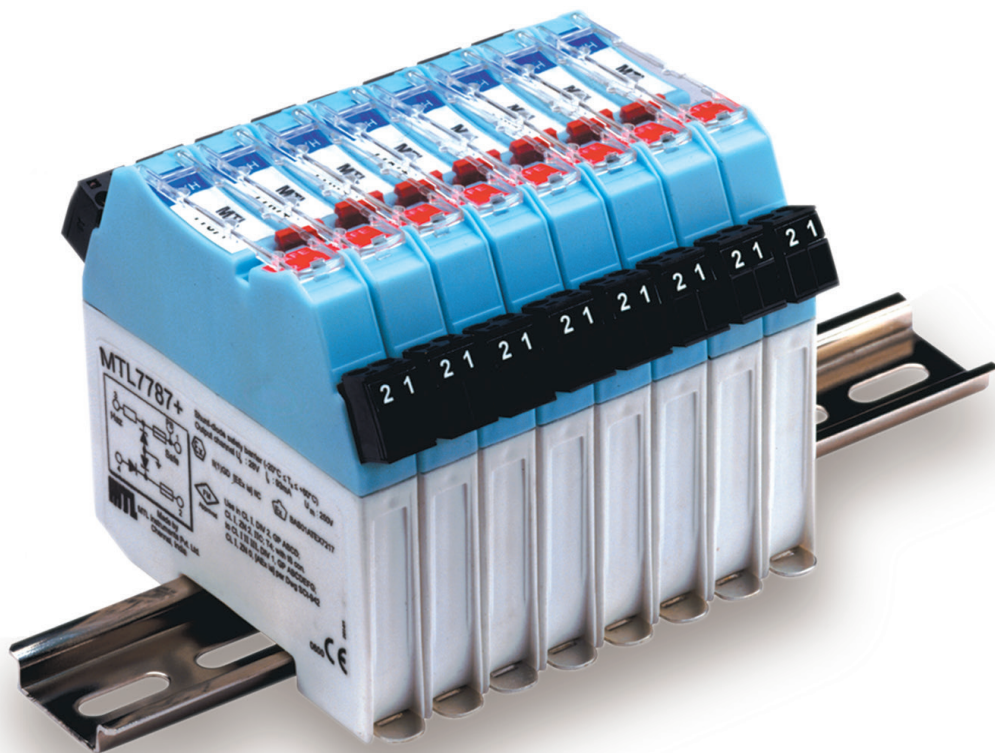




MTL7700 Series

Shunt-diode Safety Barriers



CONTENTS

PAGE

1	OVERVIEW	1
2	DESCRIPTION	1
2.1	Introduction	1
2.2	MTL7700 Series – barrier ranges	1
2.3	MTL7700 Series – accessories	2
3	SAFETY CONSIDERATIONS	3
3.1	General requirements	3
3.2	Safety checks	3
4	INSTALLATION	3
4.1	General	3
4.2	Mounting/removing barriers	3
4.3	Installing accessories	3
5	WIRING CONNECTIONS	7
5.1	General	7
5.2	Barrier connections	7
5.3	Connections to plant earth	7
5.4	Connections to dummy barriers	9
6	MAINTENANCE	9
6.1	General	9
6.2	Routine inspection	9
7	FAULT-FINDING	10
7.1	Introduction	10
7.2	Power supply check	11
7.3	Barrier resistance test	11
8	EQUIPMENT AND BARRIER TESTS	11
8.1	Thermocouple and RTD tests	11
8.2	Barrier tests	11
8.3	Tests for Active Barriers	12
8.4	Test tables for passive barriers	14
9	APPENDIX A: TYPICAL WIRING CONNECTIONS FOR SPECIFIC APPLICATIONS	17

NOTE

The following MTL7700 Series Shunt Diode Safety Barrier Assemblies were submitted to the Mine Safety and Health Administration (MSHA) of the U.S. Department of Labor for acceptance as part of an MSHA approved permissible system or machine.

MTL7715+	MTL7715P+	MTL7755ac
MTL7760ac	MTL7761ac	MTL7765ac
MTL7766Pac	MTL7767+	MTL7787+/-

These Safety Barrier Assemblies were evaluated by MSHA and judged to meet the applicable requirements of Title 30 Code of Federal Regulations, Part 18.68 (30 CFR Part 18.68) provided that a relevant installation complies with the following conditions.

- a) The installation shall preclude intermingling between intrinsically safe circuits, including their associated wires and cables, and all other circuits, wires, and cables.
 - b) The MTL7700 Series Shunt Diode Safety Barrier Assemblies must be securely mounted within a suitable dust-tight enclosure in a fresh air area of the mine or an explosion-proof enclosure.
 - c) The MTL7700 Series Shunt Diode Safety Barrier Assemblies must be grounded according to the manufacturer's instructions.
 - d) The equipment connected to the the input terminals of the barrier must not use or generate more than the maximum 120Vrms.



그림 1: MTL7700 시리즈 셉트 다이오드 안전 배리어

1 OVERVIEW

This instruction manual contains all information needed to install, maintain, fault-find and test MTL7700 Series shunt-diode safety barriers.

Section 3 includes a checklist of **essential safety factors** that must be considered when using MTL7700 Series barriers as intrinsically safe (IS) interfaces between safe and hazardous areas. *Read section 3 before beginning installation.* Users within the European Community should also refer to the supplied MTL publication:

INA7700 MTL7700 Series
 Instructions for Safe Use

It is assumed that all necessary system design, specification and engineering factors have been taken into account BEFORE installation work begins. To assist pre-planning, the following MTL publications covering the theory, design, application, specifications and certification of shunt-diode safety barriers are available:

AN9003	Application Note: <i>A user's guide to intrinsic safety</i>
AN9007	Application Note: <i>A user's guide to MTL7700 Series shunt-diode safety barriers</i>
MTL IS catalogue	The MTL IS catalogue includes detailed specifications of all MTL7700 Series barriers and accessories
IS certificates	Copies of Baseefa, FM and CSA IS apparatus and system certificates for MTL7700 Series barriers

If not supplied with the product, these publications are available either from the company website (www.mtl-inst.com) or on request from your local MTL office.

2 DESCRIPTION

2.1 Introduction

MTL7700 Series 'fourth-generation' intrinsically safe shunt-diode safety barriers are innovative successors to the MTL700 Series.

MTL7700 Series barriers are 1-, 2- or 3-channel devices that use intrinsically safe explosion-protection techniques to pass electrical signals between safe and hazardous areas, whilst limiting transferred energy to a level that cannot ignite flammable atmospheres.

Connected in series with wiring entering any hazardous area on process plant, MTL7700 Series barriers prevent explosions in all normally occurring explosive atmospheres – including mixtures of air with flammable gases, vapours, dusts and fibres – if a fault or faults develop in the safe area.

2.2 MTL7700 Series – barrier ranges

The range is based on a choice of models which, between them, cover virtually all applications – including the protection of installations incorporating uncertified devices known as 'simple apparatus' (eg, switches, thermocouples, resistive sensors, photocells and LEDs) or separately certified 'energy-storing' or 'voltage-producing apparatus' (eg, ac sensors, proximity detectors, transmitters and current-to pneumatic (I/P) converters. Being intrinsically safe, shunt-diode barriers enable maintenance work or calibration to be carried out 'live' without additional precautions. To simplify selection, several 'key' barriers (see table 1) are highlighted as meeting the majority of process control requirements.

Type	Application	Key barriers MTL	
Analogue input (low-level)	Resistance temperature detectors Thermocouples, ac sensors	7755ac 7756ac 7760ac	
Analogue output	Controller outputs, one line earthed Controller outputs, neither line earthed	7728+ 7787+	
		dc power supply	
		26V	20-35V
Analogue input (high-level)	Transmitters, 2-wire, 4-20mA	7787+	7706
Digital (on/off) input	Switches	7787+	7707+ 7741-44
Digital (on/off) output	Solenoids, alarms, LEDs	7728+	7707+

Table 1: MTL7700 Series Key barriers

2.3 MTL7700 Series – accessories

MTL7700 시리즈 배리어는 DIN 레일에 직접 장착됩니다. 다양한 마운팅, 태깅, 전원 및 접지 액세서리를 선택할 수 있습니다. 설치 세부 사항은 섹션 4.3에 나와 있습니다.

Essential accessories

다음은 일반적으로 MTL7700 시리즈 배리어를 장착하고 접지하는데 필수적인 것으로 간주됩니다.

- DIN-rail DIN 레일 (eg, THR2 or THR7000)
- Insulating spacers 절연 스페이서 (eg, ISP7000)
- Earth terminal 접지 단자 (eg, ETL7000)

개별 모듈 및 장벽 열에 대한 태깅 시스템이 여기에 설명되어 있습니다. 장벽 열에 대한 태그 지정 액세서리 아래에 아래에 나와 있습니다.

Mounting accessories (figure 2)

- THR2** 표준 DIN 레일, 35 x 7.5mm, (1m 길이)
- THR7000** 부식 가능성이 있는 환경에서 사용하기 위한 니켈 도금 DIN 레일, 35 x 7.5mm (길이 1m)
- ISP7000** 절연 스페이서: 구조 접지에서 IS 접지를 분리하기 위해 DIN 레일의 베이스에 부착합니다.

Tagging accessories for individual barriers (figure 2)

- TH7700** 개별 장벽 상단에 장착하기 위한 태그 홀더

Tagging accessories for columns of barriers (figure 2)

- TAG57** 장벽 위치를 표시하기 위해 장벽 열 위에 장착하기 위한 태깅 스트립. 크기에 맞게 절단할 수 있도록 1m 길이로 라벨과 함께 제공됩니다.
- TGL7700** TAG57 태깅 스트립과 함께 사용하기 위한 예비 라벨: 0.5m 스트립, 10개 세트로 제공.
- IMB57** 태깅 스트립 지원. 각 태깅 스트립에 2개가 필요합니다. 상단 끝 탭을 분리하여 중앙 지지대로 사용할 수도 있습니다.

Power accessories (figure 3)

- BPL7700** MTL7798 전원 공급 모듈 또는 MTL7799 더미 모듈에서 단일 열에 있는 최대 40개의 배리어에 24V dc를 공급하기 위한 전원 링크.

Earthing accessories (figure 3)

- ETL7000** IS 접지를 DIN 레일에서 적절한 플랜트 접지로 라우팅하기 위한 연결을 제공하는 접지 단자. DIN-레일 길이별로 2개를 권장합니다.

Mounting accessories (figure 2)

TAG57 장벽 위치를 표시하기 위해 장벽 열 위에 장착하기 위한 태깅 스트립. 크기에 맞게 절단할 수 있도록 1m 길이로 라벨과 함께 제공됩니다.

TGL7700 : TAG57 태깅 스트립과 함께 사용하기 위한 예비 라벨: 0.5m 스트립, 10개 세트로 제공.

THR2 표준 DIN 레일, 35 x 7.5mm, (1m 길이)

TH7700 개별 장벽 상단에 장착하기 위한 태그 홀더



IMB57

ERB57

ISP7000

ERB57O : 니켈 도금 오프셋 접지 레일 브래킷, 푸시 패스너 2개, 14mm 접지 레일 클램프 1개 및 16mm2 미만의 9mm 접지 클램프 1개와 함께 제공됩니다.

IMB57 : 태깅 스트립 지원. 각 태깅 스트립에 2개가 필요합니다. 상단 끝 탭을 분리하여 중앙 지지대로 사용할 수도 있습니다.

ETL7000(접지 단자) : IS 접지를 DIN 레일에서 적절한 플랜트 접지로 라우팅하기 위한 연결을 제공하는 접지 단자. DIN-레일 길이별로 2개를 권장합니다

ISP7000 (절연 스페이서): 절연 스페이서: 구조 접지에서 IS 접지를 분리하기 위해 DIN 레일의 베이스에 부착합니다.

