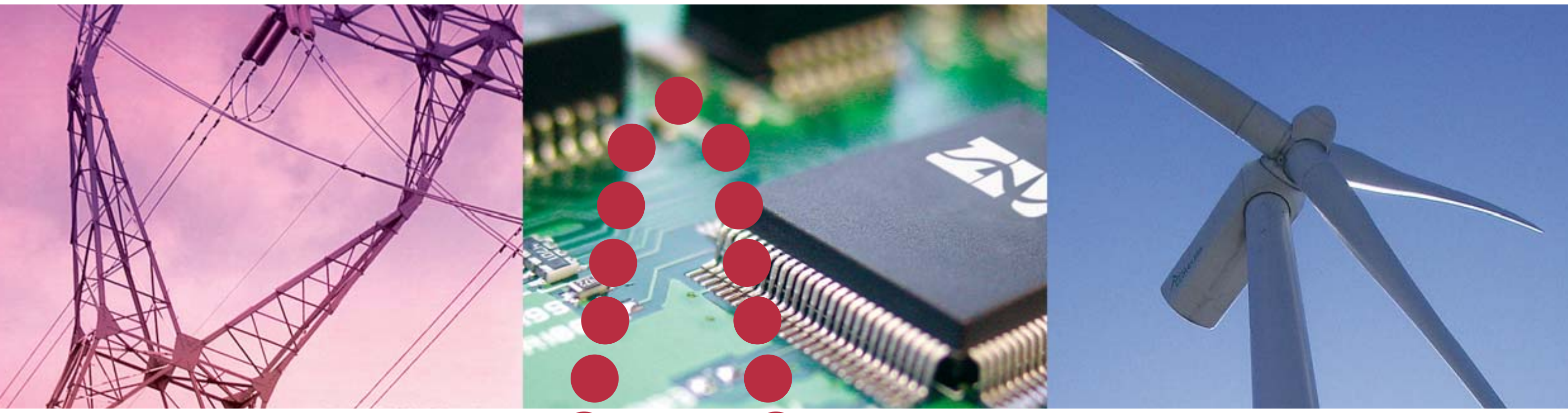
grid automation



MXI

Multifunction Motor Protection

Instructions Manual

BMXI1101Av00

License agreement for Software Embedded in Equipment

ZIV APLICACIONES Y TECNOLOGIA, S.L.
End-User Software License Agreement

THE EQUIPMENT YOU HAVE PURCHASED INCLUDES EMBEDDED SOFTWARE PROGRAM(S). THE PROGRAM IS COPYRIGHTED AND IS BEING LICENSED TO YOU (NOT SOLD) FOR USE WITH THE EQUIPMENT.

THIS IS A LEGAL AGREEMENT BETWEEN US (AS "LICENSEE) AND ZIV APLICACIONES Y TECNOLOGIA, S.L. (AS "LICENSOR") FOR THE SOFTWARE PROGRAM INCLUDED WITH THE EQUIPMENT. PLEASE READ THE TERMS AND CONDITIONS OF THIS LICENSE AGREEMENT CAREFULLY BEFORE USING THE EQUIPMENT.

IF YOU INSTALL OR USE THE EQUIPMENT, YOU ARE ACCEPTING AND AGREEING TO THE TERMS OF THIS LICENSE AGREEMENT. IF YOU ARE NOT WILLING TO BE BOUND BY THE TERMS OF THIS LICENSE AGREEMENT, YOU SHOULD PROMPTLY RETURN THE EQUIPMENT UNUSED TO YOUR SELLER, AND YOU WILL RECEIVE A REFUND OF YOUR MONEY.

Terms and Conditions of License

1. **License Grant**. Licensor hereby grants to you, and your accept, a nonexclusive and non-transferable license to use the embedded programs and the accompanying documentation, if any (collectively referred to as the "Software"), only as authorized in this License Agreement.
2. **Restrictions.** You may not (a) use, copy, modify or transfer the Software except as expressly provided in this or another Agreement with Licensor, (b) reverse engineer, decompile or disassemble or separate the components of the Software, or (c) rent, sell or lease the Software or make the Software available to others to do any of the foregoing.
3. **No Assignment.** This License is intended for your exclusive use with the purchased equipment. You agree that you will not assign, sublicense, transfer, pledge, lease, rent or share your rights under this License Agreement.
4. **Licensor's Rights.** You acknowledge and agree that the Software is the proprietary product of Licensor protected under U.S. copyright law and international treaties.. You further acknowledge and agree that all right, title and interest in and to the Software, including associated intellectual property rights, are and shall remain with Licensor. This License Agreement does not convey to you an ownership interest in or to the Software, but only a limited right of use revocable in accordance with the terms of this License Agreement.
5. **Confidentiality**. The Software is confidential and no details or information relating to the same shall be disclosed to any third party without the prior written consent of Licensor. For the purposes of this clause, sub-contract staff, employed or retained by the Licensee to perform computer systems development work, shall not be deemed to be third parties provided such staff are subject to the disclosure restrictions set forth above. In no event, except with a prior written authorization duly signed by an officer of Licensor, may you disclose any such confidential information, even for subcontracted jobs, to persons or entities that may be considered to be direct competitors of Licensor.

6. **Term**. The License Agreement is effective upon delivery of the equipment to you and shall continue until terminated. You may terminate this License Agreement at any time by returning the equipment to Licensor, or by destroying the equipment. Licensor may terminate this License Agreement upon your breach of any term hereof. Upon such termination by Licensor, you agree to return the equipment to Licensor.
7. **Warranty and Disclaimer.** Licensor warrants, for your benefit only, that the Software, when and as delivered to you, will conform to the specifications described in the instruction manuals for the equipment purchased, or any specifications agreed to in writing by Licensor with a particular customer. This warranty does not cover any minor errors or deviations from the specifications that do not affect the proper functioning of the equipment. **EXCEPT FOR THE WARRANTIES SET FORTH ABOVE, THE SOFTWARE IS LICENSED "AS IS", AND LICENSOR DISCLAIMS ANY AND ALL OTHER WARRANTIES, WHETHER EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.**
8. **Licensee's Remedy.** You sole and exclusive remedy for any breach of Licensor's warranty shall be the repair or replacement, at Licensor's sole option, of any Software that does not conform to stated specifications. Licensor shall not be responsible for any failure arising from inadequate or improper use of the Software.
9. **Limitation of Liability.** Licensor's cumulative liability to you or any other party for any loss or damages resulting from any claims, demands, or actions arising out of or relating to this Agreement shall not exceed the purchase price paid to Licensor for the equipment. In no event shall Licensor be liable for any indirect, incidental, consequential, special, or exemplary damages or lost profits, even if licensor has been advised of the possibility of such damages.
10. **Trademark.** All ZIV trademarks (including ZIVERCOM, ZIVERLOG and ZIVERSYS) are common law trademarks of Licensor. No right, license or interest to such trademarks is granted hereunder, and you agree that no such right, license or interest shall be asserted by you with respect to such trademark.
11. **Licensee's Indemnity.** You shall defend, indemnify and hold Licensor harmless against any loss or damage of any kind arising from a breach by you of this License Agreement, or any use or misuse of the Software by you or your employees, agents or representatives, and from any other of your conduct or from any claim or action by any of your customers in connection with the Software or this License Agreement.
12. **Governing Law.** This License Agreement shall be construed and governed in accordance with the internal laws of the State of Illinois, U.S.A.
13. **No Waiv**er. The failure of either party to enforce any rights granted hereunder or to take action against the other party in the event of any breach hereunder shall not be deemed a waiver by that party as to subsequent enforcement of rights or subsequent actions in the event of future breaches.
14. **Entire Agreement**. This License Agreement is the entire agreement between you and Licensor with respect to the use of the software and supersedes all prior understandings or agreements between the parties. This License Agreement may be amended only by a writing signed by an officer of Licensor.

ZIV Aplicaciones y Tecnología, S.L.
Parque Tecnológico, 2089
48016 Zamudio (Vizcaya)
48080 Bilbao
Spain

Table of Contents

Annex B. MODBUS RTU Protocol

Annex C. Schemes and Drawings

Annex D. List of Illustrations and Tables

Annex E. Warranty

1. Description

The **MXI** protection relay is designed for generator/motor protection using state-of-the-art digital technology.

The **MXI** digital design is based on a powerful microprocessor to provide protection for undercurrent, current unbalance, thermal overload, short-circuits, ground faults, blocked rotor, maximum number of startings, with additional control and metering functions.

MXI units can be applied on medium to high voltage motors, and small to medium power generators, where a reliable protection is needed.

1.1 Functions

- **Thermal Unit (49)**

The unit incorporates a thermal unit that uses as input the equivalent current calculated from the measured positive and negative sequence currents. The unit can be enabled or disabled through setting.

- **Undercurrent Unit (37)**

MXI relays incorporate an undercurrent unit that detects when the machine works under a small electrical load. This element is activated if the direct sequence current falls below a set value. The unit can be enabled or disabled through setting.

- **Zero Sequence Unit - Ground Instantaneous Overcurrent Protection) (50N) (MXI-A Model)**

The equipment incorporates an overcurrent instantaneous element for ground fault protection, with additional adjustable time delay. The unit can be enabled or disabled through setting.

- **Zero Sequence Unit - Ground Time Overcurrent Protection) (51N) (MXI-B Model)**

The equipment incorporates an overcurrent time element for ground fault protection, with additional adjustable time delay. The unit can be enabled or disabled through setting.

The unit also provides with four selectable actuation curves: inverse, very inverse, extremely inverse and definite time.

- **Number of Startings Control Unit (66)**

The number of startings control unit restricts the number of consecutive startings of a machine. The unit can be enabled or disabled through setting.

- **Negative Sequence Unit (Current Unbalance Protection) (46)**

The equipment has a negative sequence measuring unit that can be used with an inverse curve or fixed time characteristic. The unit can be enabled or disabled through setting.

- **Positive Sequence Unit (Phase Instantaneous Overcurrent Protection) (50) (MXI-A Model)**

The unit incorporates an overcurrent instantaneous positive sequence element with an additional adjustable time delay. The unit can be enabled or disabled through setting.

- **Positive Sequence Time Unit (Phase Time Overcurrent Protection) (51) (MXI-B Model)**

The unit incorporates an overcurrent time positive sequence element with an additional adjustable time delay. The unit can be enabled or disabled through setting.

The unit also provides with four selectable actuation curves: inverse, very inverse, extremely inverse and definite time.

- **Blocked Rotor Detection Unit (51RB)**

This equipment detects potential rotor blocking. The detection operates via a positive sequence overcurrent instantaneous unit with an additional adjustable time delay. The unit can be enabled or disabled through setting.

1.2 Additional Functions

- **Lockout Element**

The lockout element activates a signal when a trip occurs. The signal stays active until reset from the HMI or a digital input.

- **LED Targets**

Front panel indication consists of eight LEDs. Seven of the LEDs are user programmable. The other LED is assigned to indicate that the System is Ready (powered up, self-test OK). A list of available signals for LED programming is included in Chapter 6.

- **Status Contact Inputs**

There are two status contact inputs in the unit, both of them programmable. A list of available signals for Input programming is included in Chapter 6.

- **Auxiliary Contact Outputs**

There are three auxiliary contact outputs in the unit, two of which are programmable. Auxiliary output AUX-3, which corresponds to Unit in Service (powered up, self-test OK), is not programmable. A list of available signals for Output programming is included in Chapter 6.

- **Trip Contact Output**

MXI units have a trip contact output made of two contacts NO or NC configurable with internal jumpers.

- **Phase Selection**

The **MXI** relays can operate with 2 or 3 phase currents. A setting is available for choosing between both options.

- **Oscillography**

The oscillography has two separate functions: capture of information and display.

- **Local Information (display*)***

Available through the display on the HMI:

- Operations:

Last Trip (tripped unit)
Units Status (pickup)
Activated Inputs / Outputs

- Metering:

Positive Sequence Current
Negative Sequence Current
Thermal Status

- **Self-testing and Monitoring**

A continuously running diagnostic self-test program verifies the correct operation of the terminal unit and alerts the user of potential problems.

1.3 Model Selection

	MXI									
1		2	3	4	5	6	7	8	9	10	11

1	**Selection**					
	3	Vertical Format		**8**	Horizontal Format	
2	**Functions**					
	A	37+46+49+50+50N+51RB+66		**B**	37+46+49+51+51N+51RB+66	
3	**Rated Current**					
	1	If = 5A // In = 1A		**3**	If = 5A // Ins = 20mA	
	2	If = 5A // In = 5A		**5**	If = 1A // In = 1A	
4	**Options**					
	T	Oscillography				
5		**Power Supply**	**Status Contact Inputs**		**Power Supply**	**Status Contact Inputs**
	1	24 - 48 Vdc (*)	24 - 48 Vdc	**3**	220 - 250 Vdc (*)	48 - 250 Vdc
	2	110 - 125 Vdc (*)	24 - 125 Vdc	**4**	230 Vac	230 Vac
6	**Frequency / Language**					
	0	50Hz, Spanish		**A**	50Hz, English	
	2	60Hz, English		**C**	60Hz, Spanish	
7	**Communications**					
	1	RS232 + RS232		**4**	RS232 + Glass Fiber Optic (ST)	
	2	RS232 + Plastic Fiber Optic (1 mm.)		**5**	RS232 + RS485	
	3	RS232 + Glass Fiber Optic (SMA)				
8	**Remote Communications**					
	0	Standard		**1**	Option 0 + RS232 remote (**)	
9	**Special Models**					
	00	Standard		**15**	Optional Ground Range (0.1 x 30) x In	
10	**Type of Enclosure**					
	D	6 x 1/7 19" rack		**V**	19" rack, 6U	
11	**Communication Protocols**					
	A	Protec. no PROCOME + without Control		**F**	Protec. no PROCOME + Control MODBUS and PROCOME	
	B	Protec. no PROCOME + Control PROCOME				

(*) ±20
(**)only if COMMUNICATIONS = 1

- **Functions**

37	Undercurrent Unit.
46	Negative Sequence Unit (Current Unbalance Protection).
49	Thermal Element Protection.
50	Phase Instantaneous Overcurrent.
51	Phase Time Overcurrent.
50N	Ground Instantaneous Overcurrent.
51N	Ground Time Overcurrent.
51RB	Blocked Rotor Detection Unit.
66	Number of Startings Control Unit.

2. Technical Data

2.1 Power Supply Voltage

Selectable range depending on model:	
	24 - 48Vdc (±20%) **110 -125Vdc (±20%)** **220 - 250Vdc (±20%)** **230 Vac (±20%)**

Note: In case of power supply failure, a maximum interruption of 100 ms is allowed for 110Vdc input.

2.2 Power Supply Burden

Quiescent	**7 W**
Maximum	**20 W**

2.3 Current Analog Inputs

Rated Value	**In∅** or **N** = **5 A** or **1 A** (depending on the model) **InN = 20 mA** (optional for ground)
Thermal Withstand Capability	**4 In** (continuously) **50 In** (for 3 s) **100 In** (for 1 s)
Dynamic Limit	**240 In**
Current Circuit Burden	**<0.2 VA** (In = 5 A) **<0.05 VA** (In = 1 A)

2.4 Measuring Accuracy

Measured currents	
Internal measure accuracy	**< 5 %** or **20mA** (the greater) (for In = 1A or 5A)
Measuring times	
Definite and Inverse Time characteristic (UNE 21-136 and CEI 255)	**<5 %** or **25ms** (the greater)

2.5 Repeatability

Operating Time	**2 %** or **25 ms** (the greater)

2.6 Digital Inputs

Two electrically separate, user programmable status contact inputs

Status Contact Input Voltage Range	**24 - 125 Vdc (±20%)**
(range selectable depending on model)	**48 - 250 Vdc (±20%)**
Current Drain	**<5 mA**

2.7 Trip Output

Trip Output

The system has a trip output with two electrically separate contacts, NA or NC and an auxiliary output (AUX-1) with a commutable contact NA or NC configurable internally.

