XA 034D/06/en/07.02
50098662
FM+SGML 6.0

PROline promag 53 Division 1

Fieldbus Foundation

Ex documentation for the BA 051D and BA 052D operating instructions according to FACTORY MUTUAL standards

Ex documentation for the BA 051D and BA 052D operating instructions according to CANADIAN STANDARDS ASSOCIATION

Endress + Hauser
The Power of Know How

XA 034D/06/en/07.02
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PROline promag 53 Division 1

en

Ex documentation for the BA 051D and BA 052D operating instructions

according to FACTORY MUTUAL standards

Example: **XP / I / 1 / ABCD**

Factory Mutual

Type of Protection

XP	Explosionproof
IS	Intrinsically Safe Apparatus
AIS	Associated Apparatus with Intrinsically Safe Connections
ANI	Nonincendive Field Wiring Circuit
PX,PY,PZ	Pressurized
APX,APY,APZ	Associated Pressurization Systems/Components
NI	Nonincendive
DIP	Dust-Ignitionproof
S	Special Protection

Class

I	Class I (Gas)
II	Class II (Dust)
III	Class III (Fibre)

Division

1	Division 1
2	Division 2

Group

FM / NEC	Gases, vapours and dusts (Examples)	Min. ignition temperature [µJ]
A	Acetylene, carbon disulfide (Class I)	0.02
B	Hydrogen, ethyl nitrate (Class I)	0.02
C	Ethylene, isoprene (Class I)	0.06
D	Acetone, ethane, benzene, ethanoic acid, gasolines, diesel oil, aircraft fuel, methane, heating oil,crude oil, hexane, ether (Class I)	0.18
E	Metallic powder (Class II)	
F	Coal dust (Class II)	
G	Mill dust (Class II)	
	Textile fibres (Class III)	

Temperature Class

FM 3611	Maximum surface temperature	
T1	842 °F	450 °C
T2	572 °F	300 °C
T2A	536 °F	280 °C
T2B	500 °F	260 °C
T2C	446 °F	230 °C
T2D	419 °F	215 °C
T3	392 °F	200 °C
T3A	356 °F	180 °C
T3B	329 °F	165 °C
T3C	320 °F	160 °C
T4	275 °F	135 °C
T4A	248 °F	120 °C
T5	212 °F	100 °C
T6	185 °F	85 °C

FM

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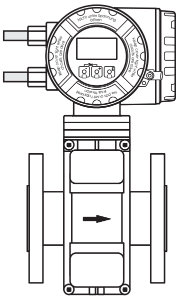
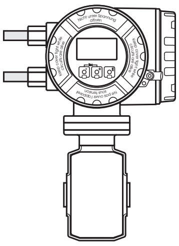
Hazardous area		Safe area
Division 1 / Zone 1	Division 2 / Zone 2	

Promag 53
P = DN 1/2"...12"
W = DN 1"...12"



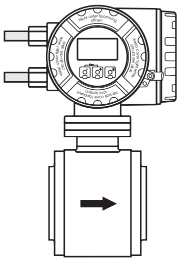
③

Promag 53
H = DN 1/12"...1"



③

Promag 53
H = DN 1 1/2"...4"



③

F06-53xxxxZZ-16-xx-xx-en-000

Division 1 / Zone 1	Division 2 / Zone 2	
Hazardous area		Safe area

- Promag 53 FOUNDATION Fieldbus flow measuring system in:
  XP-IS-DIP / I,II,III / 1 / ABCDEFG/T5-T3C
  and
  XP-IS / I / 1 / IIC / T5-T3C
- For ambient and fluid temperature ranges, and temperature class, see Page 3.

③ Transmitter terminal compartment (XP version) power supply/bus cable

Temperature tables

Measuring system Promag 53 (compact version)

at T_a = 104 °F			Max. medium temperature [°F] in					
			T5	**T4A**	**T4**	**T3C**	**T2**	**T1**
Promag H	DN 1/12"...4"		122	230	266	302	302	302
Promag P	DN 1"...8"	(PFA lining)	122	230	266	302	302	302
Promag P	DN 1/2"...12"	(PTFE lining)	122	230	266	266	266	266
Promag W	DN 1"...12"	(polyurethan lining)	122	140	140	140	140	140
Promag W	DN 2 1/2"...12"	(hard-rubber lining)	122	176	176	176	176	176

at T_a = 113 °F			Max. medium temperature [°F] in					
			T5	**T4A**	**T4**	**T3C**	**T2**	**T1**
Promag H	DN 1/12"...4"		122	230	266	266	266	266
Promag P	DN 1"...8"	(PFA lining)	122	230	266	266	266	266
Promag P	DN 1/2"...12"	(PTFE lining)	122	230	266	266	266	266
Promag W	DN 1"...12"	(polyurethan lining)	122	140	140	140	140	140
Promag W	DN 2 1/2"...12"	(hard-rubber lining)	122	176	176	176	176	176

at T_a = 122 °F			Max. medium temperature [°F] in					
			T5	**T4A**	**T4**	**T3C**	**T2**	**T1**
Promag H	DN 1/12"...4"		122	230	230	230	230	230
Promag P	DN 1"...8"	(PFA lining)	122	230	230	230	230	230
Promag P	DN 1/2"...12"	(PTFE lining)	122	230	230	230	230	230
Promag W	DN 1"...12"	(polyurethan lining)	122	140	140	140	140	140
Promag W	DN 2 1/2"...12"	(hard-rubber lining)	122	176	176	176	176	176

Note:
At the specified medium temperatures, the equipment is not subjected to temperatures impermissible for the temperature class in question.