Figure 2: MTL7700 Series mounting and tagging accessories

Item no.	Refer to section:	Action
1	3.1	설치를 시작하기 전에 제안된 시스템이 완전히 인증되었고(해당하는 경우) 가스 그룹, 온도 분류 및 필요한 영역 분류에 대한 IEC 60079-14의 관련 섹션에 포함된 권장 사항을 준수하는지 안전 문서에서 확인하십시오.
2	4.1/6.2	장벽이 안전 문서에 지정된 대로 올바른 유형과 극성인지 확인하십시오.
3	4.1	안전 문서와 IEC 60079-14의 권장 사항에 따라 필수 접지 접촉이 안전하게 이루어지도록 모든 배리어가 올바른 방향으로 장착되고 적절하게 부착되었는지 확인하십시오.
4	5.3/6.2	장벽 접지 DIN 레일과 주 전원 시스템 접지 사이의 저항을 측정하고 안전 문서에 지정된 최대 허용 저항을 초과하지 않는지 확인하십시오.
5	4.1/6.2	배리어와 위험 지역 장비 사이에 연결된 모든 케이블을 주의 깊게 검사하여 케이블이 안전 문서에 지정된 유형이고 올바른 단자에 연결되어 있는지 확인하십시오.
6	5/6.2	모든 위험 지역 케이블이 잘 고정되어 있고 다른 모든 케이블과 분리되어 있는지 확인하십시오.
7	5	위험 지역 회로에 허용된 케이블 매개변수가 초과되지 않았는지 확인하십시오(관련 인증서 또는 INA7700 참조).
8	5	모든 위험 지역 장비 및 케이블이 접지되지 않았거나 등전위 도체로 올바르게 결합되었는지 확인하십시오.
9	5.3/6.2	모든 위험 지역 케이블과 케이블 스크린이 올바르게 중단되었는지 확인하십시오. 후자는 바람직하게는 각 배리어의 위험 쪽에 있는 접지 받침 또는 ERL7을 통해 중단됩니다.
10	5.4	사용하지 않는 모든 위험 지역 케이블이 더미 배리어(MTL7799), 접지 레일(ERL7)로 중단되거나 다른 방식으로 안전하게 접지에 연결되었는지 확인하십시오.
11		모든 위험 지역 에너지 저장 장치가 독립적이고 적절하게 인증되었는지 확인하십시오.
12	4.1/ 4.3.5/ 4.3.6	모든 태깅 또는 식별 라벨을 검사하고 올바른 배리어 유형, 극성 및 회로 루프 번호와 관련이 있는지 확인하십시오.
13	5/6.2	안전 구역 장비에 연결된 모든 케이블을 주의 깊게 검사하고 장벽의 안전 구역 단자에 연결되어 있는지 확인하십시오.
14	5.3	안전 지역 장비는 안전 문서에서 특별히 허용하지 않는 한 정상 또는 결합 조건에서 접지와 관련하여 250V rms 또는 250V dc를 초과하는 전위 소스에서 공급(또는 포함)되지 않도록 하십시오.
		참고: 값이 250V rms와 동일하므로 최대 440V의 3상 공급의 한 위상이 허용됩니다.
15		모든 장벽이 습기, 먼지, 오물, 진동, 과도한 온도, 물리적 손상 및 무단 개조로부터 적절하게 보호되는지 확인하십시오.

Table 2: Safety checklist

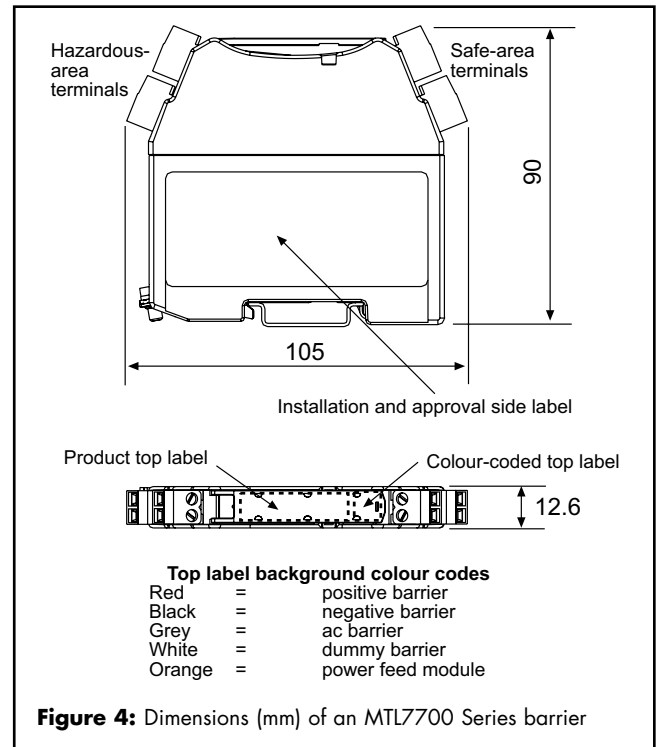


Figure 4: Dimensions (mm) of an MTL7700 Series barrier

Tagging accessories **Section 4.3.5, 4.3.6**

Power links **Section 4.3.7, 4.3.8**

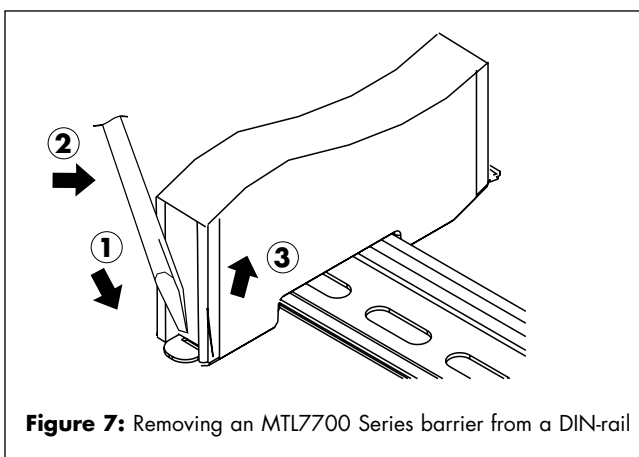
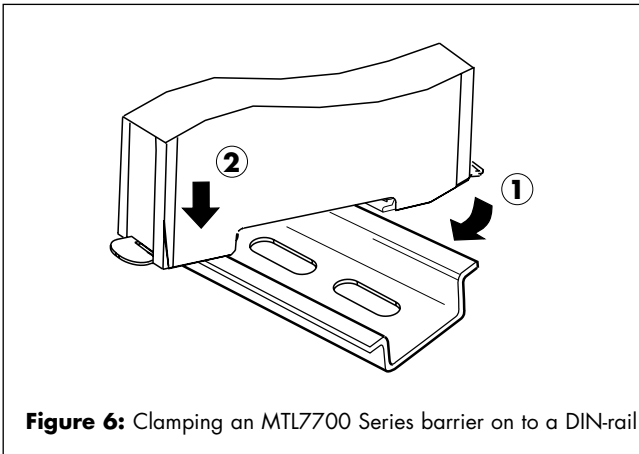
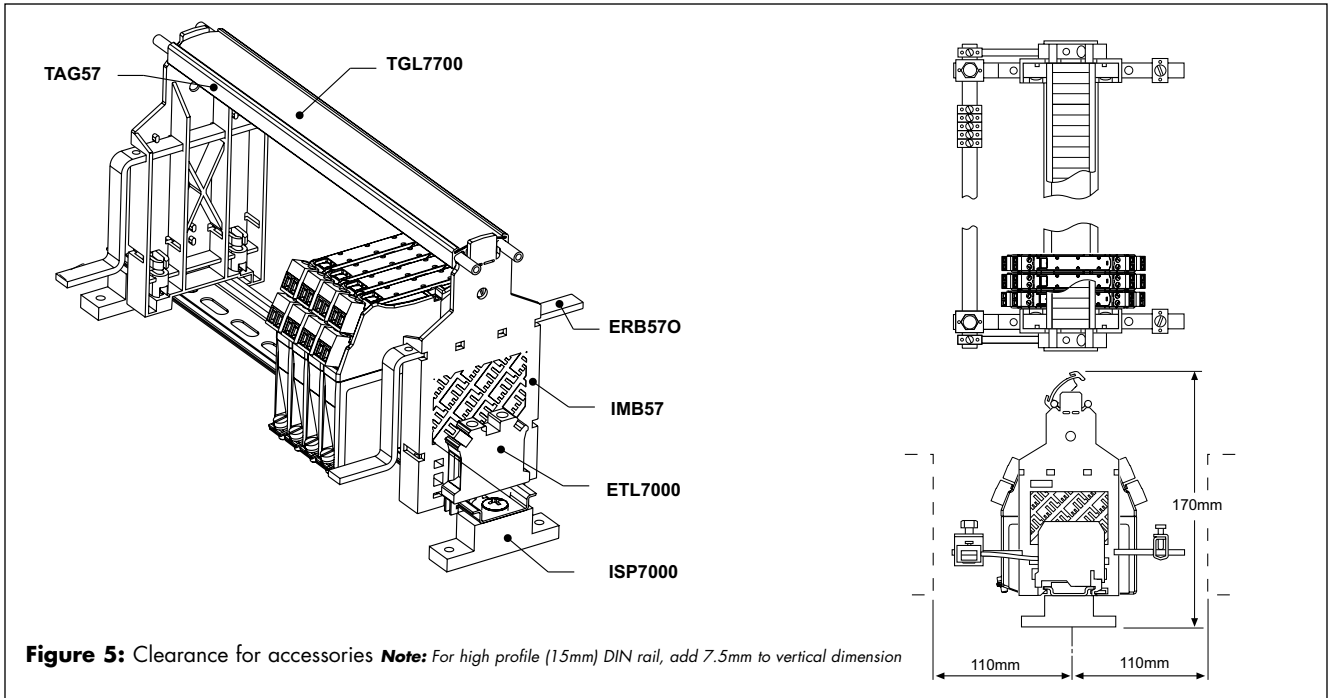
4.3.1 DIN-rail (THR2 and THR7000)

MTL은 표준(THR2) 및 도금(THR7000) 로우 프로파일 T 섹션 DIN 레일을 모두 공급할 수 있습니다. 표준 DIN-레일은 정상적인 조건에서 높은 무결성 접지를 유지하지만 공격적인 환경을 위해 MTL은 THR7000 니켈 도금 DIN-레일을 제공합니다. 두 가지 유형 모두 필요한 크기로 절단할 수 있도록 1m 길이로 제공됩니다. DIN 레일이 접지된 표면에서 격리되어야 한다는 엄격한 요구 사항은 없지만 다른 시스템과 악영향을 미칠 수 있는 오류 전류가 접지 회로를 침범할 가능성을 최소화하기 위해 권장됩니다. ISP7000 절연 스페이서는 DIN 레일을 절연하는 편리한 방법입니다. 초기 구축 중에 절연 스페이서를 설치하는 것이 장착되어 실행 중인 설치를 수정해야 한다는 사실을 나중에 발견하는 것보다 훨씬 쉽습니다.

4.3.2 Insulating spacers (ISP7000)

사용 시 ISP7000 절연 스페이서는 DIN 레일의 각 끝에 레일 길이에 따라 간격을 두고 부착됩니다. 스페이서는 로우 프로파일(7.5mm) DIN 레일에 300mm 간격으로, 하이 프로파일(15mm) 레일에 500mm 간격으로 장착하는 것이 좋습니다. 그림 8을 참조하십시오. 용도에 맞게 드릴 및 탭핑이 필요한 DIN 레일 및 장착 표면. 다음과 같이 각 스페이서를 설치합니다(그림 9).

- 장착면에 M4 나사용 구멍 2개를 뚫고 탭핑합니다.
- 제공된 2개의 M4 x 16 나사로 스페이서를 표면에 부착합니다.
- DIN 레일 베이스 중앙에 M6 여유 구멍(6.5mm)을 뚫습니다(아직 적절하게 슬롯이 없는 경우).
- 제공된 M6 x 16 나사를 사용하여 DIN 레일을 스페이서에 부착합니다.



