **100** Ohm

[d>] : relay trip level (5 x 0.3 =1.5)

V = 2 $\sqrt{2}$ x Vk x { IF-2 x (R2 + Rc + Rs) - Vk }
V = 2 $\sqrt{2}$ x 800 x { 88.25 x (1.20 + 0.333 + 100) - 800 } = 7226.7 V
7226.7 >> 3 KV, therefore, surge limiter installation is required.
Id = 400 (4 x 0.07 + 1.5) = 712A

6. SURGER ARRESTER DEVICE

SECONDARY ARRESTERS
Type L—175 Vac, 125 Vdc
DESIGN FEATURES

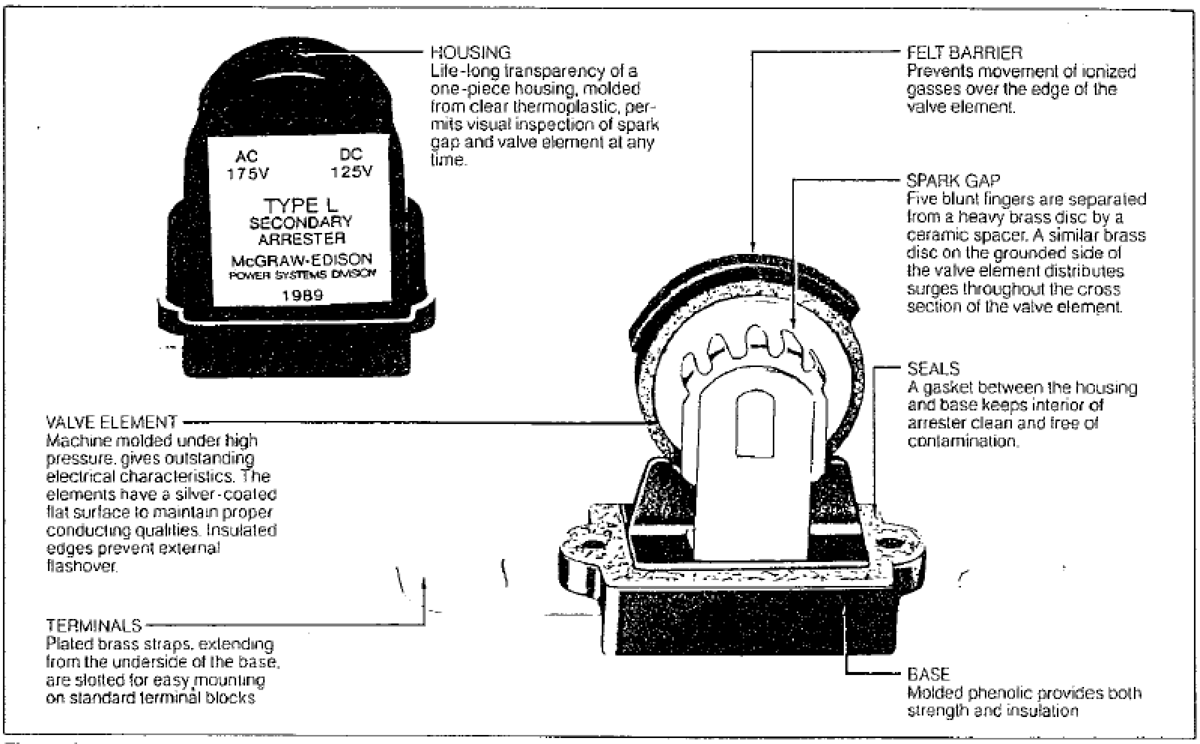
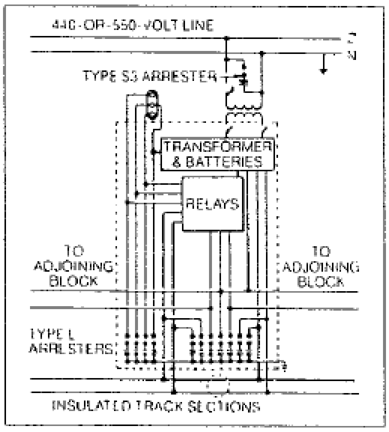


Figure 4.
Type L secondary arrester.