I DC maximum limit (with resistive load)	**30 A** for 1 s.
I DC continuous service (with resistive load)	**8 A**
Close	**2500 W**
Breaking capability (with resistive load)	**150 W** (max. **8 A**) up to **48 Vdc**
	55 W (**80 Vdc - 250 Vdc**)
	1250 VA
Break (L/R = 0.04 s)	**60 W** to **125 Vdc**
Switching Voltage	**250 Vdc**
Momentary close time trip contacts remain closed	**100 ms.**

2.8 Auxiliary Outputs

Auxiliary Outputs	
2 Commutable Contact Outputs NA or NC	
I DC maximum limit (with resistive load)	**5 A** for 30 s.
I DC continuous service (with resistive load)	**3 A**
Close	**2000 W**
Breaking capability (with resistive load)	**75 W** (max. **3 A**) up to **48 Vdc** **40 W** (**80 Vdc - 250 Vdc**) **1000 VA**
Break (L/R = 0.04 s)	**20 W** to**125 Vdc**
Switching Voltage	**250 Vdc**

2.9 Communications Link

Glass Fiber Optics	
Type	**Multimode**
Wavelength	**820 nm**
Connector	**ST**
Transmitter Minimum Power	
50/125 Fiber	**- 20 dBm**
62.5/125 Fiber	**- 17 dBm**
100/140 Fiber	**- 7 dBm**
Receiver Sensitivity	**- 25.4 dBm**

Plastic Fiber Optics (1 mm)	
Wavelength	**660 nm**
Transmitter Minimum Power	**- 16 dBm**
Receiver Sensitivity	**- 39 dBm**

RS232C Port Signals	
Terminal unit DB-9 (9-pin) front and rear connectors	**Pin 5 - GND** **Pin 2 - RXD** **Pin 3 - TXD**

RS485 Port Signals	
Used Signals	**A (-)** **B (+)**

3. Standards and Type Tests

3.1 Insulation

Insulation Test	*IEC-255-5*
Between all circuit terminals and ground:	**2 kV, 50 Hz**, for 1 minute
Between all circuit terminals:	**2 kV**, **50 Hz**, for 1 minute
Voltage Impulse Test	*IEC-255-5 (UNE 21-136-83/5)*
	5 kV; **1.2/50 µs**; **0.5 J**

3.2 Electromagnetic Compatibility

1 MHz Burst Test	*IEC-255-22-1 Class III*
	(UNE 21-136-92/22-1)
Common mode:	**2.5 kV**
Differential mode:	**1.0 kV**
Fast Transient Disturbance Test	*IEC-255-22-4 Class IV*
	(UNE 21-136-92/22-4)
	(IEC 1000-4-4)
	4 kV ±**10 %**
Radiated Electromagnetic Field Disturbance	*IEC 1000-4-3*
Amplitude modulated *(EN 50140)*	**10 V/m**
Pulse modulated *(EN 50204)*	**10 V/m**
Conducted Electromagnetic Field Disturbance	*EN 50141*
Amplitude modulated	**10 V**
Electrostatic Discharge Test	*IEC 255-22-2 Class III*
	(UNE 21-136-92/22-2) (IEC 1000-4-2)
	±8 kV ±**10 %**

Radio Frequency Emissivity	*EN 55011 (IEC 1000-4-6)*

3.3 Climatic

Temperature	*IEC 255-6*
Operating range:	**-10 ºC to + 55 ºC**
Storage range:	**-25 ºC to + 70 ºC**
Humidity:	**95 %** (non-condensing)

3.4 Power Supply

Power Supply Ripple	*IEC 255-11 / UNE 21-136-83 (11)* **< 20 %**

3.5 Mechanical

Vibration Test (sinusoidal)	*IEC-255-21-1 Class I*
Shock and Bump Test	*IEC-255-21-2 Class I*

The models comply with the EEC 89/336 standard of electromagnetic compatibility

4. Physical Architecture

4.1 General

MXI protection terminals consist of a circuit board with the following functions:

- Power Supply
- Central Processing Unit
- Analog Input Transformers
- Contact Inputs and Outputs

Depending on the terminal settings, contact inputs / outputs may be used or remain as spare signals.

Figures 4.1 and 4.2 show terminal unit front panels for **3MXI** series and **8MXI** series respectively. Dimensions of the front panels are specified at the end if this instruction manual.

Keypad, alphanumeric display, LED targets, and local communications port are located on the front panel.

The rear panel includes the circuit board connectors. The rear panel view is shown in figure 4.3 for the **8MXI** model, and in figure 4.4 for the **3MXI** model. There is one connector block for power supply and status contact inputs/outputs (20 terminal in total) and another block for the analog inputs from the transformer secondary circuits.

The rear panel includes the remote communication port.

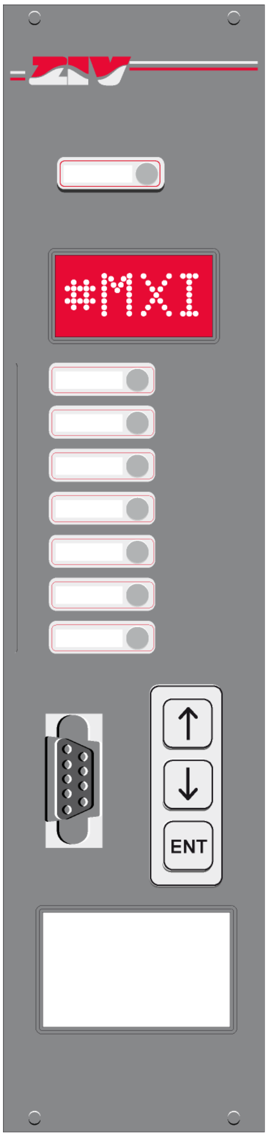


Figure 4.1: 3MXI Front View (6U x 1/7 rack).

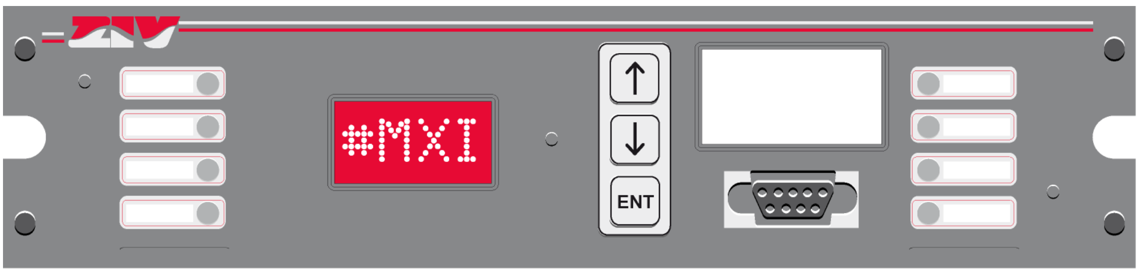


Figure 4.2: 8MXI Front View (1/7 rack x 6U).

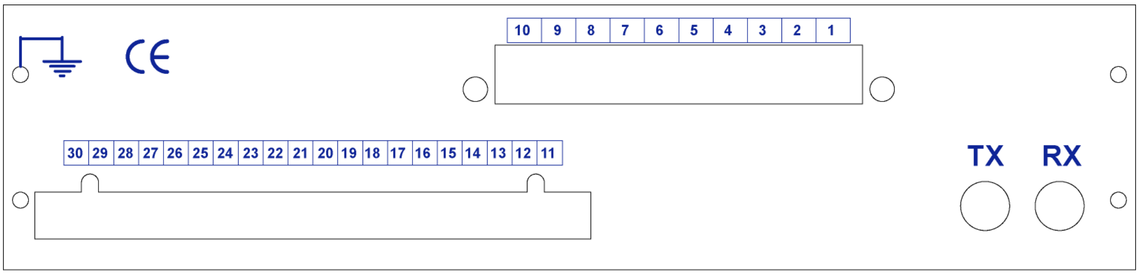


Figure 4.3: 8MXI Rear View.

4.2 Dimensions

MXI protection terminal case dimensions are 1/7 of a 19" rack wide, and 6 standard rack units high (10½"). **3MXI** terminals are vertical mount units, and **8MXI** terminals are horizontal mount units. The equipment is intended to be installed either semi-flush mounted on panels or inside a 19" rack. The **MXI** is equipped with a transparent cover which can be sealed for security purposes. The enclosure colour is graphite.

Note: 8MXI models are designed to be mounted on 1 Rack wide x 2U high adapter element. Dimension drawings for this adapter are given at the Annex D of this instruction manual.

4.3 Connection Elements

4.3.1 Terminal Blocks

Terminal connectors are permanently attached to the rear edge of the printed circuit board to facilitate external wiring and are arranged in rows (**8MXI**) or columns (**3MXI**) depending on the model: 1 row or column of 10 terminal connectors for transformer secondary inputs and 1 row or column of 20 terminal connectors for power supply input and contact inputs and outputs.

Voltage analog input terminals accept up to #11 AWG wire. The remaining circuit terminals permit wire up to #14 AWG. Communications connectors are provided on both front and rear equipment panels.

4.3.2 Removing Printed Circuit Boards (Non Self-shorting)

The equipment has been designed to enable removal of the printed circuit board. The printed circuit board is attached to the case using self-tapping screws. These screws must be removed before the board is withdrawn. It is also necessary to remove the screws on the terminal connectors.

4.3.3 Internal Wiring

The equipment uses traditional printed circuit board connections and internal buses to minimize internal wiring.

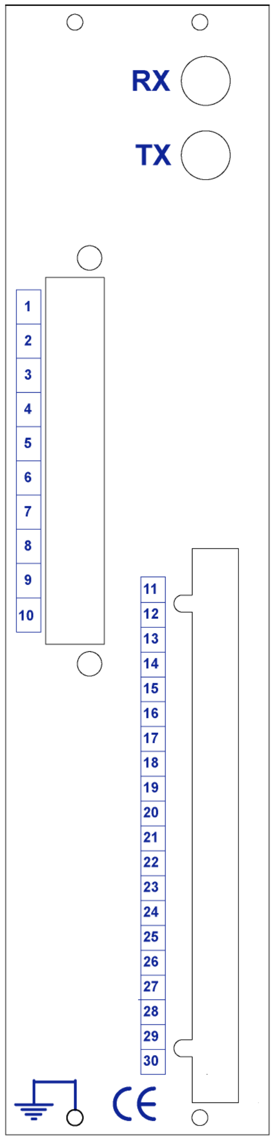


Figure 4.4: 3MXI Rear View.

5. Settings

5.1 Configuration Settings

Communications (Local Port Settings)	
Setting	**Range**
Terminal Address	All
Baud Rate	4800 Bauds
Stop Bits	1
Parity	1 (Parity) / 0 (No parity)

Communications (Remote Port Settings)	
Setting	**Range**
Terminal Address	0 to 254
Baud Rate	300 to 19200 Bauds
Stop Bits	1 or 2
Parity	1 (Parity) / 0 (No parity)
Communications Timeout	0 - 100 ms
MODBUS Protocol	YES / NO (Note)

Language	
Setting	**Range**
Language	Spanish / English

Frequency	
Setting	**Range**
Frequency	50 / 60 Hz

Note: Depending on the software version.

5.2 General Settings

General Settings		
Setting	**Range**	**Step**
Phase CT Ratio	1 - 3000	1
Ground CT Ratio	1 - 3000	1
Number of phases	2 - 3	
Event masking (only through communications)		

5.3 Protection Elements Settings

Thermal Element		
Setting	**Range**	**Step**
Enable	YES / NO	
Pickup	0.3 - 2 In	0.01 A
Time constant (heating and cooling) with engine on (τ_c)	1 - 100 min	0.01 min
Time constant (cooling) with engine off (τ_e)	1.00 - 10 x τ_c	0.01 min
Alarm Level	50 - 100 %	1 %
Connection Permission Level	30 - 90 %	1 %
Inverse Sequence Overvaluation (Ki)	1 - 10	1
Thermal Element Latch Enable	YES / NO	

Undercurrent Element		
Setting	**Range**	**Step**
Enable	YES / NO	
Pickup (in times I maximum -It-)	0.2 - 0.9 x It	0.01
Time Delay (MXI-A Models)	0.00 - 100 s	0.01 s

Ground Element (MXI-A Models)		
Setting	**Range**	**Step**
Enable	YES / NO	
Pickup (Io>) Ground standard (1 A or 5 A) Special Model 15 (1 A or 5 A) Ground In=20 mA	 0.04 - 0.48 In 1 - 30 In 0.8 - 10 mA	 0.01 A 0.01 A 0.01 mA
Time Delay	0.00 - 100 s	0.01 s

Ground Element (MXI-B Models)		
Setting	**Range**	**Step**
Enable	YES / NO	
Pickup (Io>) Ground Standard (1 A or 5 A) Special Model 15 (1 A or 5 A) Ground In=20 mA	 0.04 - 0.48 In 1 - 30 In 0.8 - 10 mA	 0.01 A 0.01 A 0.01 mA
Time Curve	Definite Time, Inverse, Very Inverse, Extrem. Inverse	
Time Dial	0.05 - 1	0.01
Time Delay	0.05-100 s	0.01 s

Number of Startings Control Element		
Setting	**Range**	**Step**
Enable	YES / NO	
Number of Startings	1 - 15	1
Time Interval	1 - 120 min	1 min
Pickup Current	0.2 - 15 In (phase)	0.1 A
Pickup Time Delay	0.30 - 80 s	0.1 s
Minimum Time that Output remains active	5 - 100 min	1 min

Negative Sequence Element		
Setting	**Range**	**Step**
Enable	YES / NO	
Curve Mode (inverse) Curve Initiate Value (Icur) Dial	YES / NO 0.1 - 1.0 0.1 - 1.0	 0.01 0.1
Fixed Time Mode (Curve Mode set on NO) TOC Pickup (in times I maximum -It-) Time Delay (MXI-A Models) Time Delay (MXI-B Models)	 (1 - 8) x It 0.00 - 100s 0.05 - 100s	 0.1 0.01s 0.01s

Positive Sequence Instantaneous Element (MXI-A Models)		
Setting	**Range**	**Step**
Enable	YES / NO	
IOC Pickup (in times I maximum -It-)	(1.00 - 12) It	0.01 It
Time Delay	0.00 - 100s	0.01s

Positive Sequence Time Element (MXI-B Models)		
Setting	**Range**	**Step**
Enable	YES / NO	
TOC Pickup (in times I maximum -It-)	(1.00 - 12) It	0.01 It
Time Curve	Definite Time, Inverse, Very Inverse, Extrem. Inverse	
Time Dial (Inverse Curve)	0.05 - 1	0.01
Time Delay (Fixed Time Curve)	0.05 - 100s	0.01s

Blocked Rotor Element		
Setting	**Range**	**Step**
Enable	YES / NO	
Pickup (in times I maximum -It-)	(1.00 - 12) It	0.1 It
Time Delay	0.00 a 100 s	0.01 s

5.4 Logic Settings

Logic Settings (Via Communications Only)	
Setting	**Range**
Trip Output Seal-in Enable	YES / NO
Trip Mask	
Positive Sequence Element	YES / NO
Negative Sequence Element	YES / NO
Zero Sequence Element	YES / NO
Thermal Element	YES / NO
Blocked Rotor	YES / NO
Number of Pickups Control Element	YES / NO
Undercurrent Element	YES / NO

5.5 Oscillography

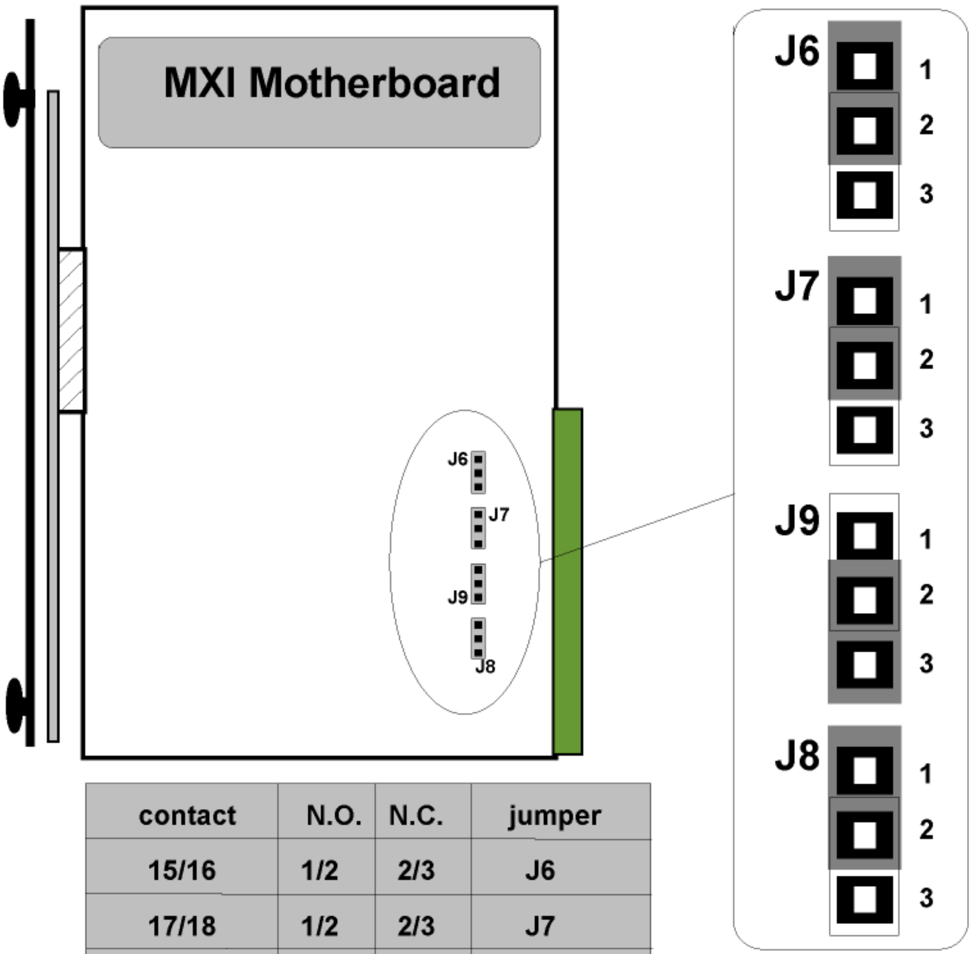
Oscillography		
Setting	**Range**	**Step**
Recording Mode (Fixed Time)	YES / NO YES = fixed time NO = variable time	
Overwrite	YES / NO	
Trigger Mode	0 = pickup 1 = trip 1 2 = trip 2	
Pre-Fault Time	1 - 2 cycles	
Record Length	20 - 300 cycles	1

Trigger Functions (Trip Mask)	
Setting	**Range**
Positive Sequence	YES / NO
Negative Sequence	YES / NO
Zero Sequence	YES / NO
Thermal	YES / NO
Blocked Rotor Element	YES / NO
Number of Startings	YES / NO
Undercurrent	YES / NO
Opening Command	YES / NO
External Pickup	YES / NO

Channels	
Setting	**Range**
Phase A	YES / NO
Phase B	YES / NO
Phase C	YES / NO
Ground	YES / NO

5.6 Status Contact Inputs, Auxiliary Contact Outputs and LED Targets

Status Contact Inputs, Auxiliary Contact Outputs and LED Targets Configuration
Users can easily program different input, output and LED target configurations via the local RS232 communications port, using the ***ZIVercom***© software. The auxiliary contact outputs and AUX-1 are configurable as N.O or N.C contacts using internal jumpers located as described in Figure 5.1.



contact	N.O.	N.C.	jumper
15/16	1/2	2/3	J6
17/18	1/2	2/3	J7
19/20	1/2	2/3	J8
19/21	2/3	1/2	J9

Figure 5.1: Internal Jumpers Output Configuration.