4.3.3 DIN-rail earth terminal (ETL7000)

그림 10을 참조하십시오. IS 접지가 장착 표면을 통해 라우팅되지 않는 애플리케이션(대부분)의 경우 DIN 레일에서 적절한 플랜트 접지로 IS 접지를 라우팅하기 위한 연결은 접지 단자(ETL7000)에 고정되어 있습니다. DIN 레일. 이중화를 제공하고 접지 테스트 절차를 단순화하기 위해 장벽 열의 양쪽 끝에 하나씩 두 개의 단자가 권장됩니다.

경고: 장착 표면에 IS 접지가 있는 드문 경우를 제외하고 MTL7700 시리즈 배리어의 한 열에서 IS 접지 연결을 제공하는 유일한 방법은 ETL7000 접지 단자를 사용하는 것입니다. 개별 배리어의 접지 스크린에 플랜트 IS 접지 연결을 만들지 마십시오. 이것은 필수입니다. 섹션 참조

5.3.

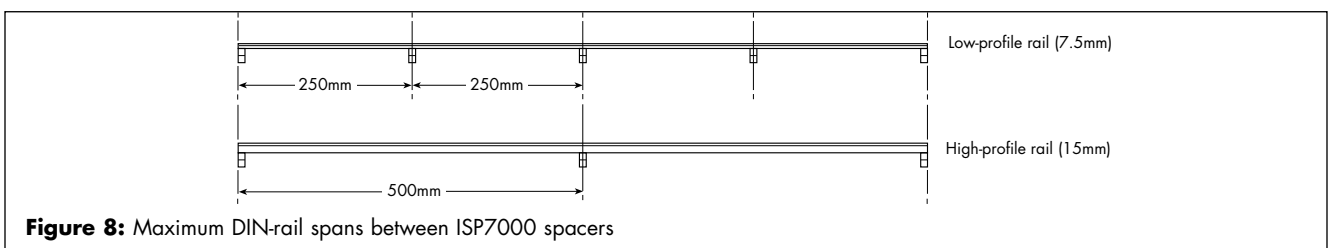
ETL7000 단자는 다음과 같이 레일에 부착됩니다. 장벽 자체와 마찬가지로 레일에 대한 접지 연결의 보안을 동일하게 유지합니다(섹션 4.2 참조).

a) DIN 레일의 한쪽 플랜지에 터미널의 고정 엔드 클램프를 겁니다.

b) 회전 엔드 클램프가 DIN 레일의 다른 플랜지에 맞물릴 때까지 터미널 본체를 아래쪽으로 누릅니다

c) 중앙 나사를 조여 터미널을 제자리에 단단히 고정합니다.

d)중요: 섹션 5.3.2에 나와 있는 대로 접지 단자를 배선하십시오.



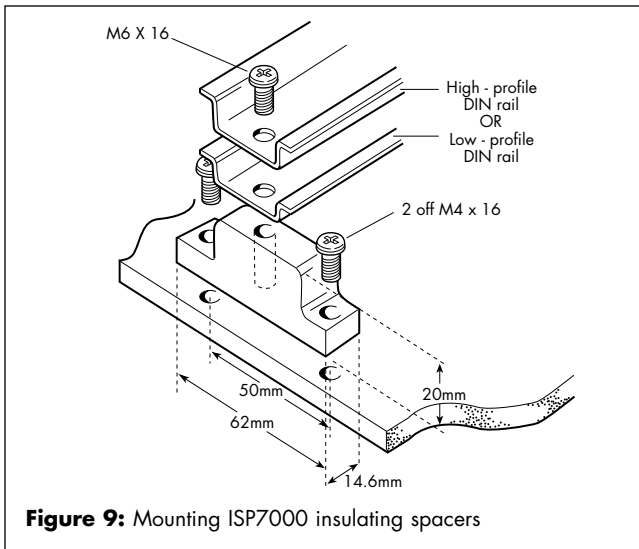


Figure 9: Mounting ISP7000 insulating spacers

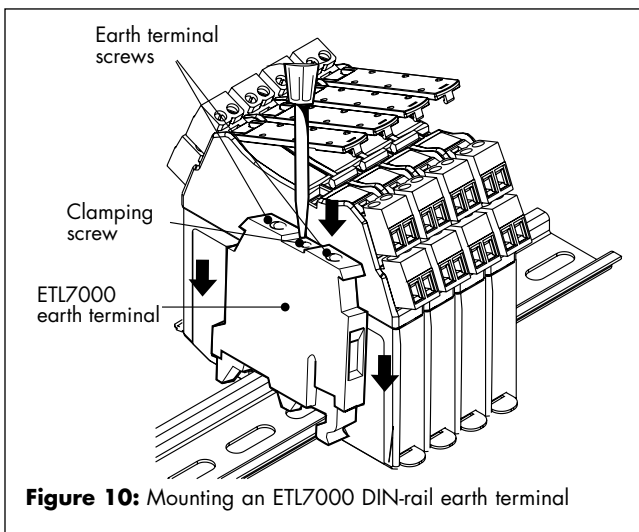


Figure 10: Mounting an ETL7000 DIN-rail earth terminal

4.3.4 Earth rail assembly (ERL7/ETM7/ERB57S/O)

A screw terminals on each barrier is available for terminating cable screens and OV returns. An alternative is provided by an earth rail assembly (figure 12). This consists of two IMB57's, ERB57S or O, mounting blocks (one for each end of a column of barriers), a length of ERL7 earth rail (supplied in 1m lengths for cutting to size), and ETM7 terminals for connecting cable screens or OV returns to the rail.

Install the earth rail assembly as follows:

- Hook the loose end-clamps of the IMB57 mounting blocks over the flanges of the DIN-rail at each end of the row of barriers.
- Making sure the blocks are flush with the end barriers or tagging strip supports, clamp them firmly into place by tightening the screws at the base of the blocks and fit 2 off ERB57O or S into supports.
- Slide the number of ETM7 terminals required for connections onto the length of ERL7 rail needed for the assembly.
- Important: wire up the earth rail assembly as given in section 5.3.3.

4.3.5 Barrier identifiers (TH7700)

TH7700 tag holders (figure 11) are clipped onto the tops of individual barriers to provide transparent holders for identification labels

- Slide the required label in between the top and lower parts of the TH7700
- Push the tag holder downwards until it clips into place.
- To unclip a tag holder, lever up the far end above terminals.

Note: Early versions of TH7700 are hinged on two small locating pins. Later versions are hinged by locating the clips at the hinged end into the rectangular apertures on the barrier body. The later design can be retrofitted on early modules by removing the hinge pins with a knife.

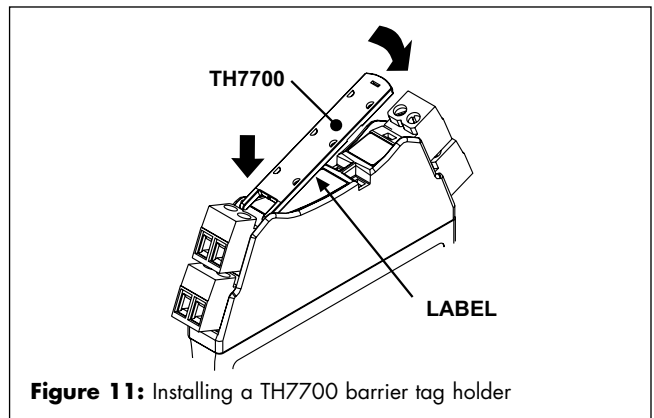


Figure 11: Installing a TH7700 barrier tag holder

4.3.6 Tagging strip assemblies(IMB57)

The tagging strip assembly (figure 12) identifies the location of individual barriers, ensuring that they are replaced correctly after removal for maintenance or testing. Once installed, the tagging strip pivots upwards to provide access to, and allow removal of, individual barriers.

Each assembly uses two tagging strip supports (IMB57), a tagging strip (TAG57) and tag labels (TGL7700).

The assembly installation procedure is:

- IMB57 tagging strip support.** Making sure that the vertical slots are on the hazardous-area side, hook the loose end-clamps of each IMB57 tagging strip support over the flanges of the DIN-rail at each end of the group of barriers.
- Make sure that the tagging strip support is flush with the end barrier in the row.
- IMB57 tagging strip support.** Clamp firmly in place by tightening the two screws located at the foot of each support.
- Remove any clic rivets from the tagging strip and slide out the label.
- Measure the distance between the top inside faces of the two tagging strip supports.
- Cut the tagging strip and label to this length with a hacksaw.
- Annotate the tagging strip label as required and slide it back into the tagging strip. Divisions on label strips are 12.6mm wide, the pitch of individual barriers.
- Clip the tagging strip onto the lugs on top of the tagging strip supports.

4.3.7 Power bus (BPL7700)

For details on using and installing a power bus, see section 5.2.3.

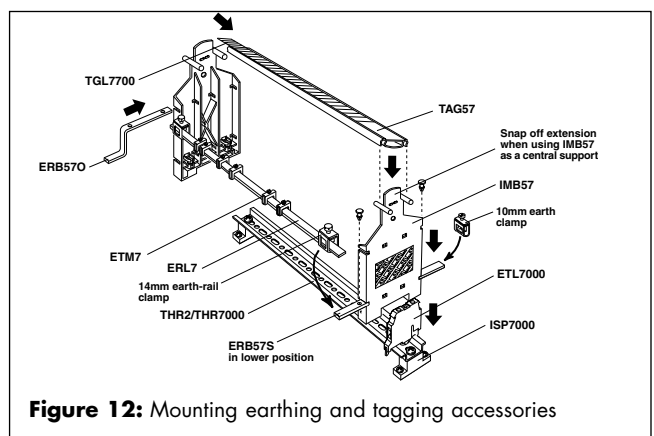


Figure 12: Mounting earthing and tagging accessories

5 WIRING CONNECTIONS

5.1 General

This section describes wiring connections as follows:

- a) Barrier connections Section 5.2
- b) Connections to plant earth Section 5.3
- c) Connections to dummy barriers Section 5.4

5.2 Barrier connections

Each barrier has 4 or 8 terminals, 2 or 4 on each side, allocated as follows:

Safe area

Terminals 1,2,5 and 6	Safe-area power and signal lines	Sections 5.2.1 and 5.2.2
-----------------------	----------------------------------	--------------------------

Hazardous area

Terminals 3,4,7 and 8	Hazardous-area signal lines	Section 5.2.1
-----------------------	-----------------------------	---------------

Torque the screw terminals to 0.4Nm.

5.2.1 Signal line connections

Connect signal lines to the screw terminals at both sides of the barrier (1 and 2 and/or 5 and 6 at the safe-area side, 3 and 4 and/or 7 and 8 at the hazardous-area side). The safe-area terminal 1 is also used as a power connection when power is provided from the safe area (see section 5.2.2 for details).

Clearly segregate hazardous-area and safe-area cabling as defined by relevant codes of practice, and route cabling to the barriers through clearly separated and identified conduits or trunking. Deal with spare cable cores or screens as described in section 5.2.3.

Before making any signal connections from the hazardous area, make sure any energy-storing devices (ie, devices NOT classified as 'simple apparatus') are certified as being compatible with the barriers to which they will be connected. Check also that the connecting cables conform with the cable types specified by the safety documentation and that the maximum cable parameters specified in MTL's IS catalogue are not exceeded. In general, cable parameters are unlikely to present problems except in installations where cables longer than 500m are called for in IIC applications.

Do not connect barriers to safe-area equipment that is supplied from (or contains) a source of potential with respect to earth that is greater than 250V rms or 250V dc under normal or fault conditions, unless this is specifically permitted by the safety documentation. This limitation does not apply to safe-area equipment fed by a three-phase 440V neutral earth supply.

