

# MTL4500/MTL5500 range

## Binary Input Modules



MTL4504, MTLx511, MTLx514, MTLx514D,  
MTL4514B, MTL4516, MTLx516C, MTLx517



### FUNCTIONAL SAFETY MANAGEMENT

These products are for use as sub-systems within a Safety System conforming to the requirements of IEC61508:2010 and enable a Safety Integrity Level of up to SIL2 to be achieved for the instrument loop in a simplex architecture.

Eaton is a certified Functional Safety Management company meeting the requirements of IEC61508 Part1:clause 6

\* Refer to content of this manual for details

# Binary Input Modules



## Contents

<b>1 Introduction</b>	<b>3</b>
1.1 Application and function	3
1.2 Variant description	3
<b>2 System configuration</b>	<b>4</b>
2.1 Associated system components	4
<b>3 Selection of product and implications</b>	<b>4</b>
<b>4 Assessment of functional safety</b>	<b>5</b>
4.1 EMC	6
4.2 Environmental	6
<b>5 Installation</b>	<b>7</b>
<b>6 Maintenance</b>	<b>7</b>
<b>7 Appendices</b>	<b>8</b>
7.1 Appendix A: Summary of applicable standards	8
7.2 Appendix B: Proof test procedure, MTL45/5500 binary input modules	9



This manual supports the application of the products in functional safety related loops. It must be used in conjunction with other supporting documents to achieve correct installation, commissioning and operation. Specifically, the data sheet, instruction manual and applicable certificates for the particular product should be consulted, all of which are available on the MTL web site.

*In the interest of further technical developments, Eaton reserve the right to make design changes.*

Module type	Hardware Fault Tolerance (HFT) †	
	0	1
MTL4504, MTL4511, MTL5511, MTL4514B, MTL5514, MTL4514D, MTL5514D, MTL4516C, MTL5516C, MTL4517 and MTL5517.		



† These modules have an inherent fault tolerance of 0.  
Duplication of modules in a voting architecture may be used to achieve HFT=1

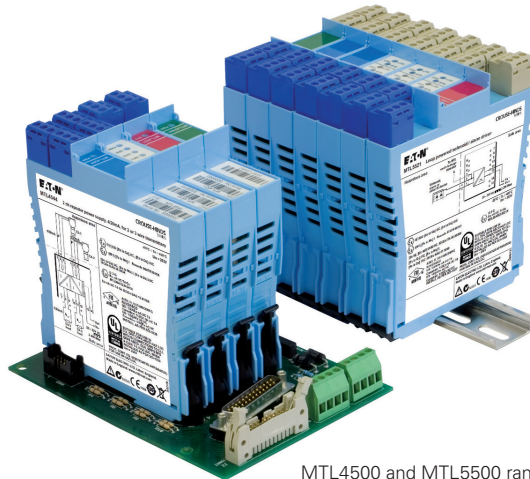
# 1 INTRODUCTION

## 1.1 Application and function

The binary input modules that are the subject of this manual are intrinsic safety isolators that enable a safe-area load to be controlled by a proximity detector or switch located in a hazardous area of a process plant. They are also designed and assessed according to IEC 61508 for use in safety instrumented systems up to SIL2 without hardware redundancy. Higher integrity levels for a SIL can be achieved by hardware duplication, for example by using the modules in a voting architecture.

In addition to the transfer of the switch status, the detection and signalling of line faults is indicated by an LED on the top of the module and also provided through a separate relay output in some models.

All of the modules are members of the MTL4500 and MTL5500 range of products.



MTL4500 and MTL5500 range

## 1.2 Variant Description

Functionally the MTL4500 and MTL5500 range of modules are the same but differ in the following way:

- the MTL4500 modules are designed for backplane mounted applications
- the MTL5500 modules are designed for DIN-rail mounting.

In both models the hazardous area field-wiring connections (terminals 1-3, and 4-6) are made through the removable blue connectors, but the safe area and power connections for the MTL45xx modules are made through the connector on the base, while the MTL55xx uses the removable grey connectors on the top and side of the module.