6. Description of Operation

6.1 Positive Sequence Element

6.1.1 Positive Sequence Instantaneous Element (MXI-A Models)

The positive sequence element is an overcurrent protection unit that works with an instantaneous element, linked to the phase current status inputs IA, IB and IC. This instantaneous element measures the current RMS value and becomes active when the RMS value exceeds the set pickup value. Reset takes place when the positive sequence value falls below 0.95 times the set value. The instantaneous element comes with a timer that can be set and allows an optional time delay of the instantaneous trips.

The following parameters of the direct sequence unit can be set:

- Enable
- Pickup
- Time

The trip permit of the positive sequence unit can be modified by the trip mask available in the logic (only via communications). A given group of elements will trip only when the setting and the corresponding mask are programmed according.

6.1.2 Positive Sequence Time Element (MXI-B Models)

The Time Overcurrent element continuously processes the RMS value of overcurrent analogic inputs IA, IB and IC. Pickup takes place when the measured value exceeds 1 time the pickup setting, and reset takes place when current value falls below 0.95 times the set value.

The time element integrates a measured value above pickup by incrementing a counter in the integrator module using an amount proportional to the input current RMS value. When the counter reaches the operate threshold, the Time Overcurrent element initiates a trip.

When the measured value drops below the pickup setting, the incrementing value is removed, causing a rapid reset of the integrator module to its initial condition with the counter at zero. Any new measured value above pickup must then start the integration interval from zero.

Three inverse time curves (Inverse, Very Inverse and Extremely Inverse), one definite time delay and one user defined time curve can be selected. Time-current characteristic curves have two independent settings: curve family, and time dial.

- **Time/Current Characteristics**

Figures 6.1, 6.2 and 6.3 show the pre-programmed time/current characteristic curves provided with the **MXI** Terminal Unit.

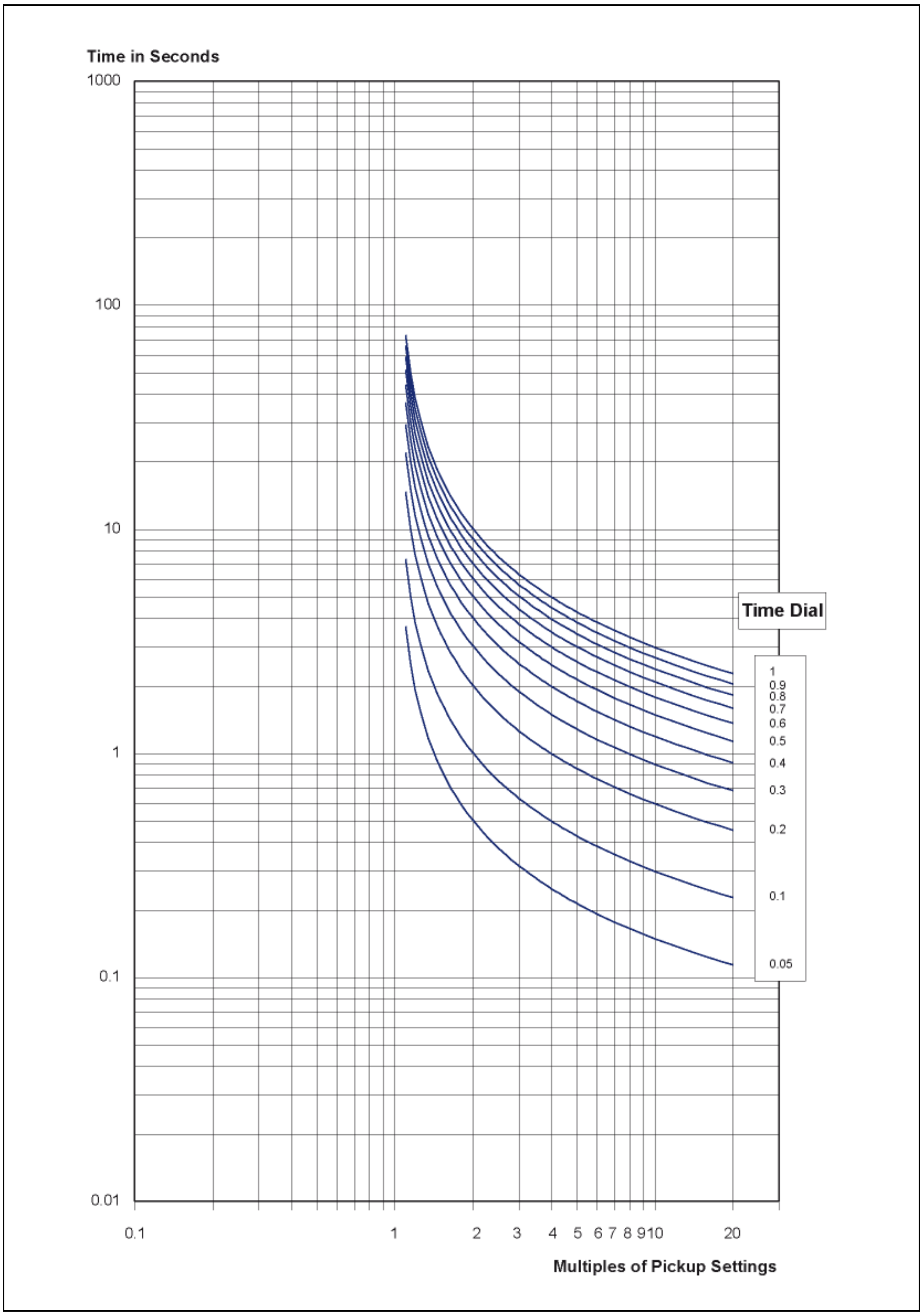


Figure 6.1: Inverse Time/Current Characteristic.

$$t = \frac{0.14}{I_s^{0.02} - 1}$$

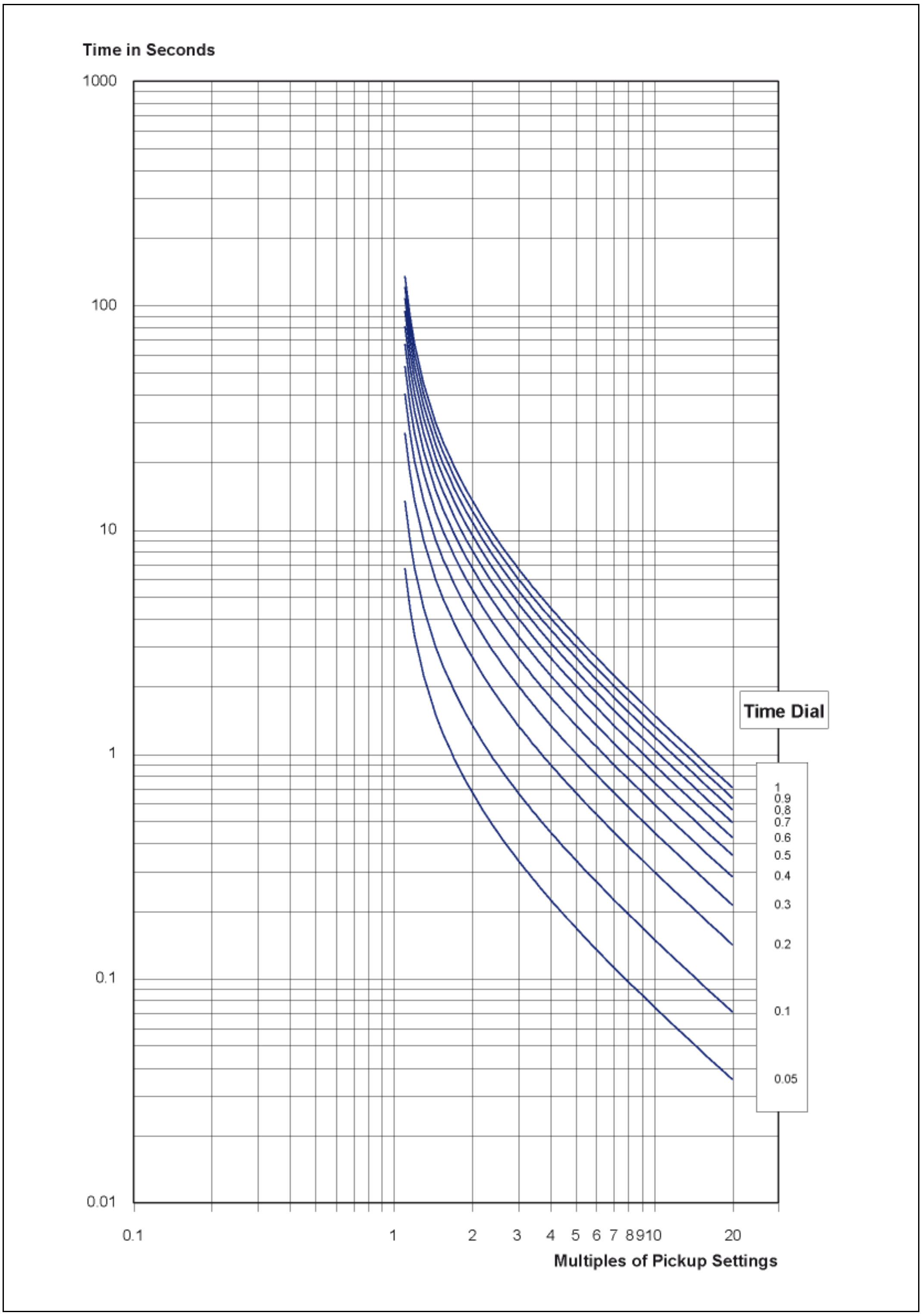


Figure 6.2: Very Inverse Time/Current Characteristic.

$$t = \frac{13.5}{I_S - 1}$$

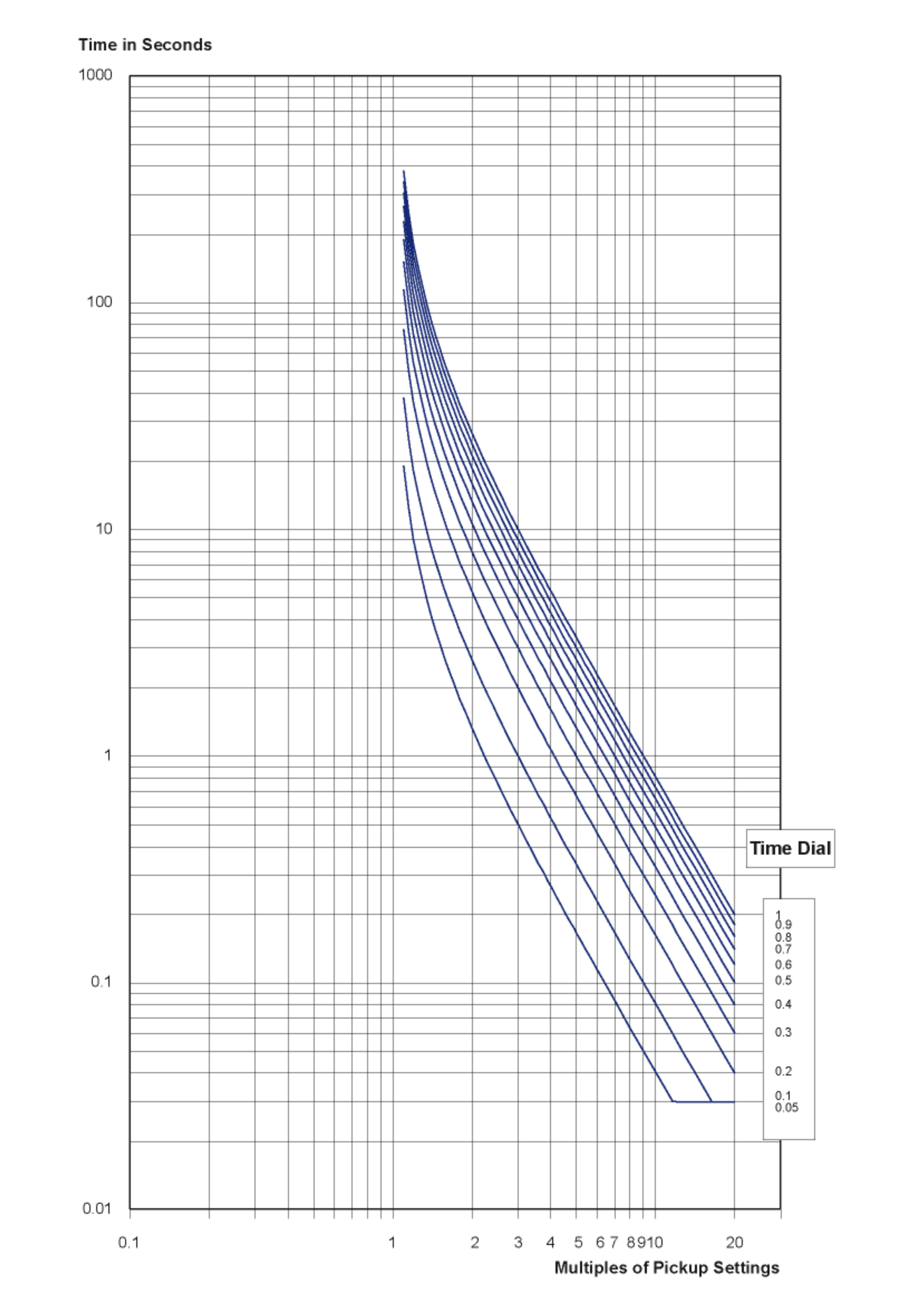


Figure 6.3: Extremely Inverse Time/Current Characteristic.

$$t = \frac{80}{I_s^2 - 1}$$

6.2 Negative Sequence Element

The Negative Sequence Element detects currents unbalance in the machine to be protected by measuring the Negative Sequence content in the line current.

Pickup of the unit takes place when the Negative Sequence value exceeds the set pickup value and reset takes place when current value falls below 0.95 times the set value.

The negative sequence element can be set to operate with inverse curve or fixed time characteristics.

The Negative Sequence Element also has a enable setting that can be modified by the trip mask available in the logic (only via communications). Trip of the element will only occur when both the enable setting and the corresponding mask are programmed according.

6.2.1 Inverse Time/Current Characteristic

Figure 6.4 shows the family of inverse time curves of the negative sequence element provided with the **MXI** relay.