See Appendix A for examples of wiring connections for specific applications.

5.2.2. Power supply connections general considerations

Take care that if barriers are connected to a safe-area power supply, connections are made correctly. If the internal safety fuse blows, it will destroy MTL7700 barriers. See Appendix A for specific connections for individual barriers and applications.

5.2.3 Bussed Power applications and connections

When a number of barriers use a common power supply, the optional power link (BPL7700) can be used. Typical applications include hazardous-area switches, solenoids and 4–20mA transmitters; and the barriers it can be used with are the MTL7706, MTL7707+, MTL7787+, MTL7787P+ and MTL774x. See figure 14 for a typical power link installation applied to hazardous-area switches.

Up to 40 barriers can be linked using the power links. The link itself is supplied from a power feed module (MTL7798). The MTL7798 power feed module is provided with a trip circuit which protects the barriers by switching off their supply if a fault (such as an overvoltage) occurs in the power source. The state of the module is indicated by one of two LED indicators:

- a) Green ON when supply is normal and being passed to the barriers.
- b) Red ON when the trip mechanism is activated indicating a fault.

After a fault has been indicated, the module can be reset by disconnecting the main power supply.

Install the power links as follows (figure 13):

- a) Mount an MTL7798 power feed module on the DIN-rail at one end of the column of barriers being supplied.
- b) Connect a safe-area 20–26V dc supply to terminals 5 and 6 of the power feed module.
- c) select the number of links required.
- d) Lift the tag holders to gain access to the power link connectors and insert the links (figure 13).
- e) Close the tag holders.
- f) To replace the barrier, lift the identifiers either side of the appropriate barrier to check which one is linked, remove the link, replace the barrier and re-insert the link and close the identifiers.

WARNING

Do not remove bussed power links with power applied if installed in FM Div 2 / ATEX Zone 2

5.2.4 Spare cores/screens/OV returns: connections

Unused cores should be connected to OV. Terminals on the earth foot simplify this.

5.3 Connections to plant earth

5.3.1 General considerations

A barrier installation must be earthed properly for correct and safe operation. Care must be taken that individual barriers are correctly mounted so that the earth connection with the DIN-rail is secure.

An installation must, in turn, be connected to a suitable plant high-integrity earth. This should be done by connecting suitable conductors to ETL7000 earth terminals (see section 5.3.2). It is also usually advisable to make sure that the DIN-rail is isolated from any possible enclosure earths by separating it from the mounting surface with ISP7000 isolating spacers (see section 4.3.2).

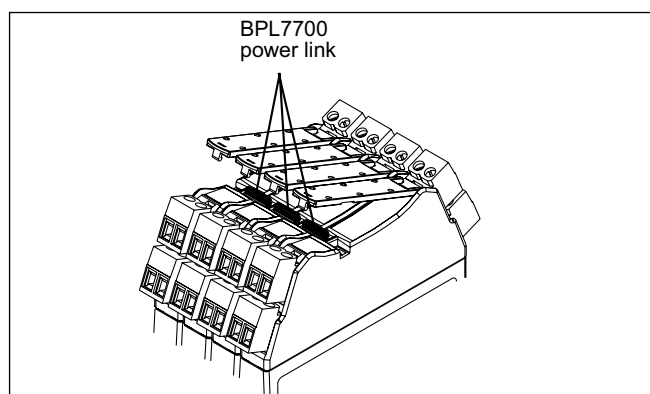


Figure 13: Power link installation

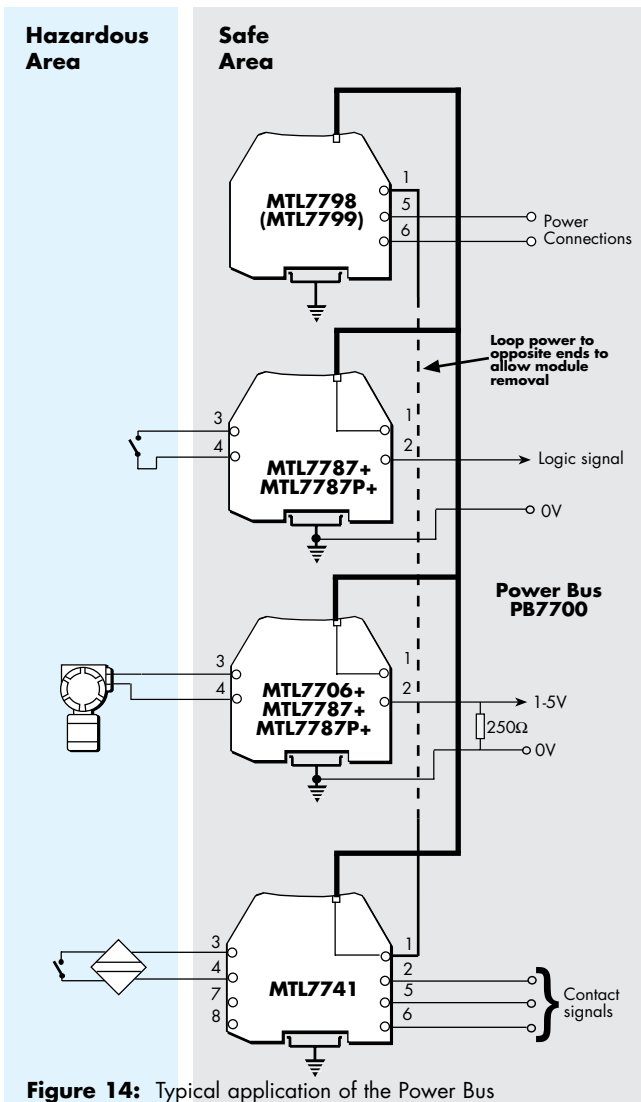


Figure 14: Typical application of the Power Bus

5.3.2 Earthing an installation

See figure 15. Connections from the DIN-rail to a suitable plant earth are made from ETL7000 earth terminals. These clip onto the DIN-rail as described in section 4.3.3 to make the vital earth connection with the rail and the barriers. They are provided with two screw-clamp terminals, to one of which a copper conductor to plant earth should be connected. This should have a resistance no greater than 1Ω though to increase safety and reduce interference, a resistance as close to 0.1Ω as possible is preferable. The cross-sectional area of the conductor should be at least 4mm^2 (12 AWG).

It is advisable to mount one ETL7000 earth terminal at each end of a column of barriers to provide redundancy by connecting both ETL7000 terminals to the plant earth. This makes it possible to introduce a multimeter into one of the loops to measure loop resistance without breaking the earth connection (figure 16) – a test which should be done periodically. In these circumstances, resistance for each cable loop should not exceed 2Ω .

The IS plant earth conductors should be clearly identified to warn against unauthorised interference. Though not mandatory, it is recommended that this should be done by winding blue insulating tape round the conductors at intervals along their length.

WARNING

Do not use earth foot terminal as an IS earth termination. Make IS earth connections using an ETL7000 earth terminal as described in section 5.3.2.

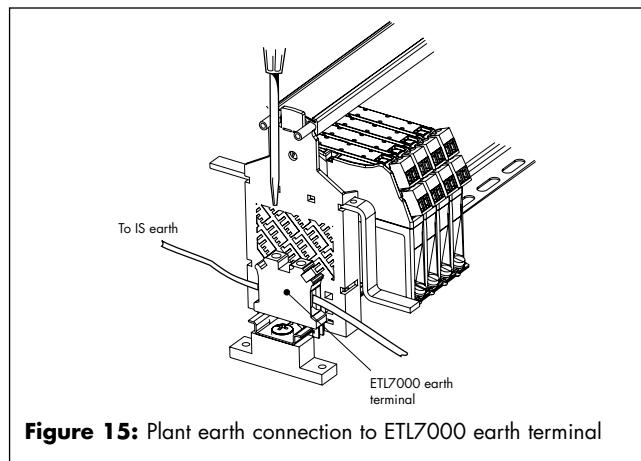


Figure 15: Plant earth connection to ETL7000 earth terminal

5.3.3 Earthing an earth rail assembly

On installations which include earth rail assemblies (see section 4.3.4) an earth conductor, normally copper wire with a cross-sectional area of at least 4mm^2 (12AWG) must be connected between ETM7 earth terminals located at each end of the rail and the 'spare' terminals on the ETL7000 terminals at each end of the column of barriers. See figure 17.

5.3.4 Hazardous-area equipment isolation

Hazardous-area equipment and interconnections should be isolated from earth sufficiently to be capable of withstanding a 500V isolation test. Such tests can, however, only be undertaken when the area is gas free so it is fortunate that most circuits can be tested at low voltages. To do this:

- Disconnect from the barrier any cable connected directly to earth or returned through a barrier with a nominal voltage of less than 10V.
- Check the resistance to earth of the safe-area terminals with a multimeter; it should be greater than $100\text{k}\Omega$.

Note: some hazardous-area equipment (eg, pH and conductivity instrumentation) is unable to withstand this insulation test. As an alternative, in these circumstances the system can comply with the installation requirements described in IS sketch 121. See also 12.2.4.in BS EN 60079-14.

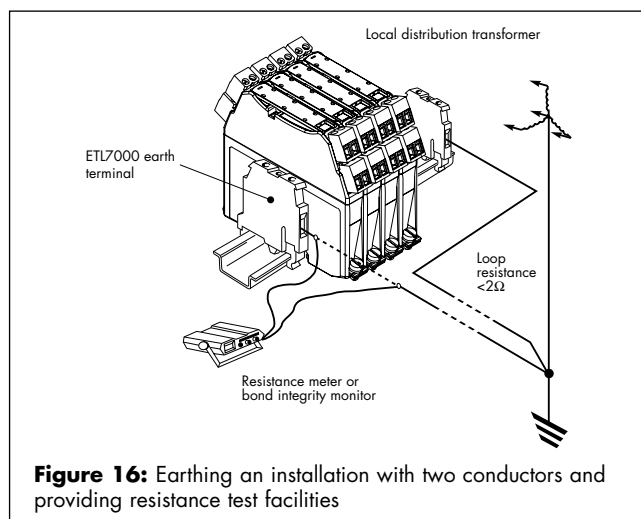


Figure 16: Earthing an installation with two conductors and providing resistance test facilities

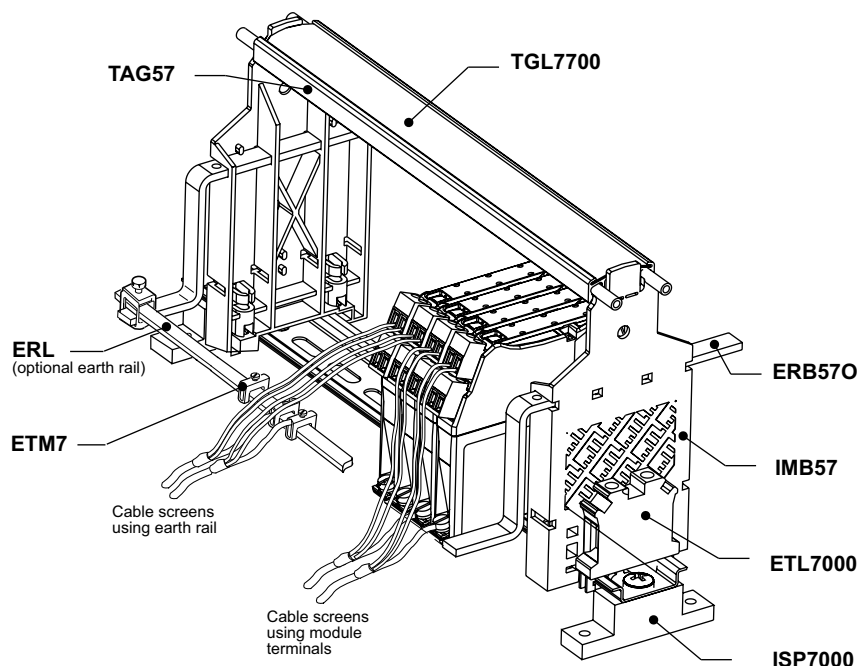


Figure 17: Earthing and screening using module earth terminals or earth rail alternative

5.3.5 Bonding practice when hazardous-area equipment cannot meet prescribed insulation standards

Where hazardous-area equipment is connected to earth (either directly or indirectly) and/or it will not withstand a 500V insulation test to ground or the alternative described in section 5.3.4, eg, strain-gauge bridges with low-voltage insulation, pH and conductivity sensors, bare and/or earthed thermocouples, and some level detectors, the following considerations apply:

Safety considerations

- The pipe, vessel, or body of the hazardous-area apparatus and/or the adjacent metallic structure must be connected to the barrier DIN-rail (see item d) by a bonding conductor of at least 4mm² cross-sectional area for lengths of 100m or less; or at least 8mm² area for lengths between 100m and 200m.
- Where bonding conductors are used, care must be taken to avoid invading other intrinsically safe systems (those not using bonding conductors) by elevation arising from currents which may flow in the common earthing systems as a result of the presence of the bonding conductor. Where this possibility cannot be avoided, then barriers associated with bonded systems should be mounted on a separate DIN-rail from those on which other barriers are mounted. Additionally, the DIN-rails themselves should also be earthed separately.
- The hazardous-area equipment and/or adjacent metallic structure bond connections must be secured against vibration and corrosion. A terminal of the type used on 'increased safety' ('e') equipment is the mandatory solution.
- The barrier DIN-rail connections must provide suitable termination facilities for the bonding conductor and usual 'earth return' by being equipped with separate increased safety ('e') terminals.