Note that the safe-area connection terminal numbers differ between the backplane and DIN-rail mounting models.

The binary input models covered by this manual are:

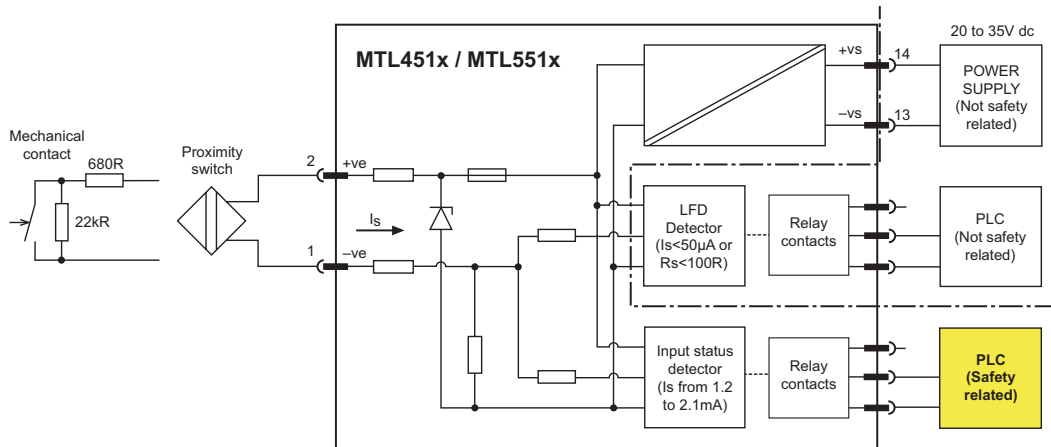
<b>MTL4504</b>	<b>single channel, switch/proximity detector repeater, independent LFD</b>
<b>MTL4511 and MTL5511</b>	<b>single channel, switch/proximity detector repeater</b>
<b>MTL4514/B and MTL5514</b>	<b>single channel, switch/proximity detector repeater, independent LFD</b>
<b>MTL4514D and MTL5514D</b>	<b>single channel, switch/proximity detector repeater, dual output</b>
<b>MTL4516/C and MTL5516C</b>	<b>dual channel, switch/proximity detector repeater</b>
<b>MTL4517 and MTL5517</b>	<b>dual channel, switch/proximity detector repeater, independent LFD</b>

*Note: To avoid repetition, further use of MTLx51x in this document can be understood to include both DIN-rail and backplane models. Individual model numbers will be used only where there is a need to distinguish them*

## 2 System configuration

The modules may be used in single-channel (1oo1) safety functions up to SIL2 without hardware redundancy. The worked example in this manual is for a SIL2 application.

The figure below shows the system configuration and specifies detailed interfaces to the safety related and non-safety-related system components. It does not aim to show all details of the internal module structure, but is intended to support understanding for the application.



The modules are designed to power a proximity detector or a switch in the hazardous area and to reflect the open or closed condition of the field switch through relay contact output to the safe-area load. The shaded area shows the safety related system connection, while the line fault connections are not safety-related but may be used to assist diagnosis of field circuit conditions. For simplicity the term 'PLC' has been used to denote the safety system performing the monitoring function of the process loop variable.

**Note: When using the dual channel module variants both channels must not be used in the same safety function to avoid concerns of common-cause failures. Similarly, only one output of the MTLx514D may be used in a safety function.**

### 2.1 Associated System Components

There are many parallels between the loop components that must be assessed for intrinsic safety as well as functional safety. In both situations the contribution of each part is considered in relation to the whole.

The module is a component in the signal path between safety-related sensors and safety-related instruments or control systems.

## 3 Selection of Product and Implications

For systematic capability of SIL2 the normally open contact of the relay should be used, with the input such that the relay is in the normally energised state. This gives the operating condition where the safe state is relay de-energised, output contact open.