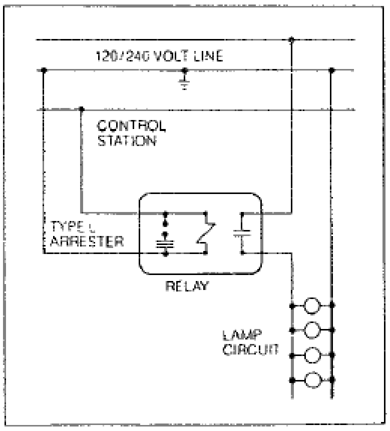
DESCRIPTION

Type L arresters protect low-voltage circuits and equipment against surges by providing a low-impedance path to ground, and quickly draining off surge voltages. The arrester promptly restores the circuit to normal by interrupting the 60 Hz current which follows the surge current.

Type L arresters meet all requirements of the Association of American Railroads (AAR) Signal Section Specification 52.51. Examples of applications of Type L secondary arresters are shown in the following diagrams.



RAILWAY APPLICATION DIAGRAM
Simplified schematic circuit diagram showing the application of McGraw-Edison Type L secondary arresters to an automatic railway block signal control. One arrester is used on each outgoing line.

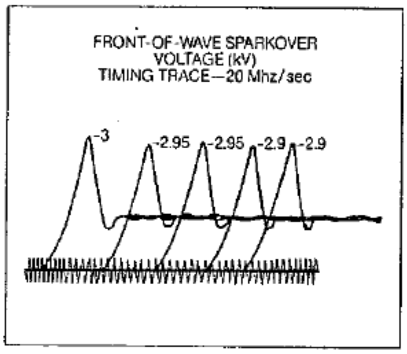


STREET-LIGHT CONTROL RELAY
A typical multiple street lighting control circuit showing Type L secondary arresters protecting the relay coil.

Secondary Arresters and Protective Gaps

Impulse Sparkover

Uniform sparkover characteristics and a long life are assured by the design of the spark gap of Type L arresters. The accompanying oscillogram shows equal impulse sparkover values for five successive shots on a wave rising 10 kV per microsecond. The average and maximum crest values are well below the 3400 volts allows by AAR Specifications.



60 Hz Sparkover

Each Type L arrester is factory tested to assure a minimum 60 Hz sparkover of 1100 volts. This sparkover value allows circuits to be field tested with a 1000-volt megohmmeter without removing the arrester from the circuit.

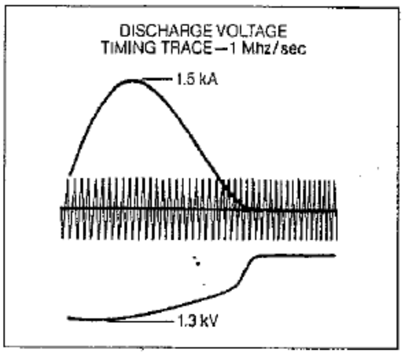
Heat, generated during arrester operation, is dissipated by the brass disc of the spark gap. If an exceptionally heavy surge damages the valve element, the fingers of the gap burn back and clear the follow current. Thus, the arrester is prevented from permanently grounding the protected circuit.

Discharge Capacity

AAR Specifications require a discharge capacity of 10,000 amps on a 4 x 10-microsecond wave. The accompanying oscillogram shows a Type L arrester discharging 15,000 amps on a 8 x 20-microsecond wave—a wave of longer duration and higher energy content.

Discharge Voltage

Low-voltage signal circuit apparatus is designed to withstand a 60 Hz voltage of 4200 volts crest for one minute. The following table shows how Type L arresters offer extra protection with very low discharge voltages.