Operational requirements

- Figure 18 shows the OV rail of the safe-area equipment returned to the barrier DIN-rail by a separate insulated conductor and the structural earths of any safe-area equipment returned separately to the neutral star-point. This reduces interference problems but is not essential for safety reasons.

f) In general, the use of barriers in all measurement leads reduces the possibility of earth circulating currents causing measurement problems.

g) Resistance from the neutral star point to 'terrestrial earth' – via the buried earth mat or rods – is determined by other regulations and is not modified or determined by the intrinsic safety requirements, which are concerned with the plant earth only.

5.4 Connections to dummy barriers

See figure 19. The MTL7799 dummy barriers provide safe connection facilities for unused cable cores, cable screens and OV returns. In addition, safe-area terminals 2 and 1 are connected internally to provide a straight 'feedthrough' 24V dc supply connection, enabling the units to be used as feed modules for use with a power bus, useful in applications where the fault trip mechanism of the MTL7798 is not needed.

6 MAINTENANCE

6.1 General

Circuits in all MTL7700 Series barriers are encapsulated and so cannot be repaired. However, provided they are correctly installed and connected (as described in sections 4 and 5 of this manual) and the circuits they protect are not themselves defective, barrier faults are highly unlikely to occur. Therefore, servicing of barrier installations consists mainly of routine inspection and earth testing as described in this section.

More information about the maintenance of barrier installations is given in BS EN 60079 -17.

6.2 Routine inspection

At intervals not exceeding two years (more frequently for harsh environments), make a visual check of the barrier installation. Personnel undertaking these checks should comply with all regulations relating to the safety of plant and personnel. Care must be taken to prevent any inadvertent direct connection between hazardous- and safe-area circuits and, at all times, the safety precautions discussed in section 3 **MUST** be observed.

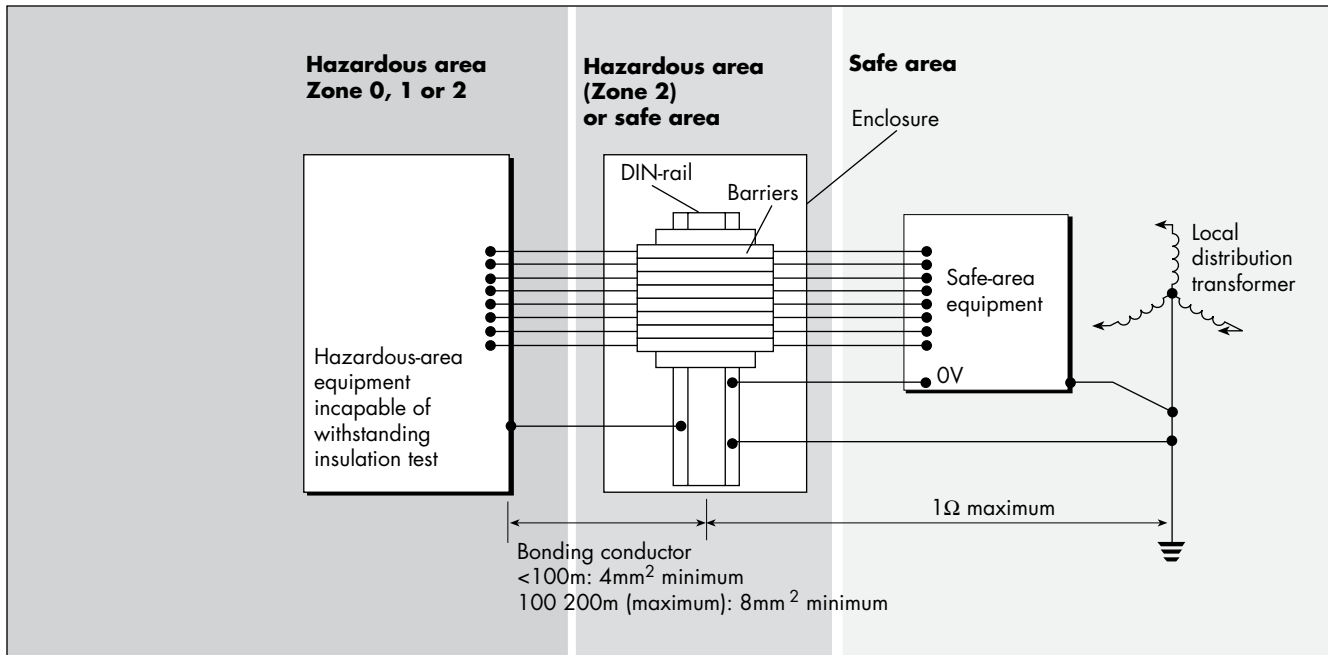


Figure 18: Bonding practice where hazardous-area equipment cannot meet required standards of insulation from earth

Check that:

- Barriers are of the types and polarities specified in the safety documentation.
- The barriers are attached securely and correctly to the DIN-rail to make sure the earth connection is safe.
- There are no apparent signs of damage or corrosion to the barriers, the ETL7000 earth terminals, the plant earth connections, and, if fitted, any earth rail assemblies.
- All hazardous-area and safe-area cable connections are made correctly and the terminals properly tightened.
- Interconnecting cables are of the type and rating specified by the safety documentation and that they are not frayed or otherwise damaged.
- All earth returns and cable screens from the hazardous area are connected to earth either through a barrier, a dummy barrier or an earth rail.
- Visually examine the earth conductors and make sure they are not damaged in any way and that their terminations are secure and free from corrosion.
- Using a low-voltage low-current test meter (ie, a meter with an output not exceeding 3V and 50mA), measure the resistance between the DIN-rail and the neutral star-point of the supply and make sure it does not exceed 1Ω. Record the reading and compare it with readings taken during previous inspections. A consistent reading repeated over a long period of time is a reassuring sign indicating a sound earth return which is likely to remain so. If two earth conductors are used as described in section 5.3.2, the loop resistance should be measured as described in that section and the reading should not be greater than 2Ω.

WARNING: do not try to carry out a high-current earth resistance test unless it is confirmed by the authority in charge of the plant that the plant is gas-free.

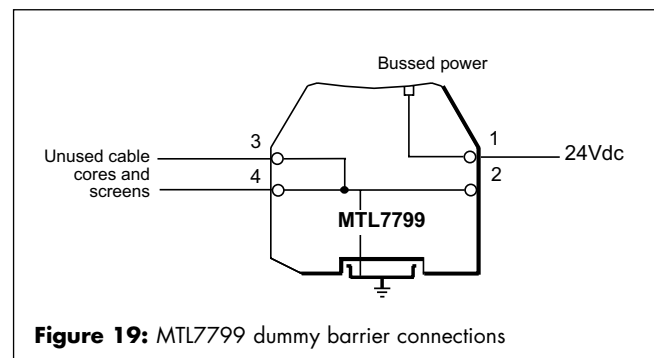


Figure 19: MTL7799 dummy barrier connections

7 FAULT-FINDING

7.1 Introduction

Most barrier-protected systems are relatively simple and their operation is easy to check. However, when fault finding is necessary, it must only be undertaken after checking with plant personnel responsible for safety that it is safe to proceed.

The fault-finding procedures described in this section call for the use of a digital multimeter – this being the most common type used. However, other types can be used provided their characteristics when measuring silicon diodes are known.

Many digital multimeters include a diode test function which is useful when diode chains are included in the test. These usually operate by passing 1mA through the diode and measuring the voltage across it. When measuring more than two diode drops in series, note that the full-scale range of some multimeters is only 2V on the diode test range. With three or more diode drops it is therefore possible that the meter may indicate over-range. In the test tables (tables 4 to 10), section 8, any drop of more than 4V is indicated as infinity (∞).

Zener diodes and ordinary silicon diodes have a typical forward voltage drop of approximately 0.6V/diode. Diode return paths with Schottky diodes have a typical voltage drop of <0.3V for each diode in the chain, eg, MTL7787+, 7787P+.

Figure 20 depicts a typical switch-status transfer circuit protected by an MTL7787+ barrier which illustrates some of the fault-finding techniques discussed in this section. To determine the serviceability of MTL7700 Series barriers, follow the steps described in sections 7.2 to 7.3.

7.2 Power supply check

Check that the power supply to an individual barrier circuit (or to an MTL7798 power feed module or an MTL7799 dummy barrier sourcing the power bus) is functional and that the voltage across the supply with respect to earth is correct. For example, in Figure 20 the presence of 24V on terminal 1 and 12V on terminal 2 when the switch in the hazardous area is closed confirms the serviceability of almost the complete circuit.

7.3 Barrier resistance test

To test the resistance of a barrier on site, refer to figure 20 and carry out the following procedure:

- Unplug hazardous-area cables from terminals 3 and 4.
- Unplug safe-area cables from terminals 1 and 2.

WARNING: Take care when handling safe-area cables; the relay contacts in figure 20 for example could be carrying mains voltage.

- Measure the end-to-end resistance of the barrier by connecting a digital multimeter (set to a suitable Ω range) between terminals 1 and 3. The reading should typically be slightly less (eg 1–3% lower) than the maximum end-to-end resistance listed in tables 4 to 10 for the appropriate barrier type or approximately 10–20% higher than the figure specified in the safety description.
- Check the functioning of the diode-return channel (MTL7787+, 7787P+, only) by selecting the diode test function on the multimeter and connecting it between terminals 4 (+ve) and 2 (–ve). This measures the forward voltage drop of the Schottky diodes in the chain: the reading should be less than 0.9V. Repeat the test with the connections reversed (ie, terminals 4 (–ve) and 2 (+ve) for an expected reading of ∞ for the reverse voltage drop.
- Tests c) and d) confirm the continuity of both barrier channels. If either channel is open-circuit it is most likely that the fuse has blown. The safe-area circuit should be investigated in an attempt to discover the cause of the fault.

Note: if the barrier is removed, make sure the safe-area and hazardous-area cables disconnected during operations **a)** and **b)** are connected to an earth-rail, a dummy barrier or insulated completely.

- If it is not possible to disconnect wiring to the barrier for steps a) and b), carry out the tests given in table 4.