Consideration should be given to the affect of the wetting current and voltage that are applied to the contacts of the relay. If the modules are used at high voltage or current within the rating of the relay specification it is advisable not to subsequently apply the module for service at low currents or voltages. This is to avoid possible problems due to degradation of the contact surfaces. The rating of the relay contact shall be limited to a maximum of 500mA/35V dc and a minimum of 50mW e.g. 10mA at  $\geq 5V$  dc in the ON state.

Using an input sensor and logic controller as defined in section 2 and these modules, a system-loop can be implemented that applies functional safety together with intrinsic safety to meet the requirements of protection against explosion hazards.

## 4 Assessment of Functional Safety

The design features and the techniques/measures used to avoid systematic faults make the modules suitable for use in an instrument loop implementing safety functions up to SIL2.

The hardware assessment shows that these Switch/Proximity Detector Interface modules:

- have a hardware fault tolerance of 0
- are classified as Type A devices (“Non-complex” component with well-defined failure modes)
- have no internal diagnostic elements

The definitions for product failure of the MTLx51x modules at an ambient temperature of 45°C were determined as follows:-

Failure mode	Failure rate (FIT)					
	MTL4504	MTLx511	MTLx514(B)	MTLx514D	MTLx516(C)	MTLx517
Ch1 output stuck ENERGISED	11	11	11	11	11	11
Ch1 output stuck DE-ENERGISED	56	184	56	20	56	56
Ch1 output state uncertain	0.6	0.6	0.6	0.6	0.6	0.6
Ch2 output stuck ENERGISED	–	–	–	–	11	11
Ch2 output stuck DE-ENERGISED	–	–	–	–	58	58
Ch2 output state uncertain	–	–	–	–	0.6	0.6
LFD/Aux relay stuck ENERGISED	8	–	8	11	–	8
LFD/Aux relay stuck DE-ENERGISED	42	–	41	20	–	41
LFD/Aux relay state uncertain	0.3	–	0.3	0.6	–	0.3
Output & LFD/Aux relay DE-ENERGISED (common failures)	128	–	128	164	128	128
Correct operation (failures have no effect)	130	109	130	109	145	165

*(FITs means failures per 10<sup>9</sup> hours or failures per thousand million hours)*

The failure rates apply to the operation of a single channel and apply whether normal phase or reverse phase is selected.

When the relay is in the ‘ENERGISED’ condition then the NO (normally open) relay contact is closed, and the NC (normally closed) contact is open.

When the relay is in the ‘DE-ENERGISED’ condition then the NO (normally open) relay contact is open, and the NC (normally closed) contact is closed.

The common failure rate for the output and for the LFD/Aux relay must be added to the individual de-energised failure rates.

- Reliability data for this analysis is taken from IEC TR 62380:2004 Reliability Data Handbook.
- Failure mode distributions are taken principally from IEC 62061:2005 Safety of Machinery.

It is assumed that the module is powered from a nominal 24V dc supply and operating at a maximum ambient temperature of 45°C.

### Example of use of MTLx511 in a safety function

In this example, the application context is assumed to be:

- the safety function is to DE-ENERGISE the output on command

The failure modes shown above can then be defined as:

Failure mode	Category
Output stuck ENERGISED	Dangerous undetected, $\lambda_{du}$
Output stuck DE-ENERGISED	Safe undetected, $\lambda_{su}$
Output state uncertain	Dangerous undetected, $\lambda_{du}$
Correct operation	Safe undetected, $\lambda_{su}$

The failure rates for these categories are then (FITs):

Model	$\lambda_{sd}$	$\lambda_{su}$	$\lambda_{dd}$	$\lambda_{du}$
MTLx511	0	293	0	11.6

In this example, the safe failure fraction is 96%. However, note, as previously stated, the design features and the techniques/measures used to avoid systematic faults, make the MTLx51x modules suitable for use in instrument loops implementing safety functions up to SIL2 in a simplex architecture.