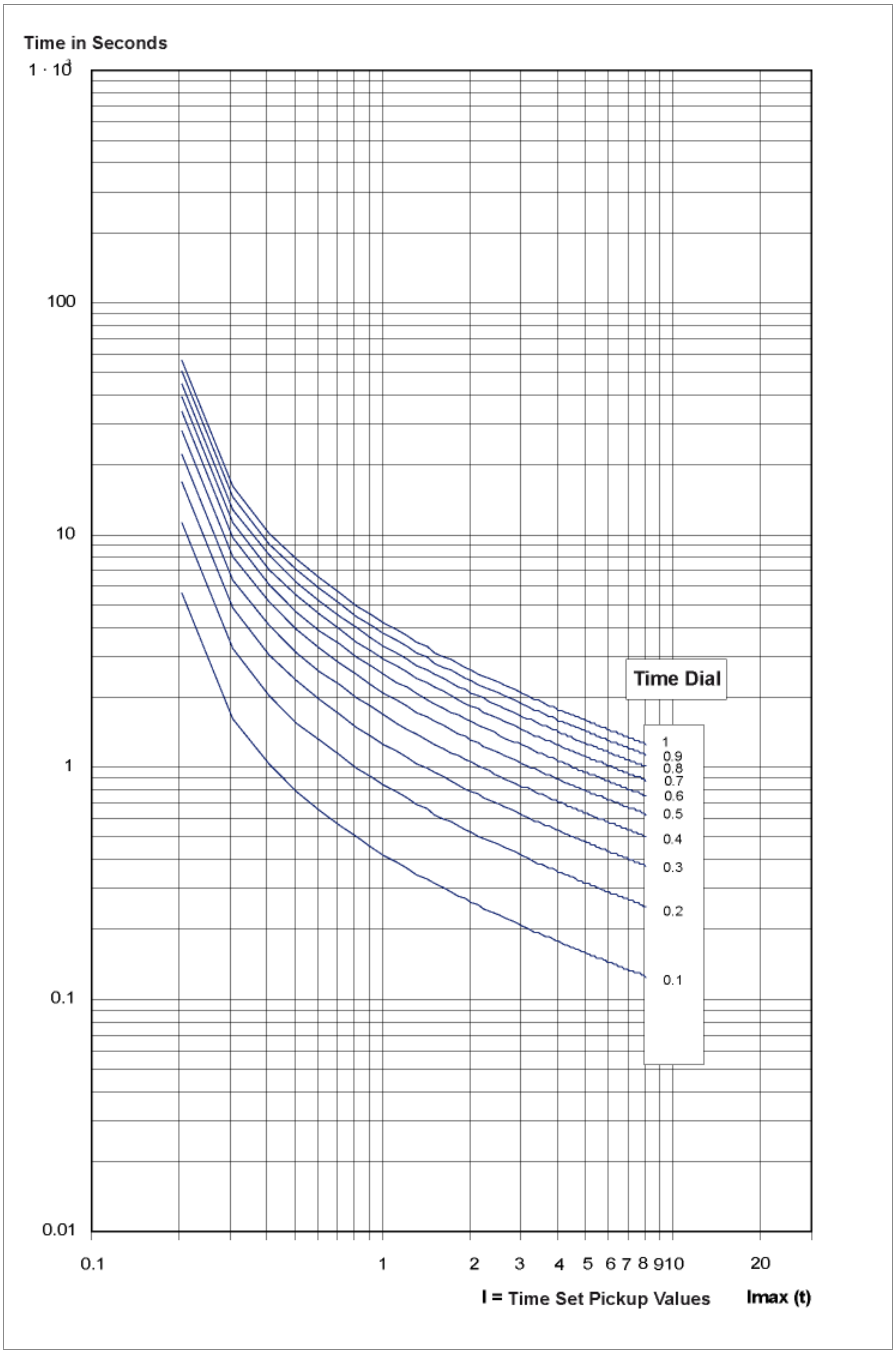


Figure 6.4: Inverse Time Curve.

$$t = \left[\frac{8}{(I \cdot 6)^{0.38} - 1} \cdot 0.5 + 0.06 \right] \cdot TimeDial$$

6.3 Undercurrent Element

The undercurrent element has an instantaneous element with an additional adjustable time delay. The element operates when it comes from a motor starting condition and a current value below 0.95 times the pickup setting x It is detected and resets when the current value is greater than 1 time the pickup setting x It.

If the “machine off” status is detected ((Id<0.15 * It), the element is disabled.

Note: “Starting condition” is determined when the positive sequence current is greater than “Maximum number of startings element” pickup setting value for a time defined in this element.

6.4 Ground Element

6.4.1 Instantaneous Ground Element (MXI-A Models)

The Instantaneous Ground Element acts in the same manner as the Positive Sequence Instantaneous Element (see 6.1.1).

6.4.2 Timer Ground Element (MXI-B Models)

The Timer Ground Element acts in the same manner as the Positive Sequence Timer Element (see 6.1.2).

6.5 Blocked Rotor Element

The blocked rotor element detects an eventual blocking of the rotor. Blocked rotor causes the starting conditions to remain as long as the machine is powered: the current increases to reach 6 or 8 times the load current.

The unit acts in the same way as the Positive Sequence element with its own settings.

6.6 Number of Startings Element

Starting conditions are determined to be when the positive sequence current is greater than the starting current setting during the time defined by the starting time setting, and later falls below 0.15 x It for 100 ms.

The number of startings element restricts the number of consecutive startings in a machine. Settings are available for the time interval, the maximum number of pickups during the interval, and a fixed time for trip output sealing.

Each time a start takes place, a counter is activated and the Number of Startings (NS) is incremented by "1". The Excessive Number of Startings Unit becomes active when the NS value reaches the pre-set number of pickups. If the positive sequence current value is below 0.15 x It for 100ms (motor stopped), the breaker trips. Reset of the element occurs when:

- The number of startings is below the set value in the time interval; or when
- Trip output sealing times out (Note)

The number of startings setting indicates how many startings can occur before the element trips. If the number of startings were set on 2, then the unit would trip after attempting to start the machine twice.

Note: If the trip output disappears before the time defined by the time window, the element resets when said window times out.

6.7 Thermal Overload Element

The thermal element input is the Equivalent Current calculated from measured positive and negative sequence currents according to the equation:

$$Ieq^2 = I1^2 + Ki \cdot I2^2$$

I1: Positive Sequence Current
I2: Negative Sequence Current
Ki: Negative Sequence Constant

The equation considers the fact of Negative sequence component having a greater contribution to machine heating than the positive sequence component.

Two different time constants will be used: one heating and cooling constant with the machine on (τ_c) and one cooling constant with the machine off (τ_e).

Heating: $$t = \tau c \cdot \ln \frac{I^2eq - I^2p}{I^2eq - I^2max}$$

Cooling: $$t = \tau_c \cdot \ln \frac{\vartheta_i}{\vartheta_f}$$ (machine on)

$$t = \tau e \cdot \ln \frac{\vartheta_i}{\vartheta_f}$$ (machine off)

Ieq = equivalent current from **I1** and **I2** (positive and negative sequence currents)
Ip = starting current, in the case of a start with the machine off (Ip = 0)
Imax = maximum current (Thermal Element Setting)
ϑ**i** = initial temperature
ϑ**f** = final temperature

6.7.1 Thermal Memory

The purpose of the thermal memory is to maintain the thermal image of the protected machine when a loss of power occurs to the protective relay. The thermal status and the time stamp is stored in REAL TIME in the relay non-volatile RAM.

6.7.2 Thermal Characteristic

Figure 6.5 shows the family of thermal curves:

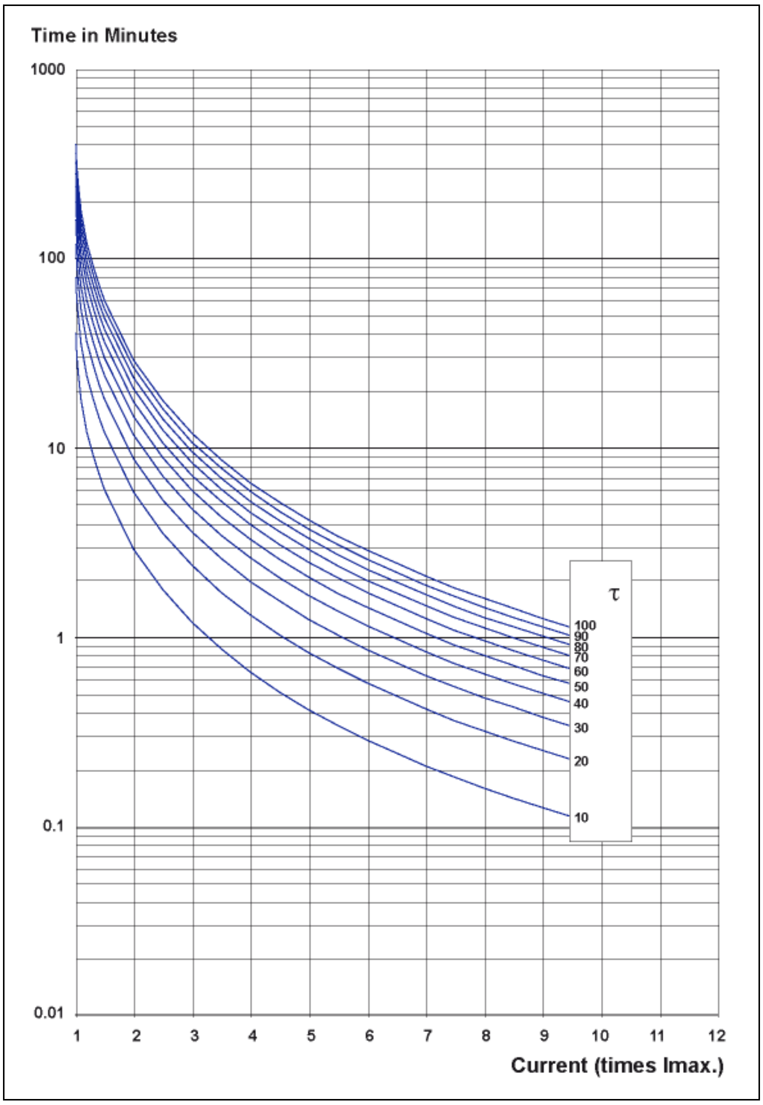


Figure 6.5: **Thermal Element Curves.**

6.8 Lockout Element

A trip by any of the protective functions in the relay activates the Lockout function (if enabled). Once active, the function will remain active until a manual Lockout Reset command is received via the local HMI, via communications or via a programmed digital input.

The Lockout status is stored in volatile memory. Loss of power will reset the Lockout conditions.

6.9 General Settings

- **Current Transformer Ratio**

The CT Ratio defines the way in which analog values are displayed in the ***ZIVercom***© communication program.

If the CT Ratio is set to 1, secondary values are displayed. Setting the CT ratio to the actual CT ratio, primary values are displayed.

The HMI always displays secondary values.

- **Phase Number**

The Phase Number setting allows using only two phases (setting on 2), the relay calculates the values for the third phase. If three phases are used, the setting has to be 3.

- **Events Masks (Via Communications Only)**

It is possible to mask events that are not necessary for analysis and troubleshooting. This function is only available via communications.

6.10 Trip Masks

There is a group of settings (available only via communications) to control the operation of the protective trips. The Trip elements controlled by this logic setting are:

I1: Positive Sequence
I2: Negative Sequence
I0: Zero Sequence
Thermal Element
RB: Rotor Block
Number of Startings
Minimum Current

The masked units remain in service but do not activate the trip contacts. The protection unit signals are recorded in the event recorder and can be used to program LED's or Auxiliary Outputs. The trip mask setting set to NO prevents the trip contact to operate. This setting still allows the unit to realize all the process, from the pickup to the trip generation. The setting set to YES permits activation of the trip contacts.

Action of the setting defined in trip mask depends also of the activation of the corresponding unit, within its own protection settings, as if the unit is deactivated, pickup of the unit is not initiated.

Warning: De-activation of all the units in the trip mask disables the operation of the trip contacts. Make sure that at least one unit has the trip mask activated.

6.11 Event Recording

Each protection function of the protection annotates an event in Event Record when one of the situations listed in Table 6-1 occurs.

Table 6-1: Event Recording

Function	Event	Byte	Bit
Pickup and Trip Outputs Activated [OC], [OD], [10], [2A], [2F], [5B]	Positive Sequence Unit Pickup	3	4
	Ground Unit Pickup	1	8
	Positive Sequence Unit Output Active	3	6
	Ground Unit Output Active	2	8
	Protection Alarm Active (Out of Service)	3	2
	Negative Sequence Unit Overcurrent Pickup	1	1
	Negative Sequence Unit Overcurrent Output Pickup	1	2
	Undercurrent Instantaneous Pickup	2	4
	Oscillography Trigger (optional)	3	5
	Thermal Unit Alarm Level Active (generic)	1	8
	Thermal Unit Alarm Level Active	3	1
	Blocked Rotor Detection Unit Active	2	1
	Maximum Number of Startings Active	2	2
	Lockout Active	3	1
	Lockout Local Reset (via digital inputs)	3	2
	Lockout Manual Reset (via HMI or communications)	3	3
Inputs [3D]	Status Contact Input IN-1 Active	1	1
	Status Contact Input IN-2 Active	1	2

- **Events Record Management**

The event record capacity is one hundred (100) events. When the record is full, a new event displaces the oldest event. The event record capacity is one hundred (100) events. When the record is full, a new event displaces the oldest event:

- Ground, positive sequence and negative sequence current values measured at the time of the event
- Date and Time of event
- Description of the event

The management of the event recorder is optimized so that simultaneous operations generated by the same event occupy a single position in the event memory. For example, the simultaneous occurrence of the Ground and Direct Sequence Pickups are recorded in the same memory position. However, if the occurrences were not simultaneous, two separate events would be generated. Simultaneous events are defined as those operations that occur within a 1 ms interval, the resolution time of the recorder.

It is reminded that the possibility to mask unnecessary events exists. Events can be masked via communications in the General Settings menu.

Warning: it is convenient to mask events that could be generated in excess, fill the event recorder (100 events) and cause anterior more relevant events to be erased. For the open phase unit for example, when the line charge is small, pickups and resets of the open phase can be constantly generated.

- **Access to the Event Record Information**

The ***ZIVercom***© communications and remote management software program is used for reading event record information. The information will appear decoded and separated for each input in the table. It is reminded that if the equipment incorporates Oscillography, the events record can only be accessed via communications.

6.12 Fault Reports

The equipment also incorporates Fault Reports where relevant fault information is stored. The register stores Fault Reports in non-volatile memory. When the register is full, a new report replaces the oldest report. The information stored in each Fault Report is listed below:

Fault Initiation Time Tag. Presents the date and time of the pickup of the first element involved in the fault. Also included are:

- The Elements Picked Up For Full Fault Duration (direct sequence / inverse sequence / ground element).

Open Command Time Tag. Presents the date and time of the trip command. It also includes:

- Fault currents. Ground, direct and inverse sequence registered 2.5 cycles after the unit pickup.
- Tripped Elements (direct sequence / inverse sequence / ground, thermal and blocked rotor element).

Fault End Time Tag. Corresponds to the date and time when the last element involved in the fault resets.

Note: the blocked rotor element doesn't generated fault reports if trips alone, because it's haven't pickup; if it's trips with another element with pickup, at the generated fault, will appear both elements.

6.13 Oscillography

The oscillography function is composed of two different subfunctions: Capture and View. The first refers to the capture and storage of protection data in the terminal unit. Capture is a part of the relay software. View refers to the collection and graphical display of the stored data. This is performed by one or more software programs run by a PC connected to the terminal unit.

- **Capture Function**

An analog record is stored each time a sample is taken. Status Contact Input signals are only stored by the Event Record function.

- **Stored Data**

The following data is stored with a resolution time equal to the sampling rate:

- Analog values of the samples selected for recording
- Starting time of the oscillography record

- **Number of Channels**

Depending on the model, up to nine new channels can be used, with the ability to activate or de-activate the channels as required with the corresponding setting.

- **Recording Mode**

The following Recording Modes are selectable: fixed time YES (Fixed Time Mode) and fixed time NO (Variable Time Mode). In the Fixed Time Mode, recording begins when the trigger function is activated. Recording stops when the pre-determined Record Length set by the user is reached. In the Variable Time Mode, recording begins when the Trigger Function is activated. Recording stops when the Trigger Function is de-activated.

- **Trigger Function**

The Trigger Function consists of a programmable mask that can be applied to permit recording to start after selected internal logic output signals or the External Oscillography Trigger Logic Input Signal. The External Oscillography Trigger signal can be assigned to any of the physical Status Contact Inputs.

This Trigger Function Control Mask is connected to each protection element within the relay. Only connections that are enabled by the mask settings will activate the oscillography Trigger Function. The activation occurs when any of the selected protection elements pick up, and de-activation occurs when all selected elements are reset.

- **Pre-fault Time**

Pre-fault Time is defined as the length of pre-fault data stored before the Trigger Function initiates a record. This time can be adjusted for either 1 or 2 cycles.

- **Oscillography Record Length**

Oscillography Record Length is defined as the fault record duration time when the Fixed Time mode is selected and is adjustable from 20 to 300 cycles.