8 EQUIPMENT AND BARRIER TESTS

8.1 Thermocouple and RTD tests

8.1.1 Thermocouple circuit testing

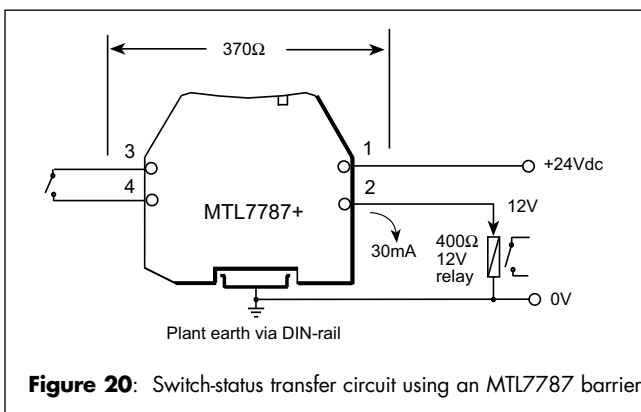


Figure 20: Switch-status transfer circuit using an MTL7787 barrier

Thermocouple test and calibration equipment is rarely certified intrinsically safe and therefore requires special authorisation before it can be used for testing or calibrating thermocouple circuits in hazardous areas. To overcome this problem, the thermocouple circuits can be protected by using an MTL7760ac barrier as shown in figure 21. This permits the thermocouple output to be measured without needing special authorisation to use uncertified thermocouple test equipment.

As it is seldom possible to measure accurately the temperatures of thermocouples located in hazardous areas, a safe way of adjusting calibration tables to compensate for plant temperatures is needed. This can be done by disconnecting the compensating cables from the thermocouple, shorting them together, and measuring the temperature of the shorting point.

8.1.2 Resistance temperature detector (RTD) circuit testing

Resistance temperature detector (RTD) circuits can be tested by disconnecting the measuring leads from the RTD head in the hazardous area and connecting them to a resistance box. Sometimes it is more convenient to connect the resistance box in the safe area, for instance at point 'xx' in figure 22. For the latter method, however, the RTD must be shorted out or an allowance made for its temperature. The effect of a negative temperature change can be simulated by connecting the resistance box into the measurement lead at point 'yy'. The advantage of connecting the resistance box at the RTD head is that any leakage can also be determined by connecting the resistance box at point 'yy'.

8.2 Barrier tests

8.2.1 General

MTL7700 Series barriers do not need to be subjected to routine testing if they are in normal use. Generally, the inspection tests described in section 6 are more than adequate. However, if the performance of barriers is in any way suspect, then carry out the detailed tests described in this section. Barriers which pass these tests satisfactorily are highly unlikely to represent an unacceptable level of risk or cause a circuit malfunction.

There are two types of test (as shown by tables 4 to 10); a simple test using a digital multimeter to test barriers on site and a more comprehensive bench test using a constant current source to establish the breakdown characteristics.

Although certification requirements concentrate on pulse-current tests, in many ways the leakage current tests described in this section are a more satisfactory method of testing suspect diodes. If a complete functional check of a barrier is needed, then the multimeter and constant current tests described in sections 8.2.2 and 8.2.3 should suffice.

8.2.2 Multimeter tests

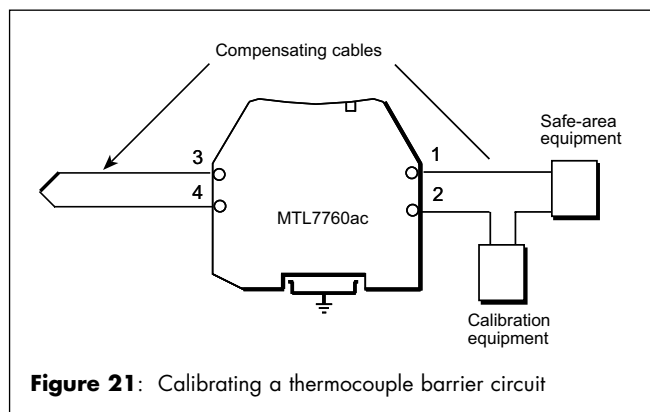
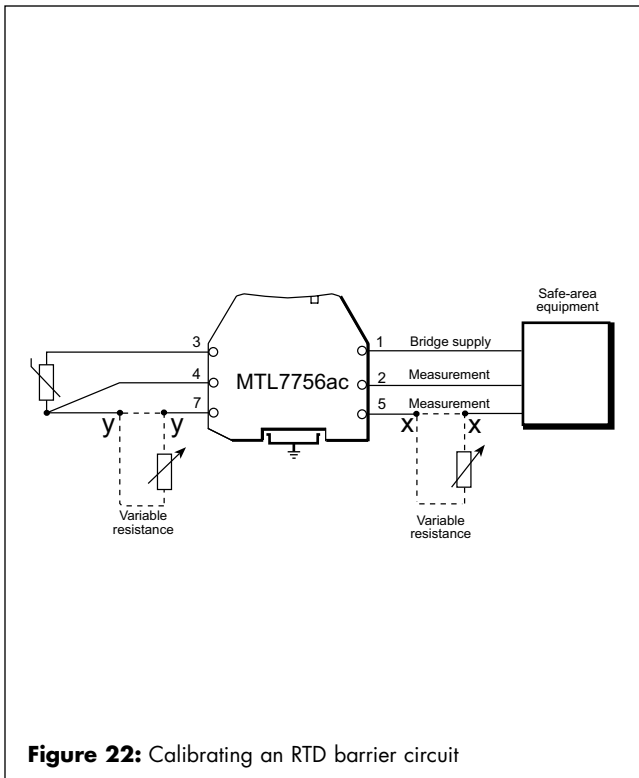
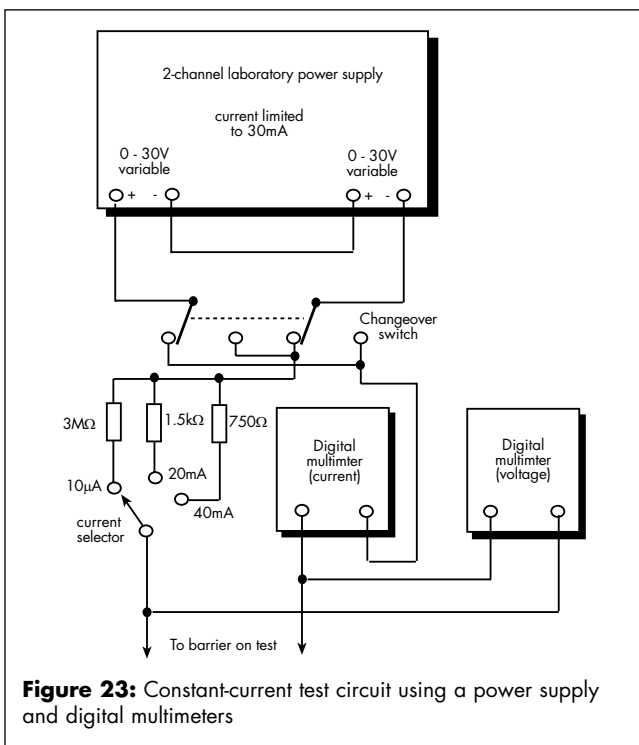


Figure 21: Calibrating a thermocouple barrier circuit



See tables 4 to 10. The use of a digital multimeter for testing barriers is described in section 7. The tables assume that the multimeter is set to a suitable Ω range for the end-to-end resistance tests (except for diode return channels) and for the continuity tests; and that the multimeter diode test function is used for the diode tests, channel isolation tests and for the end-to-end resistance tests for diode return channels.

8.2.3 Constant-current tests



For these tests (last column of tables 4 to 10) a constant-current generator capable of supplying 10µA, 20mA and 40mA currents from a 30V source is needed. Ideally, a purpose-built current generator should be used but, alternatively, a set-up based on a laboratory power supply and two multimeters (figure 23) will serve. The current is measured by one multimeter and trimmed by adjusting the output voltage of the power supply indicated on the second multimeter.

When using a constant-current generator for testing MTL7700 Series barriers, note the following points:

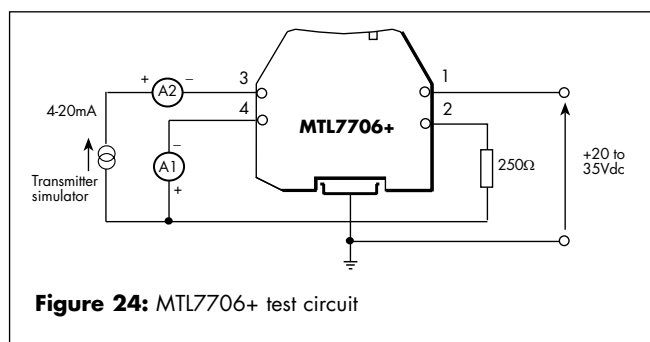
- The current must be limited to 50mA to avoid damaging the barriers.
- The accuracy of the current is not critical and can vary by $\pm 5\%$.
- Test leads must be connected securely to the barrier terminals; however, the changeover switch and current selector reduce the need for connection changes.
- Using a high resistance in series with the barrier gives more stable results and makes it easier to set the required current.

8.3 Tests for Active Barriers

8.3.1 Tests for the MTL7706+

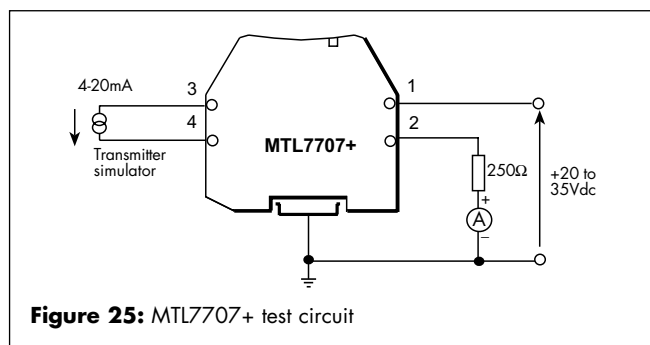
Comprehensive testing requires specialised equipment, beyond the scope of on-site tests. However, an effective test which will confirm that the unit is operating correctly is shown in figure 24. Ammeter 1 measures the transmitter simulator current of between 4 and 20mA flowing from terminal 4 and the safe-area load current flowing to terminal 4 simultaneously. Since these two currents are equal and opposite, the resulting reading on the ammeter should be virtually zero. Ammeter 2 verifies the presence of the 4–20mA transmitter signal.

8.3.2 Tests for the MTL7707+



Since this unit incorporates a built-in protection circuit, it has to be tested in a different manner to an ordinary shunt-diode barrier. Referring to figure 25, set the transmitter simulator to 4mA and to 20mA, and check that the ammeter reads approximately the same value. Then, having set the simulator to 20mA, check that the voltage between terminals 1 and 3 is less than 8.5V and between terminals 2 and 4 is less than 1.6V.

8.4 Test tables for passive barriers



8.3.3 Tests for MTL774x

The MTL774x range are switch/prox input barriers with a choice of changeover relay contacts or a solid state switch acting as the safe area interface. Relay contacts provide a universal interface capable of switching a wide range of signals including ac, low level and high level voltages. Phase reversal is achieved by connecting the normally open or normally closed contacts as required. The solid state switch variants can be configured to switch from a power rail or down to ground and makes these barriers ideal for high switching frequency applications.

When testing bus powered barriers use either an MTL7798 Power Feed module or an MTL7799 dummy barrier for direct 'feed-through' connection of a 24V dc supply.

8.3.3.1 Testing MTL7741 Barriers

The MTL7741 is a single channel switch/prox input barrier with changeover relay contacts acting as the safe area interface. To verify correct operation proceed as follows:

- Connect the barrier as shown in figure 26.
- With an ohmmeter, check that the output contacts (terminal 5 & 6) close when the input switch is closed.