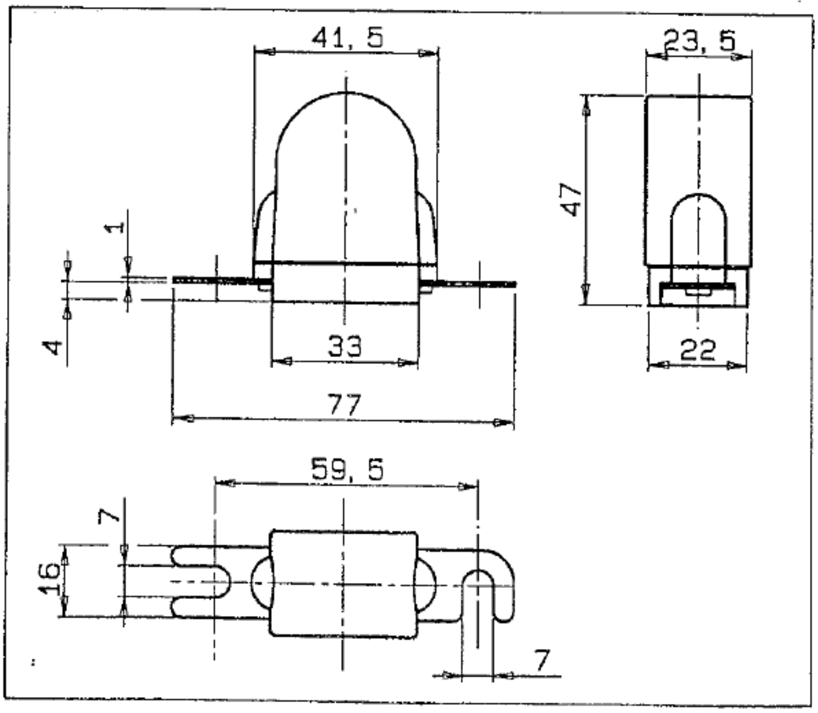


Discharge Current for 8 x 20-microsecond Discharge Current Wave (kA)	Discharge Voltage Crest (kV)	
	Average	Maximum
1.5	1.25	1.50
5.0	1.50	1.80
10.0	1.70	2.00

Duty Cycle

Type L arresters subjected to duty-cycle tests of 30 successive operations show remarkably consistent characteristics. Discharge voltages remain constant, even for 30 shots at 1500 amps on a 8 x 20-microsecond wave. Follow current is quickly and effectively interrupted.

DIMENSIONAL INFORMATION



7. ELECTRICAL CHARATERISTICS

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		
❑ Climatic tests	IEC 68-2-1 - 68-2-2 - 68-2-33			