- **Number of Records**

The number of records stored in memory varies and depends on the number of channels recorded and the length of the fault records. Once recording memory is full, the Overwrite setting determines whether or not the next event that occurs will be stored over the oldest stored record(s). Given that the records vary in length, old records will get cancelled when a new record need the space.

- **Record Storage Modes**

Start Mode: Fixed Time Mode [Fixed Time (Yes)] - Recorded data is stored whenever the Start Function is activated and continues for a time determined by the Record Length setting. Variable Time Mode [Fixed Time (No)] - Recorded data is stored while the Start Function is activated. Pre-Fault Data is stored in both cases.

Trip Mode 1: Fixed Time Mode [Fixed Time (Yes)] - Recorded data, plus pre-fault data, is stored in memory only if a trip occurs within the time set for the Record Length. If a trip occurs after this time has expired, no record is stored. Variable Time Mode [Fixed Time (No)] - Recorded data is stored whenever the Start Function is active in addition to the pre-fault data.

Trip Mode 2: Fixed Time Mode [Fixed Time (Yes)] - Recorded data, plus pre-fault data, is stored in memory only if a trip occurs within the time set for the Record Length. If no trip occurs within the time set for the Record Length, only 4 cycles of recorded data will be stored after the Start Function is activated. Variable Time Mode [Fixed Time (No)] - If no trip occurs while the Start Function remains active, only 4 cycles of recorded data will be stored after the Start Function is activated. If a trip occurs while the Start Function is active, recorded data will be stored during the whole time the Start Function remains active in addition to the pre-fault data.

Note: For the elements in which reset time can be long, it is recommended to set Fixed Time on YES.

It is reminded that information recorded during the time set as pre-fault time is always stored.

- **Overwrite**

If the Overwrite setting has been set to NO, no more records will be stored once the oscillography memory is full. In that situation, set overwrite on YES so that new records can get stored.

If the Overwrite setting has been set to YES, once the memory is full, the next record will replace the oldest record that is erased.

6.14 Contact Inputs/outputs and LED Targets

MXI units are provided with programmable inputs and outputs enabling user configuration of flexible logic designs. The equipments come out of the factory with default logic equations that can be edited using the ***ZIVercom***© software program.

6.14.1 Status Contact Inputs

The unit protection and monitoring functions can be controlled by the Logic Input Signals listed in Table 6-2 below. Any of these Logic Input Signals can be assigned to the two Status Contact Inputs of the terminal unit. The closure of a contact will thereby activate those Logic Input Signals assigned to it. Several different Logic Input Signals can be assigned to one Status Contact Input, but a given Logic Input Signal can only be assigned to one Status Contact Input.

Table 6-2: Status Contact Inputs

Num.	Name	Description	Function	Model
2	**IC**	Breaker Status (closed)	Monitors the status of the breaker	MXI-A/B
5	**APE**	External Lockout Reset	Reset the lockout signal (if the fault does not persist)	MXI-A/B
6	**CED**	Oscillography Trigger (optional)	Triggers up the oscillography	MXI-A/B

Status contact input/logic signal assignments are set by default at the factory. Users can easily program different input settings using the local RS232 communications port and the ***ZIVercom***© software.

6.14.2 Auxiliary Contact Outputs and Trip Outputs

- **Auxiliary Contact Outputs**

MXI units are provided with three auxiliary contact outputs. Two of these contacts (AUX-1 and AUX-2) are programmable. Auxiliary Contact Output (AUX-3), which corresponds to Relay in Service, is not programmable:

Terminal unit metering elements and logic functions generate a series of Logic Output Signals during terminal unit operation. Each of these signals has either a “True” or “False” value and this status can be used as an input to either of the combinational logic gates shown in Figure 6.6.

Two logic gates are available in each cell (one “OR” gate and one “AND” gate). Each gate accepts up to eight Logic Output Signals. The output of these two gates is operated by a selectable second gate. The desired final “AND” or “OR” output from the logic cell can then be connected to any one of the two programmable Auxiliary Contact Outputs (AUX-1 and AUX-2) available in the terminal unit.

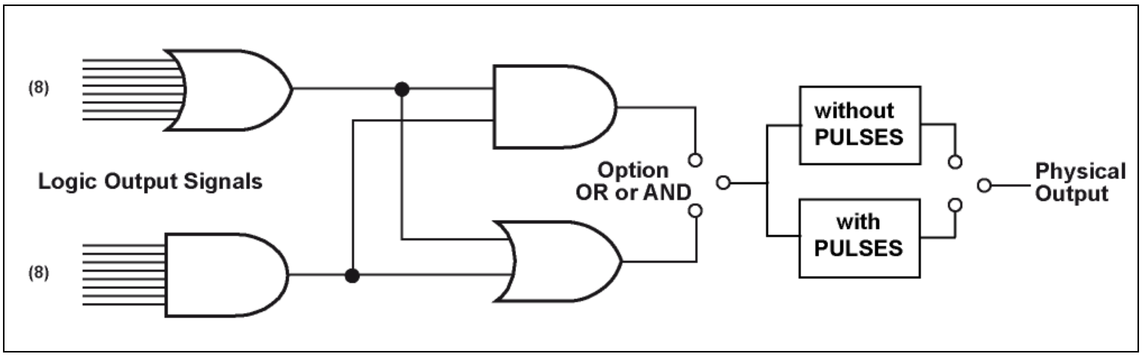


Figure 6.6: Auxiliary Contact Output Logic Cell Block Diagram.

The available Auxiliary Contact Outputs are described in Table 6-3.

Table 6-3: Auxiliary Contact Outputs

Num.	Name	Description	
1	S_SQ_P	Positive Sequence Element Trip	Trip of the elements. They are affected by their corresponding trip mask.
2	S_SQ_I	Negative Sequence Element Trip	
3	S_SQ_H	Ground Element Trip	
4	S_MI	Undercurrent Element Trip	
5	S_RB	Blocked Rotor Element Trip	
6	S_MAX_ARR	Maximum Number of Startings Active	
7	A_SQ_P	Positive Sequence Element Pickup	Element Pickups.
8	A_SQ_I	Negative Sequence Element Pickup	
9	A_SQ_H	Ground Element Pickup	
10	ALARMA_PR	Protection Module Alarm	Detects current in the line.
12	DISP	Protection Trip	OR Logic in all elements.
13	BLQ_CIERRE	Lockout Active	Becomes active when the protection generate a trip, provided the Recloser Lockout element is enabled.
14	S_TERM	Thermal Unit Active	Trip of the element at 100% of the thermal level.
15	A_TERM	Thermal Alarm Active	Alarm signal as a function of the setting of the alarm level.
16	M_SQ_P	Masked Direct Sequence Element Trip	Trip of the units non-affected by their corresponding trip mask.
17	M_SQ_I	Masked Inverse Sequence Element Trip	
18	M_SQ_H	Masked Ground Element Trip	
19	M_TERM	Masked Thermal Element Trip	
20	M_MI	Masked Undercurrent Element Trip	
21	M_RB	Masked Blocked Rotor Element Trip	
22	M_MAX_ARR	Masked Maximum Number of Startings Active	
23	ED_1	Status Contact Input IN-1	Outputs activated depending on the corresponding inputs.
24	ED_2	Status Contact Input IN-2	
25	ALARMA_EN	Alarm detected in Environment Module	
26	ALARMA_ER	Alarm detected in Error Module	
27	S_BLQC_DISP	Recloser Lockout Signal or Protection Element Trip	It is activated when the protection element trips, no matter if the recloser lockout element is enabled.

Status contact input/logic signal assignments are set by default at the factory. Users can easily program different input settings using the local RS232 communications port and the ***ZIVercom***© software.

- **Trip Outputs**

MXI units are provided with two trip output relays, each with two contacts rated for breaker trip operations. These contacts are internally configurable to NO or NC. Trip contacts correspond to terminal connectors 15-16 and 17-18. Trip outputs are not programmable.

6.14.3 LED Targets

MXI terminals are provided with eight optical indicators (LEDs) located on the front panel. Seven of the LEDs are user definable. The eighth LED is always assigned to indicate the terminal unit is "Ready" (powered up, self-test OK).

The logic cell structure, shown in the block diagram of Figure 6.7, permits the user to create combinational logic equations for the LED Target Outputs. To configure LED Target Outputs, Logic Output Signals are assigned to a LED Target Output.

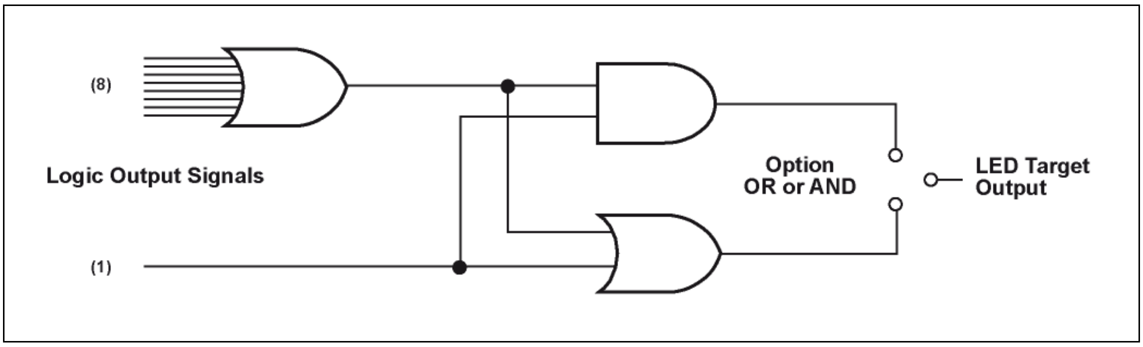


Figure 6.7: LED Target Output Logic Cell Block Diagram.

Each LED can be defined as latched or unlatched. If an LED is latched it will remain illuminated until reset, even after a condition has disappeared. The LED reset function is accomplished via the keypad (see Chapter 7: Alphanumeric Keypad and Display).

The latching function resides in the volatile memory section of the microprocessor. A power supply loss will cause any latched LED to be reset.

Each LED is pre-programmed with default logic. This logic can be modified by using the local RS232 communications port and the ***ZIVercom***© software. This can also be completed by the manufacturer before delivery at customer request.

6.15 Communications

6.15.1 Communication Settings

Communications settings are listed in Chapter 5 (Settings) and include Terminal Unit Address, Baud Rate, Stop Bits, Parity, Frontal Port Parity and Communications Timeout.

6.15.2 Communications Types

MXI Terminal Units contain two communication ports. The local port allocated on the front panel is an RS232 with fixed settings. The remote port is optional and it can be glass fiber optics (SMA or ST), 1mm plastic fiber optics, RS485, or RS232. Technical data relative to these ports is listed in Chapter 2.

6.15.3 Communication with the Unit

Communications with the unit through the communication ports is achieved using the ***ZIVercom***©, software application. This software is designed to connect with units of the **MXI** family, locally (via a PC connected to the front port) or remotely (via the rear serial port), enabling operations such as programming, settings configuration, event recording, activity reports, etc.

The ***ZIVercom***©, communication software contains passwords to provide access only to authorized personnel. ***ZIVercom***© is a user-friendly software tool running under WINDOWS™. It is possible to navigate and perform all the available actions in a series of submenus via graphical data boxes and buttons. To establish communications, the settings and Terminal Unit address in the IED and ***ZIVercom***© software must match.

The configuration of the remote communication ports can only be done through the HMI. It is reminded that the setting for the local port is fixed at 4800 bauds, 1 stop bits, and that the parity can be selected in the devices with a rear port remote communications, as described in Chapter 5. **MXI** models use two controllers, one for each communication port. Therefore communication can be established with both ports at the same time, and terminal unit status information can be accessed in local and remote mode.

This information is presented according to the following functions of the relay:

- Metering (direct and inverse sequence, ground and thermal level)
- Last Trip
- Pickup and tripping of the elements
- Contact Inputs and Outputs Status
- Settings
- Event Masks
- Closing Lockout
- Elements Masks
- Outputs / LED targets
- Events Record
- Faults report

6.16 Example of Settings Calculation

- **Example of Settings Calculation for the MXI Protection Terminals**

Motor Characteristics:

Power:	600 kW
Voltage:	3300 V
Pickup Current:	4 times In
Max. Pickup Time:	12 seg.
Max. Rotor Blocking Time:	30 seg.
Cos φ:	0.95
Maximum Overload:	15%
CTs Ratio:	150/5 A

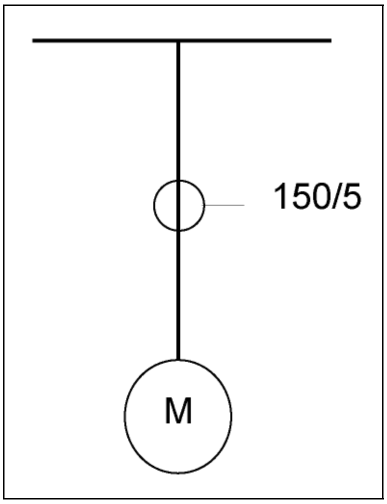


Figure 6.8: Example of Settings Calculation.

- **Calculation of the Rated Current**

For rated current calculation, the primary current corresponding to the motor maximum power is calculated first, using the following formulas:

Power (kW) = V · In · cosφ

Power (CV) = Pot. (kW) · 0.736

$$In = \frac{Power\ (kW)}{\sqrt{3} \cdot Voltage\ (kV) \cdot cos\varphi} = \frac{600}{\sqrt{3} \cdot 3.3 \cdot 0.95} = 110.49A.$$

Current transformers ratio:

Ratio: 150 / 5 A ; CT R. = 30

Current detected by the relay:

$$In = \frac{110.49}{30} = 3.683\ A$$

Given that this particular motor admits a 15% overload, the maximum admissible current is:

$$Imax = 3.683 \cdot 1.15 = 4.2354\ A$$

- **Setting of the Relay**

The setting range permitted for the relay is Imax = 1.5 - 10 A in 0.01A steps. Select the value closest to the calculated value:

$$Imax = 4.24\ A$$

- **Setting of the Phase Overcurrent Element (Positive Sequence) [I_1]**

The phase overcurrent element detects faults due to short circuits between the windings or the terminals of the motor.

The positive sequence element setting has to take into account the starting current, to prevent the actuation of the element when starting the motor.

In this case, the starting current value is 4 times the rated value.

It is suggested to set the positive sequence element to 1.5 times the pickup current value.

$$I_1 = 1.5 \cdot 4 = 6\ Imax$$

With a small time delay (50 to 80 ms) to avoid tripping during starting.

- **Setting of the Ground Element [I_0]**

For the detection of ground faults, it is usual practice to set the unit to 20% of the rated current.

In the case of a detection using three transformers in residual ground connection, it is advised to add an additional time delay, to avoid trips during starting, due to the saturation of the current transformers.

- **Setting of the Phase Unbalance Element [I_2]**

The phase unbalance or negative sequence element disconnects the motor under conditions of unbalance power. Single phase faults and single-phase start are the limits for these conditions.

We recommend a default setting of 150% of Imax, the maximum value for the current.

- **Setting of the Blocked Rotor Element**

When the motor is running or at start cannot supply the required torque, the motor has its rotor blocked.

It is then necessary to consider the starting time which in this case is 12 s, and the maximum time for blocked rotor recommended by the manufacturer, in this case 30 s.

We therefore recommend a setting of the element at 120 % of Imax and a 20 s time delay.

7. Alphanumeric Keypad and Display

7.1 Alphanumeric Display & Keypad

The dot matrix display has four characters, each one being a 7 x 5 dot matrix. It provides information on terminal unit alarms, settings, metering, status, etc. The default screen displays model identification (**#MXI**) as shown in figure on the right.

Figure 7.1: Alphanumeric Display.

The **MXI** keypad consists of 3 keys (see figure on the right). This keypad is associated with the information on the Alphanumeric Display. Only one key is accessible (the ↓ key) when the cover is installed on the equipment.

Starting from the default screen, the Local Interface has two possible operation modes. One mode operates using only a single key (when the cover is installed), and the other takes advantage of the complete keypad.

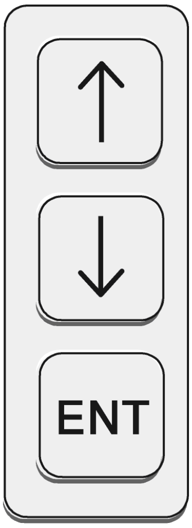


Figure 7.2: Keypad.

7.2 Keys, Functions and Operation Modes

- **Option Selection**

Using the selection keys (🡩 🡫), it is possible to scroll through the different options on the display. The ENT key is used to confirm a selection.

To scroll through different settings use the 🡫 key. Once the desired setting is found, use the ENT key to select it. The setting value will be displayed. If these setting value needs to be changed, press the ENT key a second time and the setting value will blink.