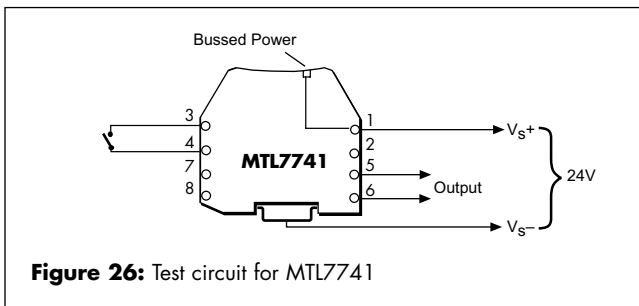


Figure 26: Test circuit for MTL7741

8.3.3.2 Testing MTL7742 Barriers

The MTL7742 is a single channel switch/prox input barrier with an open collector solid state interface to the safe area equipment. To verify correct operation proceed as follows:

- Connect the barrier as shown in figure 27.
- Check that the LED is on when the input switch is closed, and off when the input switch is open.

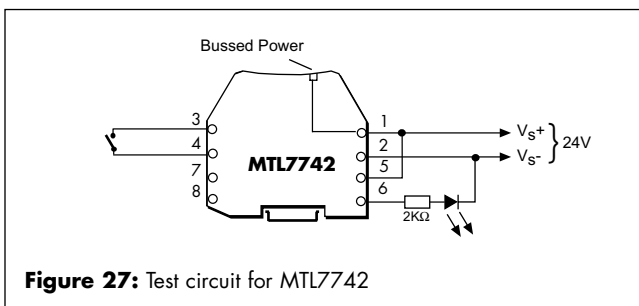


Figure 27: Test circuit for MTL7742

8.3.3.3 Testing MTL7743 Barriers

The MTL7743 is a dual channel switch/prox input barrier, each channel with a relay interface to the safe area equipment. To verify correct operation proceed as follows:

- Connect the barrier as shown in figure 28.
- With an ohmmeter, check that the output contacts (terminal 1 & 2) close when the input switch for channel 1 is closed.
- Repeat the procedure for channel 2.

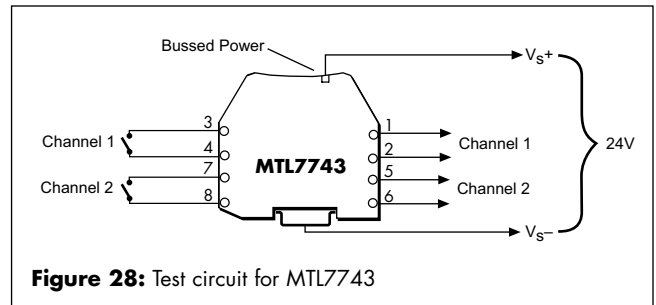


Figure 28: Test circuit for MTL7743

8.3.3.4 Testing MTL7744 Barriers

A dual channel version of the MTL7742, this module provides two solid state interfaces for prox/switch inputs. To verify correct operation proceed as follows:

- Connect the barrier as shown in figure 29.
- Connect power via the power bus
- Check that the LED is on when the input switch is closed for channel 1, and off when the input switch is open for channel 1.
- Repeat the procedure for channel 2.

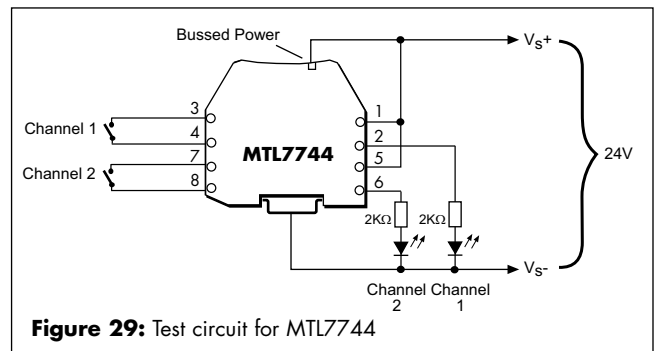


Figure 29: Test circuit for MTL7744

8.3.3.5 Testing MTL7745 Barriers

This module is a single channel interface for prox/switch inputs with line fault detection. To verify correct operation proceed as follows:

- Connect the barrier as shown in figure 30.
- With an ohmmeter, check the status of the output contacts according to Table 3

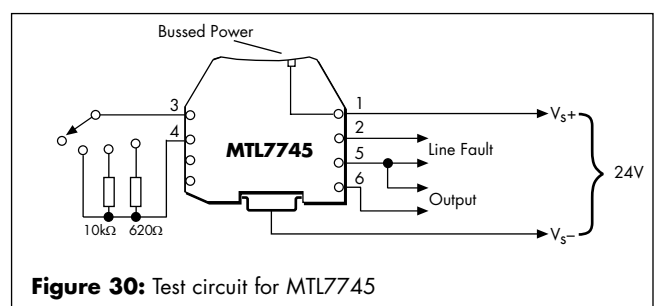


Figure 30: Test circuit for MTL7745

Input	Output	Line Fault
Open circuit	Open	Closed
Short circuit	Closed	Closed
620Ω	Closed	Open
10KΩ	Open	Open

Table 3 Test conditions for MTL7745

Tables 4 to 10 detail the tests for all MTL7700 Series 'passive' barriers. In the 'diode test' columns, the figures adjacent to the diode description indicate the number of forward-biased diodes used in the barrier chain. Using the multimeter diode test function and knowing the diode voltage drop figures (approximately 0.6V for each Zener diode and 0.3V for each Schottky diode), the expected reading across the diode chain can be determined.

BARRIER DATA				MULTIMETER TESTS				CONSTANT-CURRENT TESTS			
MTL model No.	Safety Description			End-to-end Resistance Ω		Diode Test +ve	Diode Test -ve	Terminal Voltage @ 10 μ A		Terminal Voltage @ 20mA	
	V	Ω	mA	Min	Max			Min	Max	Min	Max
7710+	10	50	200	62	75	∞	$V_{f_z} \times 1$	6	9.5	6.6	9.7
7715+	15	100	150	110	119	∞	$V_{f_z} \times 1$	12	13.6	12.4	13.7
7715P+	15	50	291	59	64	∞	$V_{f_z} \times 1$	12.6	13.3	13	13.4
7722+	22	150	147	159	174	∞	$V_{f_z} \times 2$	19.6	20.9	19.7	21.1
7728+	28	300	93	311	333	∞	$V_{f_z} \times 2$	25.9	26.5	26	26.7
7728-	28	300	93	311	333	$V_{f_z} \times 2$	∞	25.9	26.5	26	26.7
7728P+	28	237	119	241	252	∞	$V_{f_z} \times 3$	24.9	25.5	25	25.6
7729P+	28	164	170	171	184	∞	$V_{f_z} \times 3$	24.9	25.5	25	25.6

Table 4: Single channel polarised barriers

BARRIER DATA				MULTIMETER TESTS				CONSTANT-CURRENT TESTS			
MTL model No.	Safety Description			End-to-end Resistance Ω		Diode Test +ve	Diode Test -ve	Terminal Voltage @ 10 μ A		Terminal Voltage @ 20mA	
	V	Ω	mA	Min	Max			Min	Max	Min	Max
7758+	7.5	10	750	14	17	∞	$V_{f_z} \times 1$	6	6.9	6.6	7
7758-	7.5	10	750	14	17	∞	$V_{f_z} \times 1$	6	6.9	6.6	7
7764+	12	1k	12	1010	1050	∞	$V_{f_z} \times 1$	10	11.4	10.5	11.6
7767+	15	100	150	110	119	∞	$V_{f_z} \times 1$	12	13.6	12.4	13.7
7779+	28	300	93	311	333	∞	$V_{f_z} \times 2$	25.9	26.3	26	26.5
7796+	26	300	87	311	333	∞	$V_{f_z} \times 2$	23.9	24.4	24	24.6
7796+ (ch2)	20	390	51	401	428	∞	$V_{f_z} \times 2$	18.3	18.8	18.4	19
7796-	26	300	87	311	333	$V_{f_z} \times 2$	∞	23.9	24.4	24	24.6
7796- (ch2)	20	390	51	401	428	$V_{f_z} \times 2$	∞	18.3	18.8	18.4	19
7788+	28	300	93	311	333	∞	$V_{f_z} \times 2$	25.9	26.4	26	26.6
7788+ (ch2)	10	50	200	62	75	∞	$V_{f_z} \times 1$	6	9.5	6.6	9.7
7788R+	28	300	93	311	333	∞	$V_{f_z} \times 2$	25.9	26.4	26	26.6
7788R+ (ch2)	10	50	200	62	75	V_r	V_r	0	0	6.2	6.8

Table 5: Dual channel polarised barriers

Note: V_{f_z} is the voltage dropped by a forward biased zener diode - 0.6V typically
 V_r is the voltage dropped by the sense and current limit resistors - 3.2V for a typical 1mA test current

BARRIER DATA				MULTIMETER TESTS				CONSTANT-CURRENT TESTS			
MTL model No.	Safety Description			End-to-end Resistance Ω		Diode Test +ve	Diode Test -ve	Terminal Voltage @ 10 μ A		Terminal Voltage @ 20mA	
	V	Ω	mA	Min	Max			Min	Max	Min	Max
7728ac	28	300	93	311	333	∞	∞	25	26.7	25.6	8.9

Table 6: Single channel

BARRIER DATA				MULTIMETER TESTS				CONSTANT-CURRENT TESTS			
MTL model No.	Safety Description			End-to-end Resistance Ω		Diode Test +ve	Diode Test -ve	Terminal Voltage @ 10 μ A		Terminal Voltage @ 20mA	
	V	Ω	mA	Min	Max			Min	Max	Min	Max
7761ac	9	90	100	98	107	∞	∞	6	8.6	6.9	8.9
7761Pac	9	350	26	361	378	∞	∞	6.8	8.6	7.7	8.9
7764ac	12	1k	12	1010	1050	∞	∞	10	11.6	10.8	11.9
7766ac	12	150	80	159	174	∞	∞	10	11.6	10.8	11.9
7766Pac	12	75	157	84	92	∞	∞	9.6	10.9	10.4	11.2

Table 7: Dual-channel ac barriers

BARRIER DATA				MULTIMETER TESTS				CONSTANT-CURRENT TESTS			
MTL model No.	Safety Description			End-to-end Resistance Ω		Diode Test +ve	Diode Test -ve	Terminal Voltage @ 10 μ A		Terminal Voltage @ 20mA	
	V	Ω	mA	Min	Max			Min	Max	Min	Max
7755ac	3	10	300	15	19	$V_{fd} \times 3$	$V_{fd} \times 3$	1	2.1	1.8	2.4
7756ac	3	10	300	15	19	$V_{fd} \times 2$	$V_{fd} \times 2$	0.7	1.4	1.2	1.6

Table 8: 2/3 channel low voltage ac barriers

BARRIER DATA				MULTIMETER TESTS				CONSTANT-CURRENT TESTS			
MTL model No.	Safety Description			End-to-end Resistance Ω		Diode Test +ve	Diode Test -ve	Terminal Voltage @ 10 μ A		Terminal Voltage @ 20mA	
	V	Ω	mA	Min	Max			Min	Max	Min	Max
7760ac	10	50	200	62	75	∞	∞	6	9.5	6.9	9.8
7765ac	15	100	150	112	124	∞	∞	12	14.1	12.7	14.4
7778ac	28	600	47	614	651	∞	∞	24.0	24.4	25.4	26.0

Table 9: Dual-channel star-connected ac barriers

Note: V_{fd} is the voltage dropped by a forward biased rectifier diode - 0.6V typically

BARRIER DATA				MULTIMETER TESTS				CONSTANT-CURRENT TESTS			
MTL model No.	Safety Description			End-to-end Resistance Ω		Diode Test +ve	Diode Test -ve	Terminal Voltage @ 10 μ A		Terminal Voltage @ 20mA	
	V	Ω	mA	Min	Max			Min	Max	Min	Max
7787+	28	300	93	311	333	∞	$V_{f_z} \times 2$	26.6	27.4	26.7	27.6
7787+ (ch2)	28	—	—	$\infty (+)$	$0.9V + 26$	∞	$V_{f_z} \times 2$	26.6	27.4	26.7	27.6
7787P+	28	237	119	241	253	∞	$V_{f_z} \times 3$	26.4	27.4	26.5	27.6
7787P+ (ch2)	28	—	—	$\infty (+)$	$0.9V + 26$	∞	$V_{f_z} \times 2$	26.6	27.4	26.7	27.6
7789+	38	300	93	614	651	∞	$V_{f_z} \times 2$	26.6	27.4	26.7	27.6
7789+ (ch2)	28	—	—	$\infty (+)$	$0.9V + 26$	∞	$V_{f_z} \times 2$	26.6	27.4	26.7	27.6

Table 10: Diode return barriers

Note: V_{f_z} is the voltage dropped by a forward biased zener diode - 0.6V typically

APPENDIX A: TYPICAL WIRING CONNECTIONS FOR SPECIFIC APPLICATIONS.