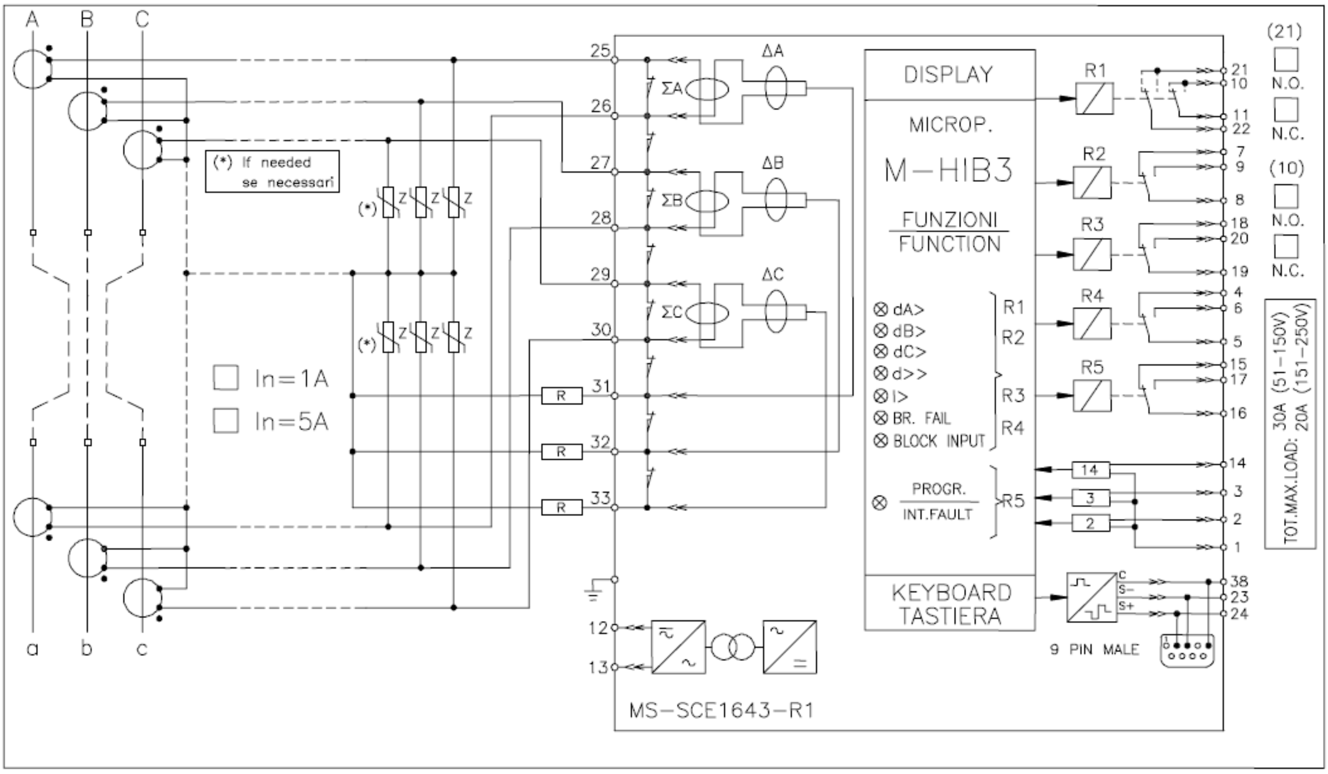
CE EMC Compatibility (EN50081-2 - EN50082-2 - EN50263)

❑ Electromagnetic emission	EN55022 IND. ENV.			
❑ Radiated electromagnetic field immunity test	IEC61000-4-3 ENV50204	level 3	80-1000MHz 900MHz/200Hz	1 1
❑ Conducted disturbances immunity test	IEC61000-4-6	level 3	0.15-80MHz	1
❑ Electrostatic discharge test	IEC61000-4-2	level 4	6kV contact / 8kV ai	
❑ Power frequency magnetic test	IEC61000-4-8		1000A/m	5
❑ 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 4	2kV, 5/50ns, 5kHz	
❑ HF disturbance test with damped oscillatory wave (1MHz burst test)	IEC60255-22-1	class 3	400pps, 2,5kV (m.c.	
❑ 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		200ms	
❑ Resistance to vibration and shocks	IEC60255-21-1 - IEC60255-21-2 – 10-50Hz – 1g			