- **Change of Settings (Range)**

For settings with a numeric value (inside a range) the procedure is as follows: The first digit in the setting will blink. Pressing the 🡩 key is possible to scroll through the different values for that digit. Once the selection is made, press the 🡫 key to set it and the next digit will blink. Repeat the procedure until the setting value is completed.

For digits where no changes are desired, press the 🡫 key to skip to the next digit. Once every digit has been adjusted press the ENT key to set the value and the screen will show the setting identifier. Proceed to the next setting by pressing the 🡫 key.

The system does not allow to exceed the range for a given setting. When setting a value out of range, the value resets to zero and the blinking cursor is placed on the first digit.

- **Change of Settings (Options)**

For settings with preset options, it is possible to scroll through the different values using the 🡩 and 🡫 keys. Once the selection is displayed, press the ENT key to set the value and the screen will show the setting identifier. Proceed to the next setting by pressing the 🡫 key.

- **Exit Menus or Settings**

After an operation has been performed (selection, change of settings, viewing information, etc.) move to the previous level in the menu by pressing the 🡩 key.

7.3 Screen Sequence Using a Single Key

From the default screen, press the ↓ key to access the following screen sequence:

- Positive and negative sequence metering, negative sequence and thermal status value
- Trip indication and unit or units that tripped since the last reset
- Trip indication reset display
- Lockout reset display
- Thermal latch reset display
- LEDs reset display

First of following figures present the sequence of screen accessible by pressing the down arrow key ↓, when the protection has tripped. Second of following figures show the sequence of screens that are displayed by pressing the down arrow key ↓, when the protection has not tripped. The shaded areas shown in both figures depict screen groups dependent on the **MXI** model, with different content for each model. The shaded areas depict screen common for each model. The screen mnemonics will change depending on the selected language (English or Spanish) and are explained in the following paragraphs.

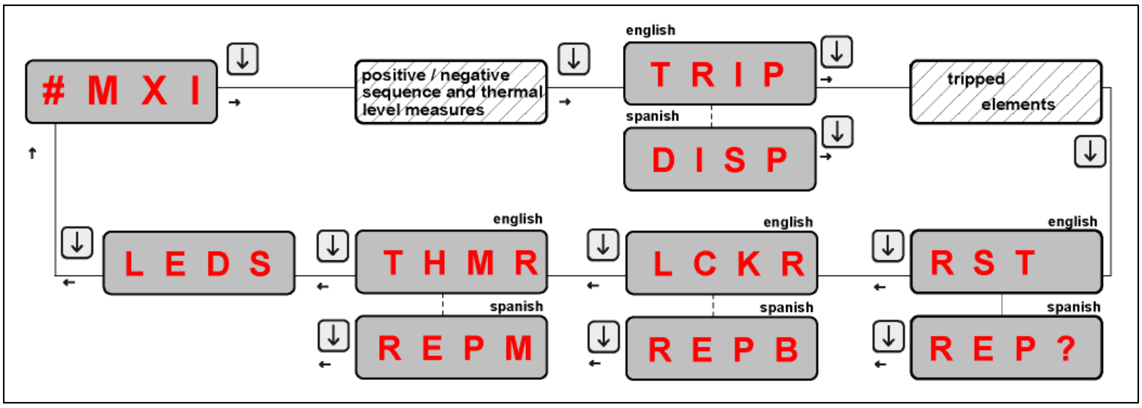


Figure 7.3: General Screen Sequence using the ↓ key (with Trip Indication).

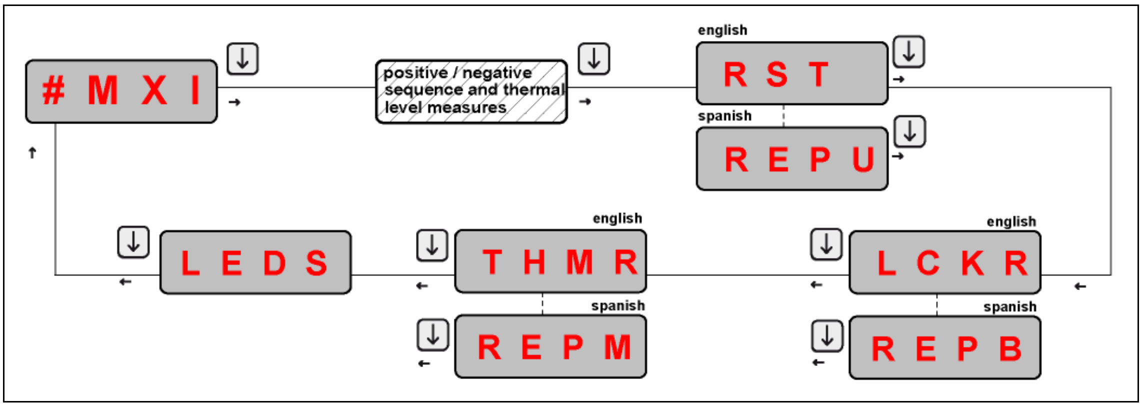


Figure 7.4: General Screen Sequence using the ↓ key (without Trip Indication).

The mnemonics used in the figures are:

TRIP DISP	Screen indicating a Protection Trip. Indicates that a trip occurred and that it has not been reset.
RST REP?	Trip Reset Indication Screen. If there is a trip indication and only in this case, this screen allows the operator to reset the trip indication by pressing the down arrow key 🡻 for more than two seconds.
LCKR REPB	Lockout Reset Screen This screen allows the operator to reset the lockout order by pressing the down arrow key 🡻 for more than two seconds. In this case, a screen is displayed with the order confirmation: OK?. Press ENT to confirm the order and proceed to resetting the element. The message BLOQ is then displayed.
THRM REPM	Thermal Memory Reset Screen. Press the down arrow key 🡻 for more than two seconds to reset the Thermal Memory element and display the message R_OK.
LEDS	LED Targets Reset. It is possible to reset the LED Targets by pressing and holding the 🡻 key for more than two (2) seconds and display the message L_AC.

For all these reset options, if you press the down arrow key 🡻 normally (for less than two seconds), the system moves on to the next screen without resetting the data screen on display.

The mnemonics used in the Positive Sequence Current, Negative sequence Current and Thermal Status Value screens are:

D:	This screen on the left indicates that the display of the measured positive sequence current follows.
2.46	Positive Sequence Current Value (example).
I:	This screen on the left indicates that the display of the measured negative sequence current follows.
5.60	Negative Sequence Current Value (example).
t(%)	This screen on the left indicates that the display of the thermal status value follows.
0000	Thermal Status Value.

The mnemonics used in the tripped elements screens are:

T_PS D_SD	Positive Sequence Element Trip.
T_NS D_SI	Negative Sequence Element Trip.
T_TU D_TE	Thermal Element Trip.
T_BR D_RB	Blocked Rotor Element Trip.
T_ST D_NA	Number of Startings Control Element Trip.
T_GU D_TI	Ground Element Trip.
T_UC D_MI	Undercurrent Element Trip.

7.4 Screen Sequence Using the Complete Keypad

From the default screen (see Figure 7.1), there are a series of screen sequences. Using the selection keys (↑ ↓) and the ENT key is possible to access the following options.

- **Measures and last trip**
- **Settings**
  generals
  protection
  oscillographic
- **Information**
  inputs status
  output status
  units status
- **Configuration**
  communications
  language
  frequency

For a global display of the screen sequence and the keys used to move forward in the sequence, below there is a table describing the process.

- **General Settings: HMI Access**

SETT	**GNRL**	**PCT:**
INFO	PROT	**NCT:**
CONF	OSCI	**PH**

- **Protection Settings: HMI Access**

SETT	GNRL	**TU**	**ENBL**
INFO	**PROT**	UC	**It>**
CONF	OSCI	GU	**HC**
		ST	**CC**
		NS	**ALRM**
		PS	**CONN**
		BR	**Ki**
			LTCH

SETT	GNRL	TU	**ENBL**
INFO	**PROT**	**UC**	**I<**
CONF	OSCI	GU	**TIME**
		ST	
		NS	
		PS	
		BR	

Mod. MXI-A

SETT	GNRL	TU	**ENBL**
INFO	**PROT**	UC	**Io>>**
CONF	OSCI	**GU**	**TIME**
		ST	
		NS	
		PS	
		BR	

Mod. MXI-B

SETT	GNRL	TU	**ENBL**
INFO	**PROT**	UC	**Io>**
CONF	OSCI	**GU**	**TIME**
		ST	**CURV**
		NS	**DIAL**
		PS	
		BR	

TU	ENBL	
UC	Io>	**INV**
GU	TIME	**VINV**
ST	**CURV**	**EINV**
NS	DIAL	**FIX**
PS		
BR		

SETT	GNRL	TU	**ENBL**
INFO	**PROT**	UC	**NoST**
CONF	OSCI	GU	**Band**
		ST	**Ipck**
		NS	**Tpck**
		PS	**Tenb**
		BR	

CURV setting YES

SETT	GNRL	TU	**ENBL**
INFO	**PROT**	UC	**CURV**
CONF	OSCI	GU	**CIV**
		ST	**DIAL**
		NS	
		PS	
		BR	

CURV setting NO

SETT	GNRL	TU	**ENBL**
INFO	**PROT**	UC	**CURV**
CONF	OSCI	GU	**Ii>**
		ST	**TIME**
		NS	
		PS	
		BR	

Mod. MXI-A

SETT	GNRL	TU	
INFO	**PROT**	UC	
CONF	OSCI	GU	
		ST	
		NS	**ENBL**
		PS	**Id>>**
		BR	**TIME**

Mod. MXI-B

SETT	GNRL	TU	
INFO	**PROT**	UC	
CONF	OSCI	GU	**ENBL**
		ST	**Id>**
		NS	**TIME**
		PS	**CURV**
		BR	**DIAL**

TU		
UC		
GU	ENBL	
ST	Id>	**INV**
NS	TIME	**VINV**
PS	**CURV**	**EINV**
BR	DIAL	**FIX**

SETT	GNRL	TU	
INFO	**PROT**	UC	
CONF	OSCI	GU	
		ST	
		NS	**ENBL**
		PS	**Irb>**
		BR	**TIME**

- **Oscillographic Settings: HMI Access**

SETT	GNRL	**TIME**
INFO	PROT	**DEL**
CONF	**OSCI**	**REG**
		FUNC
		CHNL
		PRE
		LONG

- **Information Menu: HMI Access**

SETT	**IN**
INFO	**OUT**
CONF	**PCKP**

- **Communications Configuration: HMI Access**

SETT	**COMM**	**ADDR**
INFO	LANG	**BAUD**
CONF	FREQ	**STOP**
		PARI
		FPAR
		TOUT
		MODB

- **Language Configuration: HMI Access**

SETT	COMM	**ENGL**
INFO	**LANG**	**ESP**
CONF	FREQ	

- **Frequency Configuration: HMI Access**

SETT	COMM	
INFO	LANG	**50Hz**
CONF	**FREQ**	**60Hz**

8. Receiving Tests

8.1 General

Improper handling of electrical equipment is extremely dangerous; therefore, only skilled and qualified personnel familiar with appropriate safety procedures and precautions should work with this equipment. Damage to equipment and injury to personnel can result when proper safety precautions are not followed. The following general safety precautions are provided as a reminder:

- High magnitude voltages are present in auxiliary supply and measuring circuits even after equipment has been disconnected.
- Equipment should be solidly grounded before handling or operating.
- Under no circumstances should the operating limits of the equipment be exceeded (auxiliary voltage, current, etc.).
- The auxiliary supply voltage (AC or DC) should be disconnected from the equipment before extracting or inserting any module, otherwise damage may result.

The number, the type and the specific characteristics of the acceptance tests for the **MXI** units are detailed in the following table.

MXI	Preliminary inspection
	Power supply test
	Sequence components metering test
	Ground Element test
	Thermal Element Test
	Undercurrent Element Test
	Status contact inputs, auxiliary contact inputs, recloser lockout, and LED targets tests
	Communication tests

8.1.1 Accuracy

The results obtained in electrical testing greatly depend on the accuracy of the measuring instruments and test source signals (auxiliary power supply voltage, AC currents and AC voltages). It is extremely important that there is little or no distortion (<2%) present in the test source signals as harmonics can affect measuring element precision when levels are above reference conditions used to certify the performance accuracy of equipment.

Therefore, verification of the information specified in the Technical Data section of this manual can only reasonably be achieved using test equipment under nominal reference conditions with tolerances as indicated in national and international testing standards EN 21-136 and ICE 255. Unless there is absolute compliance with these standards and practices, acceptance tests performed on equipment should only focus on operation verification and not on measurement accuracy.

We can safely assure that this protection terminal made of non linear elements will be affected differently from an ampere meter of ac by the existence of harmonics, given that metering is carried out in a different way in either case.

8.2 Preliminary Inspection

The following equipment aspects should be examined:

- The unit is in good physical condition, mechanical parts are securely attached and no assembly screws are missing.
- The unit model number and specifications agree with the equipment order.

8.3 Insulation Test

While testing for insulation of switchgear and external wiring, it is recommended to disconnect the terminal unit to avoid damage, since insulation testing has been performed by the manufacturer. The following paragraphs describe common mode and transverse mode insulation tests:

- **Common Mode**

Wire all rear connection terminals together except for terminal 30 and all the terminals connected to a power supply. And disconnect the earth connection terminal of the case. Apply 2000 Vac for 1 minute between interconnected terminals and metal case.

- **Transverse Mode**

Divide the terminals into terminal groups as indicated below:

1 - 2
3 - 4
5 - 6
7 - 8
11 - 12 - 13 - 14
15 - 16 - 17 - 18
19 - 20 - 21 - 22 - 23 - 24 - 25 - 26 - 27
28 - 29

Apply 2000 V_{AC} for 1 minute between each pair combination of terminal groups.

Note: Internal capacitors can generate an elevated tension if insulation-testing points are removed and the test voltage has not decreased.

8.4 Sequence Components Metering Tests

Set all the transformer ratios on 1 and the operation mode on 2 phases. Apply to each of the phases the currents listed in Table 8-1 and verify that the operating currents are within the specified ranges.

Table 8-1: Sequence Components Metering Tests

Phase	Applied Current	Positive Sequence	Negative Sequence
A	1 / 0º	0.31 minimum	0.62 minimum
B	1 / -240º	0.35 maximum	0.70 maximum
A	1 / 0º	0.62 minimum	0.31 minimum
B	1 / -120º	0.70 maximum	0.34 maximum
A	1 / 0º	0.31 minimum	0.31 minimum
B	0 / 0º	0.35 maximum	0.35 maximum
A	10 / 0º	3.16 minimum	3.16 minimum
B	10 / 0º	3.50 maximum	3.50 maximum

8.4.1 Positive Sequence Element Test

Place out of service the three-phase operation mode and enable only the Positive Sequence Element.

- **Pickup and Reset**

Set It of the thermal unit on X A. Apply current through the A phase. Verify, for the settings of Table 8-2, that the flag of the pickup status of the positive sequence overcurrent element gets set on "1", in a stable manner, when the current reaches a value between VA_MIN and VA_MAX. The set value that appears in the table is expressed in times It. Verify, in each case, that resetting occurs for values of 100 % the set value.

Table 8-2: Positive Sequence Element Test

		Positive Sequence Element Pickup		Applied Current through one phase only (Note)	
Element Setting	Pickup Value	VA_MIN	VA_MAX	VA_MIN	VA_MAX
y	x • y	x • y • 0.95	x • y • 1.05	3[x • y • 0.95]	3[x • y • 1.05]

Note: The value of y corresponds to the setting of It. The result of the pickup values is taken into account for the setting of the number of phases on 3. The values are due to the fact that the positive sequence is the vectorial sum of:

$$I_1 = \frac{1}{3}\left[I_A + I_B\left(rotation\ 120^o\right) + I_C\left(rotation\ 240^o\right)\right]$$

If only one phase is applied I_1= 1/3 I applied; therefore the positive sequence is three times weaker that the applied current.

- **Tripping Fixed Time**

Set the time on 0 s and the setting of the element on X times It. Apply a current, for one phase, of (6 • X • It) Aac and verify that the times are inferior to 65 ms.

Repeat the test with the time setting on X s and verify that the measured time is within the range X ±5% or ±25 ms.

- **Negative Time**

For a determinate curve, the actuation time will be by selected dial and the applicate current (see time/current characteristic curves, Chapter 6). The tolerance will be ±5% or ±25 ms.

8.4.2 Negative Sequence Element Test

Place out of service the three-phase operation mode and enable only the Negative Sequence Element.

- **Pickup and Reset**

Set It of the thermal unit on X A. Apply current through the terminals 1 and 2. Verify, for the settings of Table 8-3, that the flag of the pickup status of the negative sequence overcurrent element gets set on "1", in a stable manner, when the current reaches a value between VA_MIN and VA_MAX. The set value that appears in the table is expressed in times It. Verify, in each case, that resetting occurs for values close to 100 % of the set value.