#### 4.1 EMC

The MTL4500 and MTL5500 modules are designed for operation in normal industrial electromagnetic environment but, to support good practice, modules should be mounted without being subjected to undue conducted or radiated interference, see Appendix A for applicable standards and performance criteria.

#### 4.2 Environmental

The MTL4500 and MTL5500 modules operate over the temperature range from -20°C to +60°C, and at up to 95% non-condensing relative humidity.

The modules are intended to be mounted in a normal industrial environment without excessive vibration, as specified for the MTL4500 & MTL5500 product ranges. See Appendix A for applicable standards and levels.

In applications using MTL4500 range, where the environment has a high humidity, the mounting backplanes should be specified to include conformal coating.

Continued reliable operation will be assured if the exposure to temperature and vibration are within the values given in this specification.

## 5 Installation

There are two particular aspects of safety that must be considered when installing the MTL4500 or MTL5500 modules and these are:

- **Functional safety**
- **Intrinsic safety**

Reference must be made to the relevant sections within the instruction manual for MTL4500 range (INM4500) or MTL5500 range (INM5500) which contain basic guides for the installation of the interface equipment to meet the requirements of intrinsic safety. In many countries there are specific codes of practice, together with industry guidelines, which must also be adhered to.

For functional safety applications the equipment should not be subjected to shock impacts of greater than 5g to ensure that the mechanical relay contacts are not affected.

Provided that these installation requirements are followed then there are no additional factors to meet the needs of applying the products for functional safety use.

To guard against the effects of dust and water the modules should be mounted in an enclosure providing at least IP54 protection degree, or the location of mounting should provide equivalent protection such as inside an equipment cabinet.

## 6 Maintenance

To follow the guidelines pertaining to operation and maintenance of intrinsically safe equipment in a hazardous area, yearly periodic audits of the installation are required by the various codes of practice.

In addition, proof-testing of the loop operation to conform with functional safety requirements should be carried out at the intervals determined by safety case assessment.

Proof testing must be carried out according to the application requirements, but it is recommended that this be carried out at least once every three years.

Refer to Appendix B for the proof testing procedure of the MTL4500 or MTL5500 modules.

Note that there may also be specific requirements laid down in the E/E/PE operational maintenance procedure for the complete installation.

If an MTL4500 or MTL5500 module is found to be faulty during commissioning or during the normal lifetime of the product then such failures should be reported to the MTL office. When appropriate, a Customer Incident Report (CIR) will be notified to enable the return of the unit to the factory for analysis. If the unit is within the warranty period then a replacement unit will be sent.

Consideration should be made of the normal lifetime for a device of this type which would be in the region of ten years.

Note also that the maximum number of switching cycles under the load conditions given in section 3 is  $22 \times 10^4$  at 500mA dc, rising to  $9 \times 10^6$  at 10mA dc.

## 7 Appendices

### 7.1 Appendix A: Summary of applicable standards

This annex lists all standards referred to in the previous sections of this document:

<b>IEC 61508:2010</b>	Functional safety of electrical/electronic/programmable electronic safety-related systems. Parts 1 and 2 as relevant
<b>EN 60947-5-6:2001</b>	Control circuit devices and switching elements – DC interface for proximity sensors and switching amplifiers (NAMUR)
<b>EN 61131-2:2007</b>	Programmable controllers – Part 2: Equipment requirement and tests (EMC requirements)
<b>EN 61326-1:2006</b>	Electrical equipment for measurement, control and laboratory use – EMC requirements. (Criterion A)
<b>BS EN 61326-3-1:2008</b>	Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 3-1: Immunity requirements for safety related systems and for equipment intended to perform safety related functions (functional safety) – General industrial applications. (Criterion FS)
<b>NE21 : 2007</b>	Electromagnetic Compatibility of Industrial Process and Laboratory Control Equipment. (Criterion A)
<b>Lloyds Register Type Approval System : 2002, Test Specification Number 1.</b>	Specifically vibration: 1.0mm displacement @ 5 to 13.2Hz and 0.7G acceleration @13.2Hz to 100Hz per IEC60068-2-6, test Fc
<b>EN 60068-2-27: 2009</b>	Environmental testing. Test Ea and guidance. Shock. (Criterion FS)