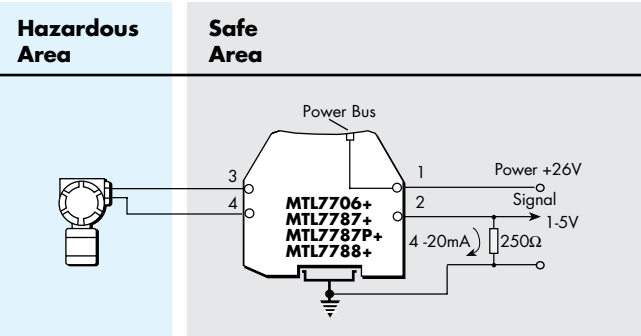


Figure A1: 2-wire transmitters

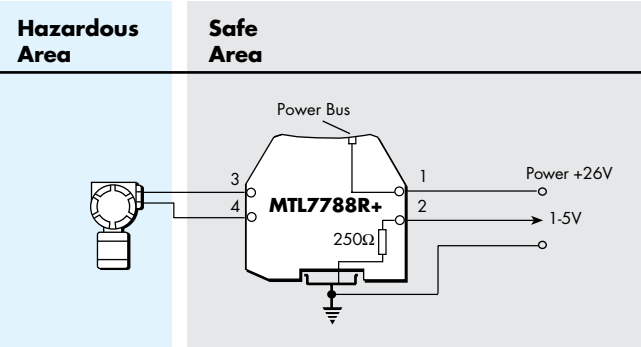


Figure A2: 2-wire transmitters with 250Ω conditioning

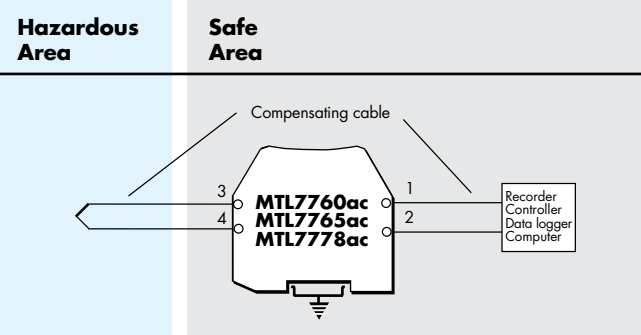


Figure A3: Thermocouple/mV input

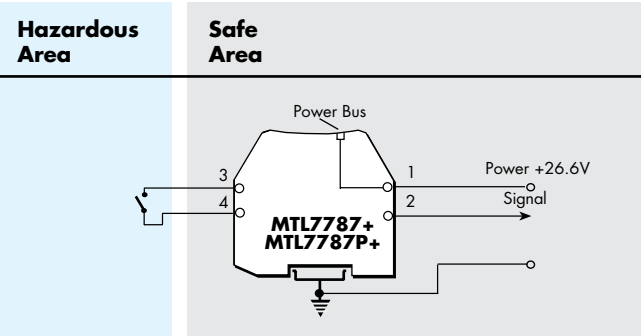


Figure A4: 2-wire transmitter/switch input

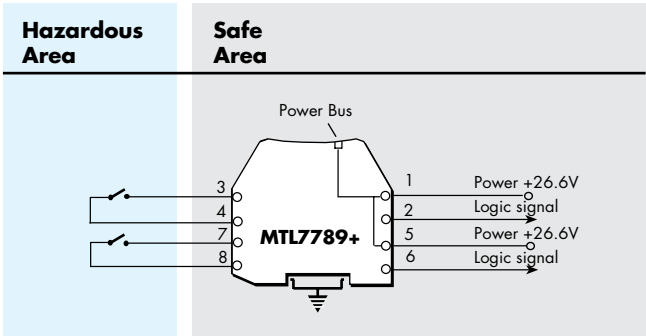


Figure A5: 2-channel switch inputs

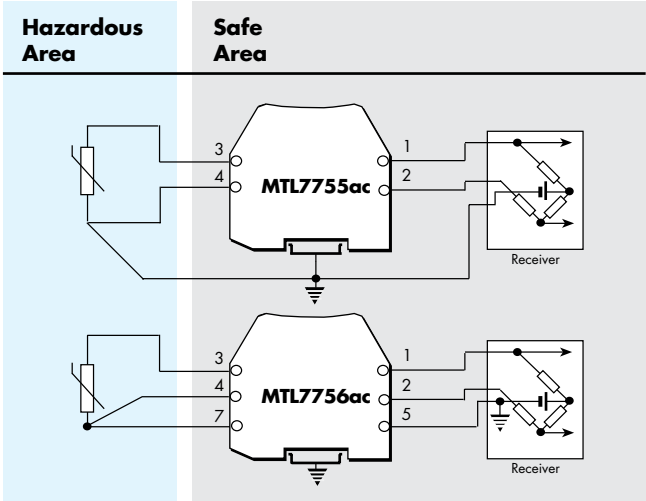


Figure A6: Low-level analogue inputs (RTD's)

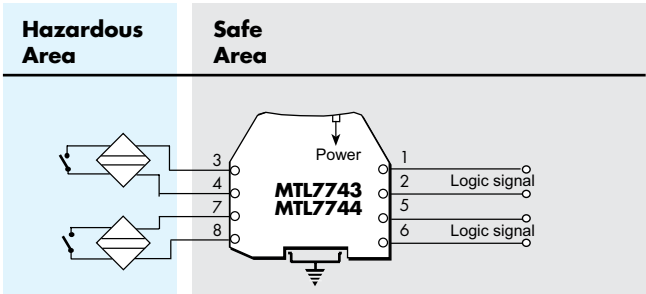


Figure A7: 2-channel switch/proximity input

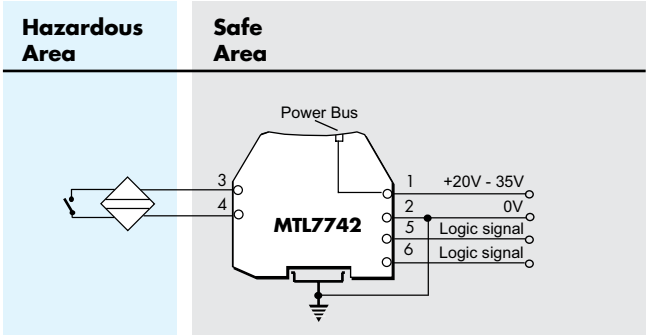


Figure A8: Single channel switch/proximity input

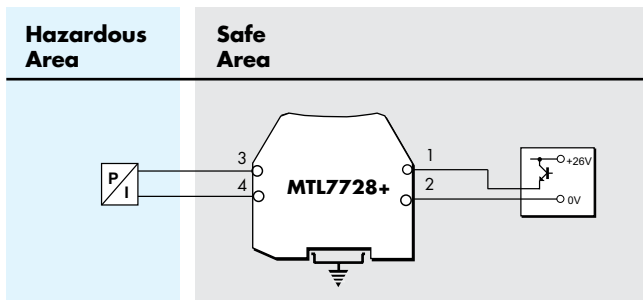


Figure A9: Analogue output

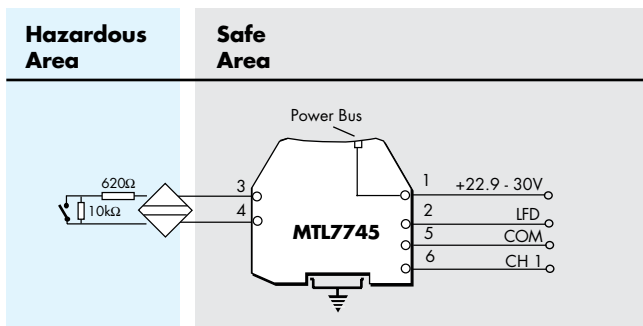


Figure A10: Single channel switch/proximity input with Line Fault Detect

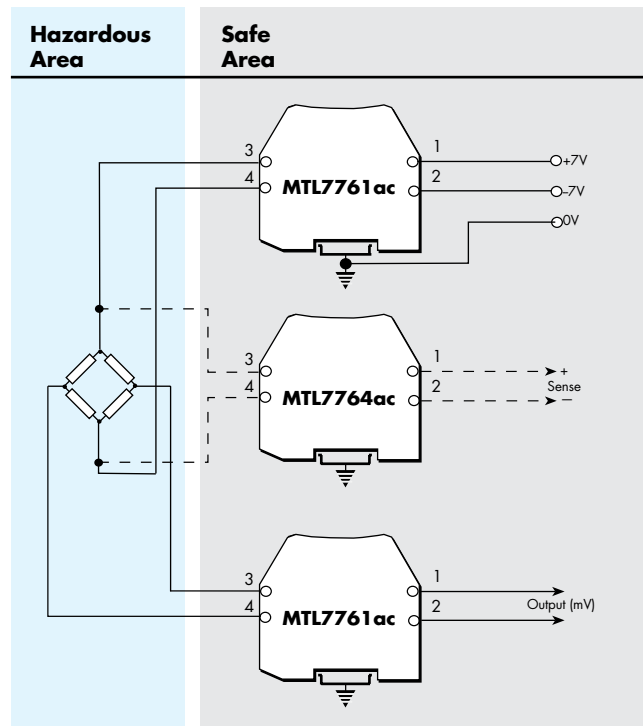


Figure A13: Strain-gauge bridges

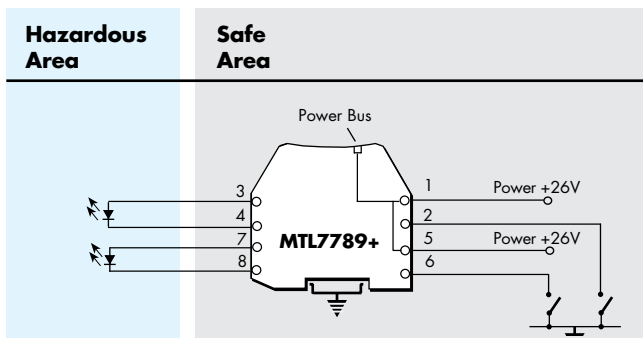


Figure A11: Low power digital outputs

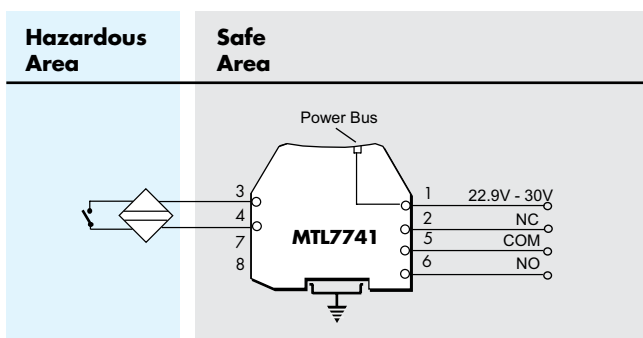


Figure A12: Single channel switch/proximity input with cutout relay

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