Table 8-3: Negative Sequence Element Test

		Negative Sequence Element Pickup		Applied Current through one phase only (Note)	
Element Setting	**Pickup Value**	**VA_MIN**	**VA_MAX**	**VA_MIN**	**VA_MAX**
y	x • y	x • y • 0.95	x • y • 1.05	3[x • y • 0.95]	3[x • y • 1.05]

Note: The value of y corresponds to the setting of It. The result of the pickup values is taken into account for the setting of the number of phases on 3. The values are due to the fact that the negative sequence is a vectorial sum of:

$$I_2 = \frac{1}{3}\left[I_A + I_B\left(rotation\,240^o\right) + I_C\left(rotation\,120^o\right)\right]$$

If only one phase is applied I_2= 1/3 I applied; therefore the negative sequence is three times weaker that the applied current.

- **Tripping Time (Fixed Time Mode)**

Set the time on 0 s and the setting of the element on X times It. Apply a current, for one phase, of (6 • X • It) Aac and verify that the times are inferior to 65 ms.

Repeat the test with the time setting on X s and verify that the measured time is within the range X ±5% or ±25 ms.

- **Tripping Time (Curve Mode)**

For a fault value X times the value of It and for specific values of the start value and dial, verify the tripping times against the curve in Figure 6.1. Times tolerance is marked by the variation of ±5% of the value of X.

8.5 Ground Element Test

Enable only the Ground Element.

- **Pickup and Reset**

Apply current through the ground input.

Verify, for the settings of Table 8-4, that the flag of the pickup status of the ground element gets set on "1", in a stable manner, when the current reaches a value between VA_MIN and VA_MAX.

Table 8-4: Ground Element Test		
Setting (Aac)	**VA_MIN**	**VA_MAX**
X	(X • 0.95)	(X • 1.05)

Verify, in each case, that resetting occurs for values close to 95 % of the set value.

- **Tripping Times (Fixed Times)**

Set the time on 0 s. Apply a current value twice the ground element setting value, and check that the times are inferior to 65 ms.

Repeat the test with the time setting on X s, and verify that the measured time is within the range of X ±5% or ±25 ms.

- **Inverse Time**

For a determinate curve, the actuation time will come by the selected dial and the applied current (see Characteristics Curves on Chapter 6). Verify that the measured time is within the range of X ±5% or ±25 ms.

8.6 Undercurrent Element Test

Place out of service the three-phase operation mode and enable only the undercurrent element.

- **Pickup and Reset**

Apply current through the terminals 1 and 2.

Verify, for the settings of Table 8-5, that the flag of the pickup status of the undercurrent element gets set on "1", in a stable manner, when the current reaches a value between VA_MIN and VA_MAX. Verify, in each case, that resetting occurs for values close to 100 % of the set value.

Table 8-5: Undercurrent Element Test					
		Undercurrent Element Pickup		Applied Current through one phase only (Note)	
Element Setting	Pickup Value	VA_MIN	VA_MAX	VA_MIN	VA_MAX
x	x • y	x • y • 0.9 • 0.95	x • y • 0.9 • 1.05	3[x • y • 0.9 • 0.95]	3[x • y • 0.9 • 1.05]

Note: The value of y corresponds to the setting of It. The result of the pickup values is taken into account for the setting of the number of phases on 3. The values are due to the fact that the negative sequence is a vectorial sum of:

$$I_1 = \frac{1}{3}\left[I_A + I_B\left(rotation120^o\right) + I_C\left(rotation240^o\right)\right]$$

If only one phase is applied I_1= 1/3 I applied; therefore the positive sequence is three times weaker than the applied current.

- **Tripping Time**

Set the time on 0 s and the setting of the element on X times It. Apply a current, through one phase, of (X • It) Aac and verify that the times are inferior to 65 ms.

Repeat the test with the time setting on X s and verify that the measured time is within the range X ±5% or ±25 ms.

8.7 Thermal Element Test

Enable only the thermal element and verify that before initiating the test the thermal level is at zero.

At the moment of the trip check that the thermal level is within the range 0.98 - 1.02 (98% - 102%).

Switch off the current; verify that the thermal level, when the trip is reset, is within the range ±0.4 (4%) of the value of the setting connection enable.

Check also that when the thermal element acts, a trip is produced and the trip contact outputs of the equipment get activated.

Testing of the thermal element can be carried out, depending on the test equipment available in three different ways: by injecting current through only one phase, by applying a one-phase current, by applying a one-phase current to the three phases or lastly by applying a three-phase current.

- **Testing by Injecting Only One Phase**

I I= I applied (applied phase current)

I_1 = 1/3 I , given that $$I_1 = \frac{1}{3}\left[I_A + I_B(rotation\ 120^o) + I_C(rotation\ 240^o)\right]$$

I_2 = 1/3 I , given that $$I_2 = \frac{1}{3}\left[I_A + I_B(rotation\ 240^o) + I_C(rotation\ 120^o)\right]$$

Then, the equivalent current I_{eq} is:

$$I_{eq} = \sqrt{I_1^2 + kI_2^2} = \sqrt{\left(\frac{1}{3}I\right)^2 + k\left(\frac{1}{3}I\right)^2} \Rightarrow I_{eq} = \frac{1}{3}I\sqrt{k+1} \Rightarrow I = \frac{3I_{eq}}{\sqrt{1+k}}$$

Assuming a three-phase system with an overload that do not originate any unbalance in the line, the equivalent current is equal to the positive sequence current and also equal to the applied three-phase, given that I_2=0.

$$I_{eq} = I_1 = I_{three-phase}$$

Therefore, in these conditions when I_2=0, there would be equivalence between the balanced three-phase current and its corresponding one-phase current when it comes to realizing the test:

$$I_{one-phase} = I = \frac{3I_{three-phase}}{\sqrt{1+k}}$$

The tripping time would therefore be given by the equation:

$$t = \tau_c \ln \frac{Ieq^2 - Ip^2}{Ieq^2 - I^2max}$$ If starting from a resting state I_p=0

$$t = \tau_c \ln \frac{Ieq^2}{Ieq^2 - I^2max}$$

For example, for a value of k=1; Imax = 2A; τ_c = 2 m and a one-phase current of 6A (that corresponds to a three-phase current of 4.9 A):

$$Ieq^2 = \left(\frac{6}{3}\right)^2 + (1)\left(\frac{6}{3}\right)^2 = 8$$

$$\tau = 2\,ln\frac{8}{8-4} = 1.38\,min. = 83s.$$

Assuming an error of ±5% in the measure, we would get a time interval for the trip of 75.5s to 96.9s.

- **Testing by Injecting a One-phase Current Applied to the Three Phases**

The way of injecting the current for this test is indicated in Figure 8.1.

Depending on the applied currents, the calculation of the positive and negative sequence current is as follows:

$$I_1 = \frac{1}{3}\left[I_A + I_B(rotation120^o) + I_C(rotation240^o)\right]$$

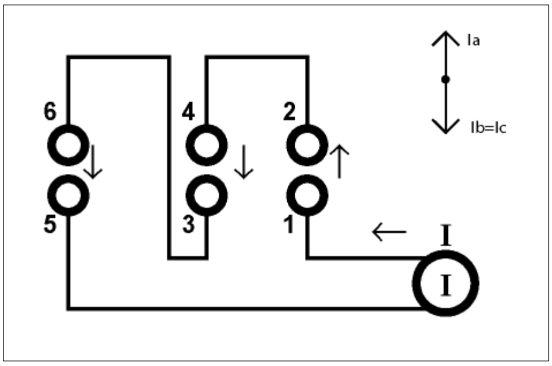
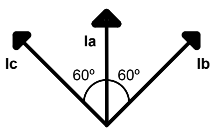


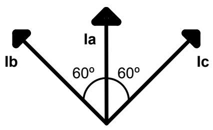
Figure 8.1: Drawing of the Application of the Same Current to the Three Phases.



and as a result:

$$I_1 = \frac{2I}{3}$$

$$I_2 = \frac{1}{3}\left[I_A + I_B(rotation\ 240^o) + I_C(rotation\ 120^o)\right]$$



and as a result:

$$I_2 = \frac{2I}{3}$$

The equivalent current being:

$$\left(\frac{2I}{3}\right)^2 + k\left(\frac{2I}{3}\right)^2 = Ieq^2 \Rightarrow I = \frac{3I_{eq}}{2\sqrt{1+k}}$$

Assuming a three-phase system with an overload that does not originate any unbalance in the line, the equivalent current is equal to the positive sequence current and equal to the applied three-phase current, as I_2=0.

$$I_{eq} = I_1 = I_{three-phase}$$

Therefore, for these conditions of I_2=0, we would get an equivalence between the balanced three-phase current and its corresponding one-phase current when carrying out the test that would be:

$$I_{one-phase} = \frac{3I_{eq}}{2\sqrt{1+k}}$$

Tripping time would be given by the equation:

$$t = \tau \bullet \ln \frac{Ieq^2}{Ieq^2 - I^2max}$$ if starting from I_p=0

For example, for k=1; I_{max}=2A; τ_c = 2 m and a 6A current (equivalent to a 5.65A three-phase current):

$$Ieq^2 = \left(\frac{2 \cdot 6}{3}\right)^2 + 1\left(\frac{2 \cdot 6}{3}\right)^2 = 32$$

$$\tau = 2 \ln \frac{32}{32-4} = 0.267 \, min. = 16 s.$$

Assuming an error of ±5% in the measure; that would mean a range for the tripping time of 14.4 s to 17.9 s.

- **Test Carried Out with a Three-Phase Testing Equipment**

By injecting a balance currents system, we get that the negative sequence current is zero and the positive sequence is equal to the applied current; therefore the equivalent current will be:

$$I_{eq} = \sqrt{I^2 + k(0)} \Rightarrow I_{eq} = I$$

The tripping time is then given by the equation

$$t = \tau \bullet \ln \frac{Ieq^2}{Ieq^2 - I^2max}$$ if starting from rest I_p=0

Should you want to carry out the test only with two phases (for new models) you would have first to set the equipment to two phases (within the general settings menu). In a second time, you would have to inject two phases of a balanced system, applying what is indicated above, as the equipment calculates the other phase and consider a balanced three-phase system.

8.8 Blocked Rotor Element Test

Enable only the blocked rotor element. Apply current through the A phase.

Verify, for the settings of Table 8-6, that the flag of the pickup status of the undercurrent element gets set on "1", in a stable manner, when the current reaches a value between VA_MIN and VA_MAX. Verify, in each case, that resetting occurs for values close to 95 % of the set value.

Table 8-6: Blocked Rotor Element Test

		Blocked Rotor Element Pickup		Applied Current through one phase only (Note)	
Element Setting	**Pickup Value**	**VA_MIN**	**VA_MAX**	**VA_MIN**	**VA_MAX**
y	x • y	x • y • 0.95	x • y • 1.05	3[x • y • 0.95]	3[x • y • 1.05]

Note: The value of y corresponds to the setting of it. The result of the pickup values is taken into account for the setting of the number of phases on 3. The values are due to the fact that the positive sequence is a vectorial sum of:

$$I_1 = \frac{1}{3}\left[I_A + I_B\left(rotation\ 120^o\right) + I_C\left(rotation\ \ 240^o\right)\right]$$

If only one phase is applied I_1= 1/3 I applied; the positive sequence is three times weaker than the applied current.

- **Tripping Time**

Set the time on 0 s and the setting of the element on X times It. Apply a current, through one phase, of (6 • X • It) Aac and verify that the times are inferior to 65 ms.

Repeat the test with the time setting on X s and verify that the measured time is within the range X ±5% or ±25 ms.

8.9 Contact Inputs, Auxiliary Outputs, Lockout and LED Targets Test

Apply the rated voltage for the equipment and the model. The “in service” led must light up.

- **Status Contact Inputs**

Apply the rated voltage between the input terminals, taking always into account the polarity of the contacts.

Place yourself in the inputs screen of the Information menu (see Chapter 7, alphanumeric keypad and display) and verify that the inputs are activated (“on”). Switch the voltage off and verify that the inputs get deactivated (“off”).

- **Auxiliary Outputs**

To test the auxiliary outputs, you will have make them trip depending on how they have been configured. If they do not have any configuration, the outputs can be configured as activation of the physical inputs. That way at the same time as the inputs are being tested, correct tripping of the output contacts AUX1 and AUX2 is verified.

- **Lockout**

To verify the lockout element, configure one output as lockout. Check that when the trip has reset, the auxiliary contacts remain closed. Those contacts will reset when sending the reset order to the lockout element.

- **LEDs**

To test the LEDs, press the down arrow key 🡻 from the screen at rest until the led targets reset screen appears. Maintain the key pressed down until all the LEDs have been switched on. Release the key and check that all the LEDs switch off.

8.10 Communication Tests

To carry out the communication test, it is necessary to supply the equipment with its rated voltage value and the In Service Led should then be switched on.

Test will be performed through local communications port, allocated on front panel. This port has the fixed settings that follow:

Baud Rate	**4800 bauds**
Stop Bits	**1**
Parity	**0 (no parity) - 1 (even parity)**

Connect to the terminal unit through the local communications port using a DB9 (9-pin) serial connection wire. Synchronize time using the ***ZIVercom***© software program. Disconnect the communications wire and disconnect the terminal unit power supply and wait for two minutes. Afterwards, connect the power supply and connect to the terminal unit through the remote communications port. Activate the cyclical mode in the ***ZIVercom***© software program and verify that time actualizes properly.

8.11 Installation

8.11.1 Location

The location where the terminal unit is to be installed should meet the following minimum conditions to ensure correct operation, long service life, and ease of installation and maintenance:

- Absence of dust
- Absence of dampness
- Absence of vibration
- Adequate lighting
- Easy access
- Horizontal or Vertical mount

Mounting should be in accordance with the schemes attached at the Annex D of this instructions manual.

8.11.2 Connection

Terminal number 30 should be solidly grounded to ensure disturbance filtering circuits operate properly. The wire used for grounding these terminals should be stranded 14 AWG. Ground wire length should be minimized and should not exceed 12”. The ground connector of the enclosure, located at the rear of the equipment should also be grounded.

A. PROCOME 3.0 Communications Protocol

A.1 Settings

PROCOME 3.0 Configuration Settings	
Setting	**Range**
Communications Password Enable	YES / NO
Communications Password Timeout	1 - 1440 min.
Communications Password	8 characters

These settings are establishing communication through the remote port. Only can be modified through ***ZIVercom***© communication program.

A.2 Description of Operation

A.2.1 Event Record

Table A-1: Event Record

function	event	byte	bit
33750	Measurement annotation	1	1

A.2.2 Inputs

There exists the possibility of the physical inputs functioning with inverse logic, assigning one or a set of them to a digital input or to its negated.

A.2.3 Communicating with the Unit

Using the PROCOME profile, it is possible to communicate with the unit to request control changes and to execute orders. In this case, the distance to the fault calculated by the locator is transmitted as one more measurement.

A.3 Alphanumeric Keyboard and Display

A.3.1 Communications

Selecting the communications option brings up a menu composed of the settings: terminal address, baud rate, stop bits, parity, frontal port parity, communications timeout, communications password enable and communications password timeout.

The setting of communications password enable makes it possible to enable the password access function to establish communication with the unit via the rear port: YES means enabling the permission and NO, disabling.

The setting of communications password timeout allows establishing a period of time for activating a lockout of communication with the unit (whenever communication is via the rear port): if the set time elapses with no activity taking place in the communications program, the system locks itself in this state. Consequently, it will be necessary to restart the communication.

The last setting of the communications group, communications password, makes it possible to establish a specific password to access communication with the unit through the rear port (only through ***ZIVercom***©, communications program. This password must have 8 characters, which will be entered using the numerical keys and the key corresponding to a dot.

A.3.2 Accessing the Information

The variations in the settings menus described in the preceding sections are reflected in the information menus, with the same layout shown. Note that the information menu only allows viewing the established settings and does not allow modifying them.

B. MODBUS RTU Protocol

B.1 Preliminary Information

This document is intended as a reference on the implementation of the **MODBUS RTU** protocol in the **MXI**.

This document describes the **MODBUS** map of addresses (inputs, outputs, metering registers and commands) and their equivalent in the **MXI** relay.

The functions implemented are as follows:

Function	Description
01	Reading of Outputs (Read Coil Status)
02	Reading of Inputs (Read Input Status)
04	Reading of Metering Registers (Read Input Registers)
05	Commands (Force Single Coil)

Any other function non-included in the table above will be considered illegal and the exception code 01 (Illegal function) will be returned as a reply.

B.2 Reading of Outputs (Read Coil Status)

Map of Modbus addresses for MXI

The Output Modbus addresses assigned to the **MXI** relay are as follows:

Address	Description
0200H (*)	Recloser Lockout
0201H	Aux-1 Status
0202H	Aux-2 Status

Assigned addresses are fixed. The content of the addresses indicated with an (*) is also fixed, the content of the other addresses being variable (it depends on the configuration selected by the end-user for each relay).