## 7.2 Appendix B : Proof Test Procedure, MTL45/5500 Binary Input Modules

### MTLx51x Proof Test Procedure

Test sequence:

1. System –Normal operation test
2. Input / Output characteristic functional safety test.
3. System- Normal operation test

#### 1. System - Normal operation test

Make sure that the module to be tested is operating normally in the target system, without errors and in energised mode. If the module is connected in a faulty or de-energised loop, restore normal, fault free and energised conditions before testing.

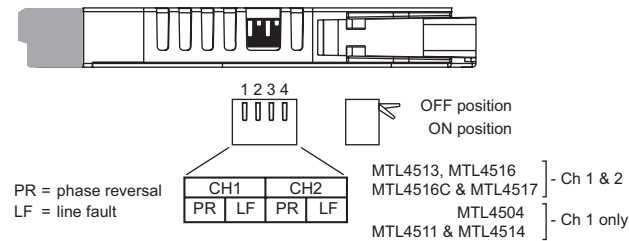
#### 2. Input/Output characteristic functional safety test

Observe normal anti-static precautions when handling equipment during device testing.

Remove the unit from the target system and connect the appropriate input test circuit and dc power supply. Please note, that it is acceptable to leave the unit in the target system, provided it has been secured, and that the I/O terminals are disconnected from the system and available for test. Alternatively, for the backplane mounted MTL45xx modules, use a separate backplane for this purpose to facilitate access to the power and output connections.

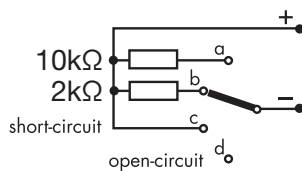
#### Configuration Switch Settings

The configuration switches on the edge of the module define the phase of the input/output relationship and the use of the line fault detection for each channel.



Record the settings of these switches for the module under test so that the condition can be restored following completion of the tests.

#### Input Conditions



#### Switch – simulation conditions

- a) **Normal**- field switch open
- b) **Normal** - field switch closed
- c) **Line Fault**- Test for short circuit
- d) **Line Fault**- Test for open circuit

The switch arrangement shown enables the four basic conditions of the field loop to be simulated and the operation of the isolator module to be checked.

Connect the power supply  $V_s$  (nominal 24.0V, min/max. range 20.0 to 35.0V) to terminals 13 and 14 (+ve to terminal 14).

Connect the '+' & '-' switch terminals to the input terminals and turn on the dc power to the module.

## Output Results

Operate the switch through the various positions and confirm expected operation of the module. It is recommended that the results are recorded in a table such as that shown below.

Example table with LFD on

Input switch position	Channel contacts		Expected 'Status' LED condition	Actual 'Status' condition	LFD contacts *		Expected 'LFD' LED condition	Actual 'LFD' condition
	NC	NO			NC	NO		
a	Closed	Open	OFF		Closed	Open	OFF	
b	Open	Closed	ON		Closed	Open	OFF	
c	Closed	Open	OFF		Open	Closed	ON	
d	Closed	Open	OFF		Open	Closed	ON	

\* If provided on the module. Conditions shown are for MTLx514 and MTLx517 variants. For MTL4504 the LFD contact states are reversed.

**Note that the phase reversal switch on the module will reverse the channel output conditions, but not the LFD output. If appropriate, repeat these measurements for channel 2.**

### 3. System - Normal operation test

Disconnect the test setup from the unit and connect the original system configuration. Make sure, as before, that the tested unit is operating normally in the target system, without errors and in energised mode.