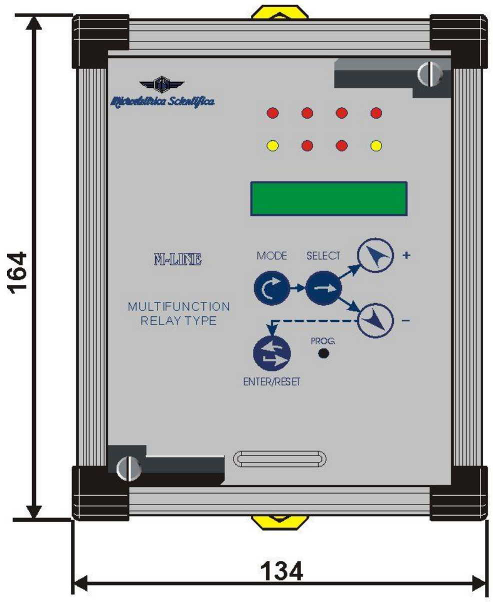
CHARACTERISTICS

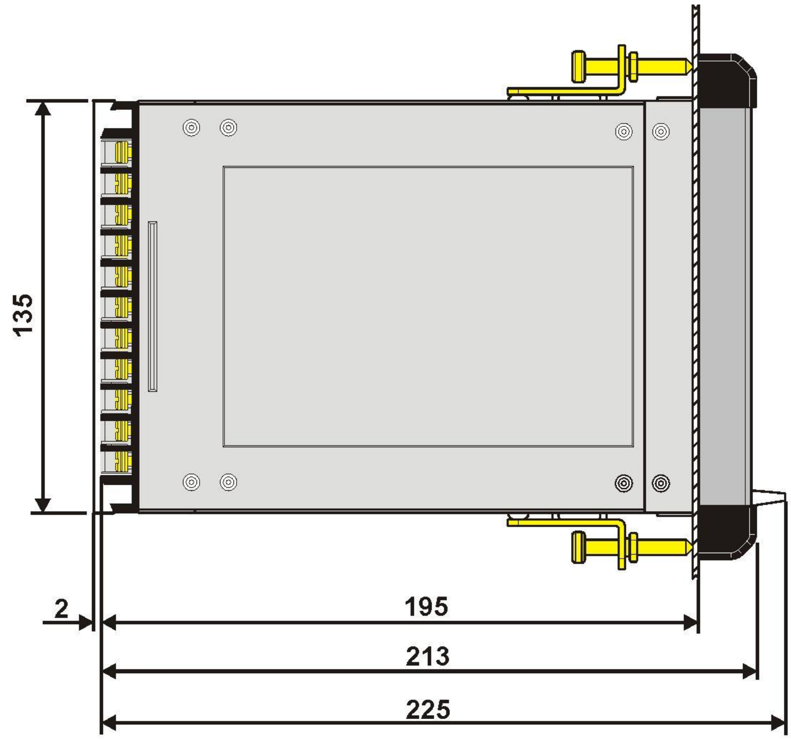
❑ Accuracy at reference value of influencing factors	2% Rated Input 2% +/- 10ms	for measure for times
❑ Rated Current	In = 1 or 5A	
❑ Current overload	200 A for 1 sec; 10A continuos	
❑ Burden on current inputs	Phase : 0.02VA at In = 1A ; 0.4VA at In = 5A	
❑ Average power supply consumption	8.5 VA	
❑ 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.)	
❑ Operation ambient temperature	-10°C / +55°C	
❑ Storage temperature	-25°C / +70°C	
❑ Humidity	IEC68-2-3 RH 93% Without Condensing at 40°C	

8. CONNECTION DIAGRAM

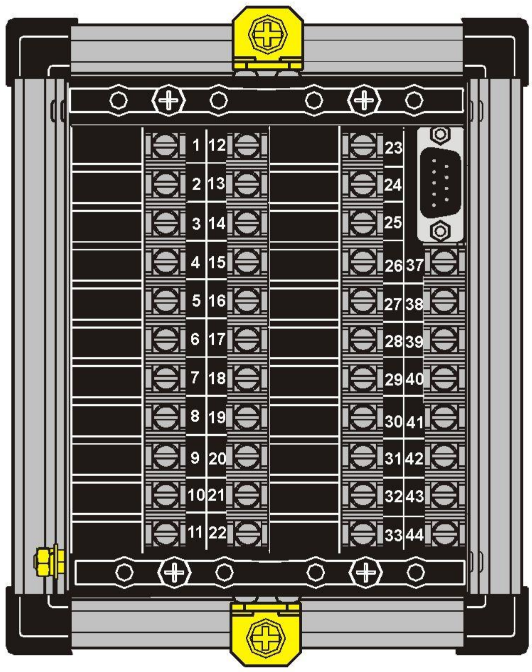


9. OVERALL DIMENSIONS





FORATURA PANNELLO
PANEL CUT-OUT
115x137 (LxH)



VISTA POSTERIORE - MORSETTI DI CONNESSIONE
VIEW OR REAR - TERMINAL CONNECTION