The rest of addresses of the range will be considered as illegal and the exception code 02 (Illegal Data Address) will be returned as a reply).

B.3 Reading of Inputs (Read Input Status)

Map of Modbus addresses for MXI

The Input Modbus addresses assigned to the **MXI** relay are as follows:

Address	Description
0000H	INPUT-1 Status
0001H	INPUT-2 Status

Assigned addresses are fixed, their content being variable (it depends on the configuration selected by the end-user for each relay).

The rest of addresses of the range will be considered as illegal and the exception code 02 (Illegal Data Address) will be returned as a reply.

B.4 Reading of Metering Register (Read Input Registers)

Map of Modbus addresses for MXI

The Modbus addresses for the Metering Input Registers assigned to the **MXI** relay as follows:

Address	Description
2000H	Phase A Current Metering
2001H	Phase B Current Metering
2002H	Phase C Current Metering
2003H	Ground Current Metering
2004H	Positive Sequence Current Metering
2005H	Negative Sequence Current Metering
2006H	Thermal per cent

The rest of addresses of the range will be considered as illegal and the exception code 02 (Illegal Data Address) will be returned as a reply.

B.5 Commands (Force Single Coil)

Map of Modbus addresses for MXI

The range of Modbus addresses for commands in the **MXI** relay is as follows:

Address	Value	Function
0200H	0000H-OFF	Close Lockout Reset

The rest of addresses of the range will be considered as illegal and the exception code 02 (Illegal Data Address) will be returned as a reply.

Any other value different from 00H or FHH will be considered as illegal and the exception code 03 (Illegal Data Value) will be returned as a reply.

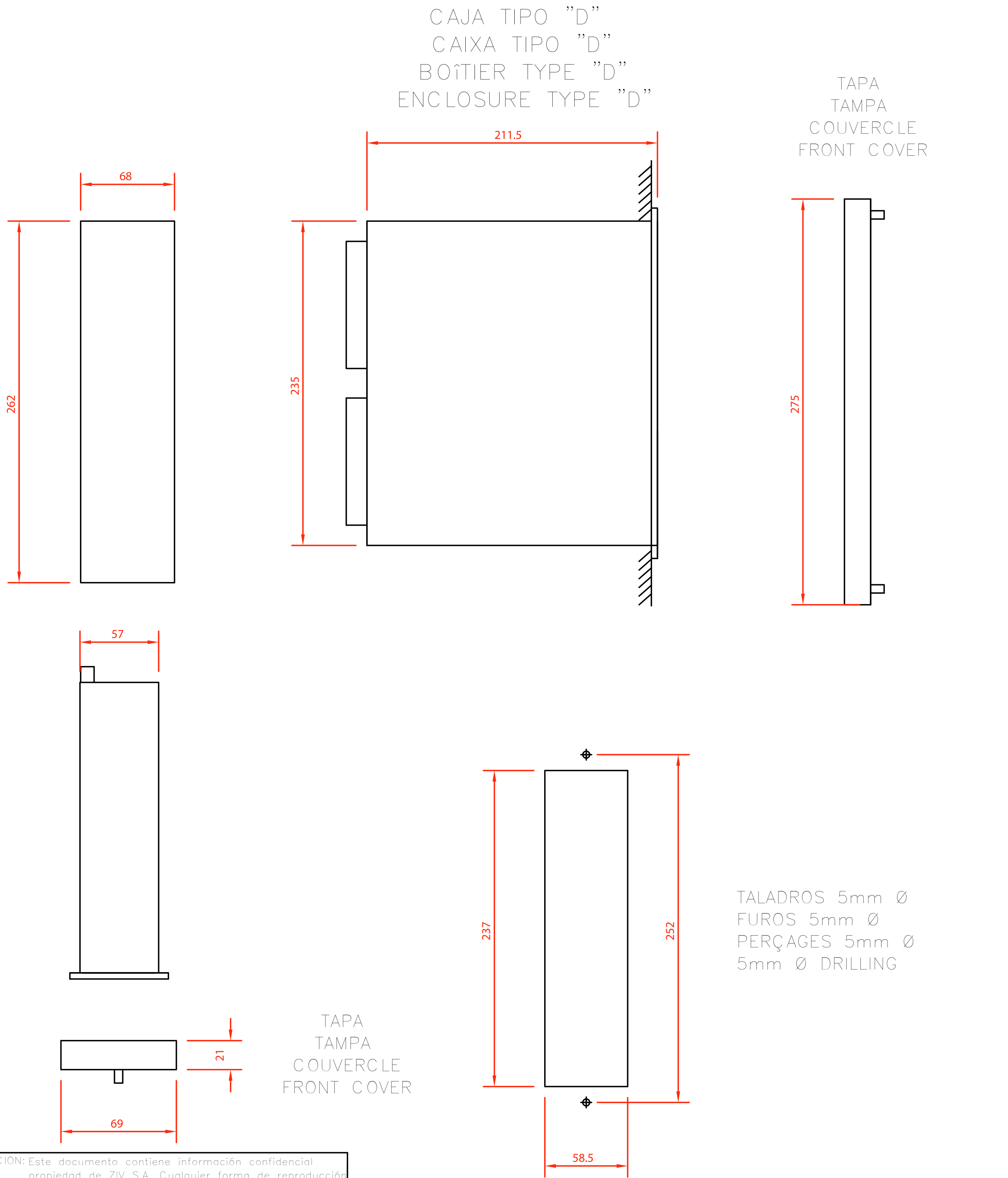
C. Schemes and Drawings

Dimension and Drill Hole Schemes

3MXI	>>4BF0100/0016
8MXI	>>4BF0100/0026

External Connection Schemes

MXI-A/B	>>3RX0147/0007 (generic)



REVISIONES		0	CDN9605104	1	CDR9809104
2	CD0202125	3	CD0901130	4	
5		6		7	
8		9		10	
11		12		13	
14		15		16	

ZIV Aplicaciones y Tecnología S.L.

TITULO> DIMENSIONES Y TALADRADO

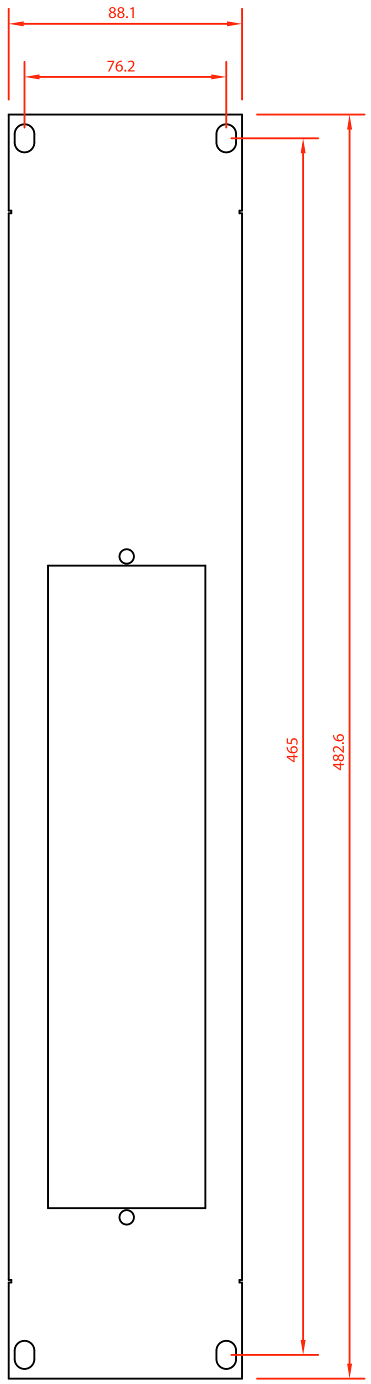
PROYECTO> CAJA TIPO "D" 6U 1/7RACK

Rev.0
Rev. 1 14/9/98
Rev. 2 14/2/02
Rev. 3 6/2/09
Rev. 4 27/7/10

NUMERO> 4BF0100/0016

	Fecha	Nombre
Dibujado	3/5/96	J.C.S.
Aprobado	3/5/96	R.O.

Hoja:1
Continua en Hoja:



REVISIONES		0	CDN9904147	1	CD0202125
2	CD0901130	3		4	
5		6		7	
8		9		10	
11		12		13	
14		15		16	

ZIV Aplicaciones y Tecnología S.L.

TITULO> PLACA ADAPTACION A 19''X 2U

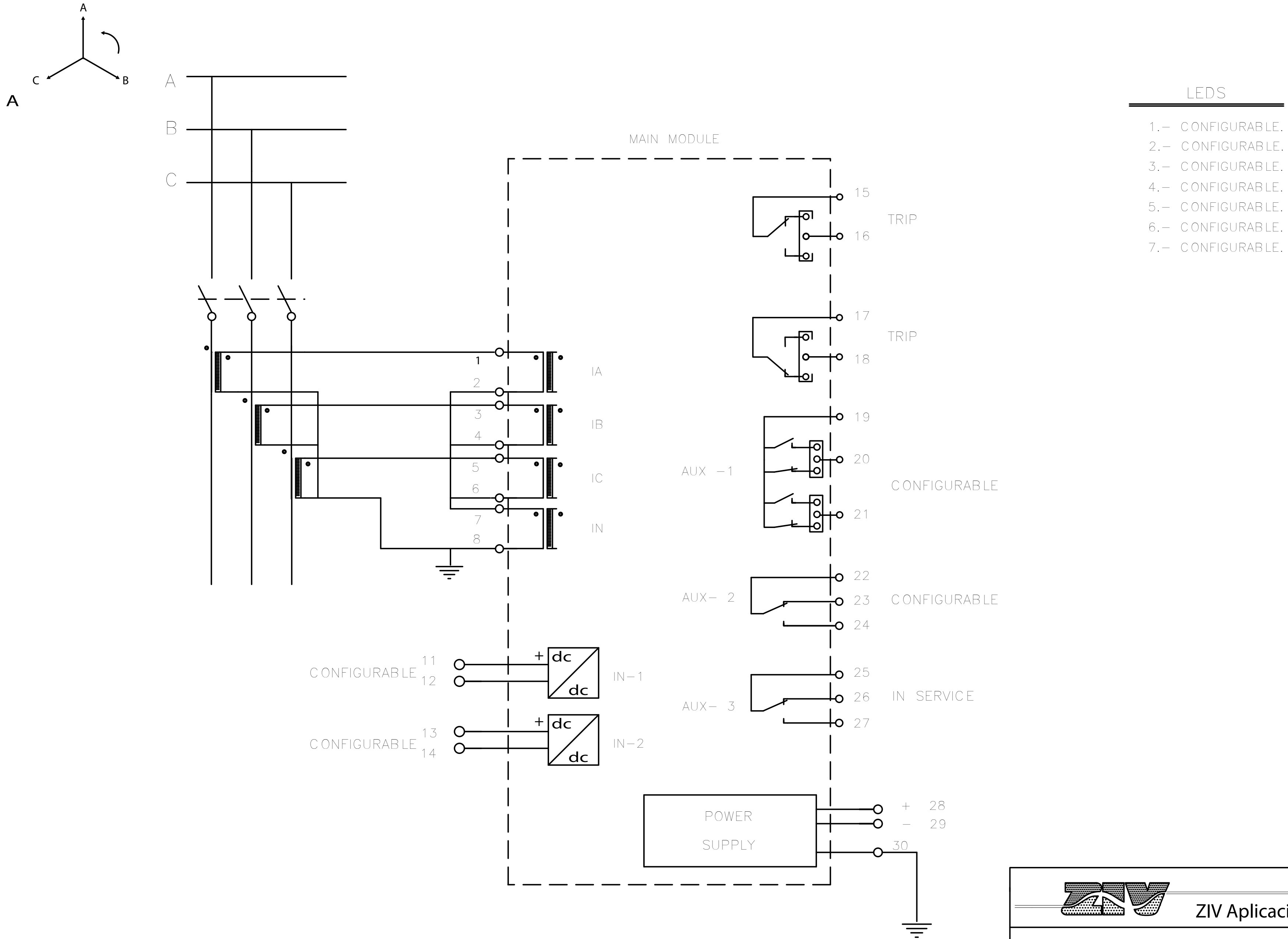
PROYECTO> RELE INDUSTRIAL

Rev.0
Rev. 1 14/2/02
Rev. 2 6/2/09

NUMERO> 4BF0100/0026

	Fecha	Nombre
Dibujado	29/4/99	J.C.S.
Aprobado	29/4/99	R.O.

Hoja: 1
Continua en Hoja:



"WARNING"
This document contains trade secret information of Z I V
Unauthorized disclosure is strictly prohibited and may result in serious legal consequences.

REVISIONS	0	CD0307151	1	CD0402145	2		3		4	
5	6		7		8		9		10	
11	12		13		14		15		16	

ZIV Aplicaciones y Tecnología, S.L.

TITLE> EXTERNAL CONNECTIONS 3/8MXI-A/B

PROJECT> MOTOR PROTECTION

Rev.0
Rev. 1 17/02/04

NUMBER> 3RX0147/0007

	Date	Name	Sheet:1
Drawn	1/08/03	J.C.S.	Continued on Sheed:
Approved	1/08/03	J.M.Y.	

D. List of Illustrations and Tables

D.1 List of Figures

D.2 List of Tables

E. Warranty

ZIV GRID AUTOMATION, S.L.
Standard Product Warranty

All new products sold to customers are warranted against defects in design, materials, and workmanship for a period of ten (**10**) years from the time of delivery (at the moment the product leaves ZIV GRID AUTOMATION premises, as indicated in the shipping documents). Customer is responsible of notifying ZIV GRID AUTOMATION of any faulty conditions as soon as they are detected. If it is determined that the new product defect is covered by the warranty, ZIV GRID AUTOMATION will repair, or substitute the product at its own discretion to the customer at no charge.

ZIV GRID AUTOMATION may, at its own discretion, require the customer to ship the unit back to the factory for diagnosis before making a determination as to whether it is covered by this warranty. Shipping costs to the ZIV GRID AUTOMATION factory (including but not limited to, freight, insurance, customs fees and taxes, and any other expenses) will be the responsibility of the customer. All expenses related to the shipment of the repaired or replacement units back to the customer will be borne by ZIV GRID AUTOMATION.

Customers are responsible for all expenses related to the shipment of defective units back to ZIV GRID AUTOMATION when it is determined that such units are not covered under this warranty or that the fault is not ZIV GRID AUTOMATION´s responsibility. Units repaired by ZIV GRID AUTOMATION are warranted against defects in materials, and manufacturing for a period of one (1) year from the time of delivery (at the moment the product leaves ZIV GRID AUTOMATION premises, as indicated by the shipping documents), or for the remaining of the original warranty, whichever is greater.

ZIV GRID AUTOMATION warranty does not cover: 1) improper installation, connection, operation, maintenance, and/or storage, 2) minor defects not interfering with the operation of the product, possible indemnities, misuse or improper usage, 3) abnormal or unusual operating conditions or application outside the specifications for the product, 4) application in any way different from that for which the products were designed, 5) repairs or alterations performed by individuals other than ZIV GRID AUTOMATION employees or an authorised representative.

Limitations:

1) Equipment or products provided but not manufactured by ZIV GRID AUTOMATION. Such products may be covered by a warranty issued by the corresponding manufacturer.
2) Software: ZIV GRID AUTOMATION warrants that the licensed Software corresponds with the specifications included in the instruction manuals provided with the units, or with the specifications agreed with the end-customer. ZIV GRID AUTOMATION sole and entire liability, and customer exclusive remedy, with respect to any claims relating to the Software shall be to provide a new set of diskettes free of charge.
3) In the case that a bank guarantee or similar instrument be required to back up the warranty period, such warranty period, and only for these purposes, will be of a maximum of twelve (12) months from the time of delivery (at the moment the product leaves ZIV GRID AUTOMATION premises, as indicated in the shipping documents).

THIS WARRANTY IS IN LIEU OF ANY OTHER WARRANTIES AND ZIV GRID AUTOMATION HEREBY DISCLAIMS ANY OTHER WARRANTY, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL ZIV GRID AUTOMATION BE LIABLE FOR ANY INDIRECT, INCIDENTAL, CONSEQUENTIAL, OR SPECIAL DAMAGES OR FOR ANY OTHER LOSS, INJURY, DAMAGE, OR EXPENSE OF ANY KIND INCLUDING LOST PROFITS OR ANY OTHER PECUNIARY LOSS ARISING FROM ANY SOURCE.

ZIV GRID AUTOMATION, S.L.
Parque Tecnológico, 210
48170 Zamudio - Bizkaia - Spain
Tel.- (+34)-(94) 452.20.03
Fax - (+34)-(94) 452.21.40