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## AUSTRALIA

MTL Instruments Pty Ltd,  
10 Kent Road, Mascot, New South Wales, 2020, Australia  
Tel: +61 1300 308 374 Fax: +61 1300 308 463  
E-mail: mtl-salesanz@eaton.com

## BeNeLux

MTL Instruments BV  
Ambacht 6, 5301 KW Zaltbommel  
The Netherlands  
Tel: +31 (0)418 570290 Fax: +31 (0)418 541044  
E-mail: mtl.benelux@eaton.com

## CHINA

Cooper Electric (Shanghai) Co. Ltd  
955 Shengli Road, Heqing Industrial Park  
Pudong New Area, Shanghai 201201  
Tel: +86 21 2899 3817 Fax: +86 21 2899 3992  
E-mail: mtl-cn@eaton.com

## FRANCE

MTL Instruments srl,  
7 rue des Rosieristes, 69410 Champagne au Mont d'Or  
France  
Tel: +33 (0)4 37 46 16 53 Fax: +33 (0)4 37 46 17 20  
E-mail: mtlfrance@eaton.com

## GERMANY

MTL Instruments GmbH,  
Heinrich-Hertz-Str. 12, 50170 Kerpen, Germany  
Tel: +49 (0)22 73 98 12-0 Fax: +49 (0)22 73 98 12-2 00  
E-mail: csckerpen@eaton.com

## INDIA

MTL India,  
No.36, Nehru Street, Off Old Mahabalipuram Road  
Sholinganallur, Chennai- 600 119, India  
Tel: +91 (0) 44 24501660 /24501857 Fax: +91 (0) 44 24501463  
E-mail: mtlindiasales@eaton.com

## ITALY

MTL Italia srl,  
Via San Bovio, 3, 20090 Segrate, Milano, Italy  
Tel: +39 02 959501 Fax: +39 02 95950759  
E-mail: chmninfo@eaton.com

## JAPAN

Cooper Crouse-Hinds Japan KK,  
MT Building 3F, 2-7-5 Shiba Daimon, Minato-ku,  
Tokyo, Japan 105-0012  
Tel: +81 (0)3 6430 3128 Fax: +81 (0)3 6430 3129  
E-mail: mtl-jp@eaton.com

## NORWAY

Norex AS  
Fekjan 7c, Postboks 147,  
N-1378 Nesbru, Norway  
Tel: +47 66 77 43 80 Fax: +47 66 84 55 33  
E-mail: info@norex.no

## RUSSIA

Cooper Industries Russia LLC  
Elektrozavodskaya Str 33  
Building 4  
Moscow 107076, Russia  
Tel: +7 (495) 981 3770 Fax: +7 (495) 981 3771  
E-mail: mtlrussia@eaton.com

## SINGAPORE

Cooper Crouse-Hinds Pte Ltd  
No 2 Serangoon North Avenue 5, #06-01 Fu Yu Building  
Singapore 554911  
Tel: +65 6 645 9864 / 5 Fax: +65 6 487 7997  
E-mail: sales.mtlsing@eaton.com

## SOUTH KOREA

Cooper Crouse-Hinds Korea  
7F, Parkland Building 237-11 Nonhyun-dong Gangnam-gu,  
Seoul 135-546, South Korea.  
Tel: +82 6380 4805 Fax: +82 6380 4839  
E-mail: mtl-korea@eaton.com

## UNITED ARAB EMIRATES

Cooper Industries/Eaton Corporation  
Office 205/206, 2nd Floor SJ Towers, off. Old Airport Road,  
Abu Dhabi, United Arab Emirates  
Tel: +971 2 44 66 840 Fax: +971 2 44 66 841  
E-mail: mtlgulf@eaton.com

## UNITED KINGDOM

Eaton Electric Ltd,  
Great Marlings, Butterfield, Luton  
Beds LU2 8DL  
Tel: +44 (0)1582 723633 Fax: +44 (0)1582 422283  
E-mail: mtlenquiry@eaton.com

## AMERICAS

Cooper Crouse-Hinds MTL Inc.  
3413 N. Sam Houston Parkway W.  
Suite 200, Houston TX 77086, USA  
Tel: +1 281-571-8065 Fax: +1 281-571-8069  
E-mail: mtl-us-info@eaton.com