Approvals

No. / approval type	Description
J. I. 3002554 (See Page 5 for notes on special conditions)	for the electric flow measuring system Promag 53 FOUNDATION Fieldbus **Identification:** see below

Measuring system Promag 53 FOUNDATION Fieldbus (compact version)

Promag 53***-***********.

G = FOUNDATION Fieldbus, intrinsically safe
K = FOUNDATION Fieldbus

Promag 53 H	DN 1/12"...4":	**XP-IS-DIP / I,II,III / 1 / ABCDEFG / T5-T3C;** **XP-IS / I / 1 / IIC / T5-T3C**
Promag 53 P	DN 1/2"...12":	**XP-IS-DIP / I,II,III / 1 / ABCDEFG / T5-T3C;** **XP-IS / I / 1 / IIC / T5-T3C**
Promag 53 W	DN 1"...12":	**XP-IS-DIP / I,II,III / 1 / ABCDEFG / T5-T3C;** **XP-IS / I / 1 / IIC / T5-T3C**

Notified body

The Promag measuring system was tested for approval by the following named entity:

FM: Factory Mutual Research

Special conditions

1. Install per National Electrical Code ANSI/NFPA 70.

2. Control room equipment shall not use or generate more than 250 V rms.

3. The specified temperature class in conjunction with the ambient temperature and the medium temperature must be in compliance with the tables on Page 3.

4. Use of the devices is restricted to mediums against which the process-wetted materials are adequately resistant.

5. Use supply wires suitable for 41 °F above ambient temperature, but at least for 176 °F.

6. Devices connected to terminals Nos. 20 to 27 of the Promag 53 FOUNDATION Fieldbus transmitter must be rated for U_m = 260 V and I_m = 500 mA: it is impermissible to connect devices with higher ratings to these terminals.
   (Does not apply to Promag 53***-***********G with intrinsically safe output circuit).

General warnings

Warning:
- Installation, connection to the electricity supply, commissioning and maintenance of the devices must be carried out by qualified specialists trained to work on Ex-rated devices.

- Compliance with national regulations relating to the installation of devices in potentially explosive atmospheres is mandatory, if such regulations exist.

- Open the device only when it is de-energized (and after a delay of at least 10 minutes following shutdown of the power supply).

- The housing of the Ex-rated transmitter can be turned in 90° steps. Whereas the non-Ex version has a bayonet adapter, however, the Ex version has a thread. Recesses for centering the worm screw are provided to prevent inadverted movement ot the transmitter housing.
  It is permissible to turn the transmitter housing through a maximum of 180° during operation (in either direction), without compromising explosion protection.
  After turning the housing the worm screw must be fastened again.

- The screw cap has to be removed before the local display can be turned, and this must be done with the device de-energized (and after a delay of at least 10 minutes following shutdown of the power supply).

Electrical connections

Power supply connection

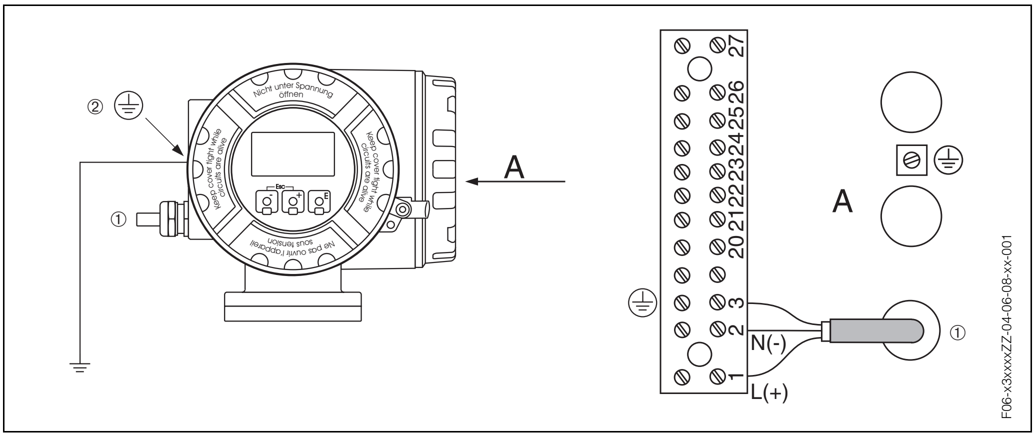


Fig. 1: ① = Power supply cable
② = Ground terminal for potential equalisation
A = View A

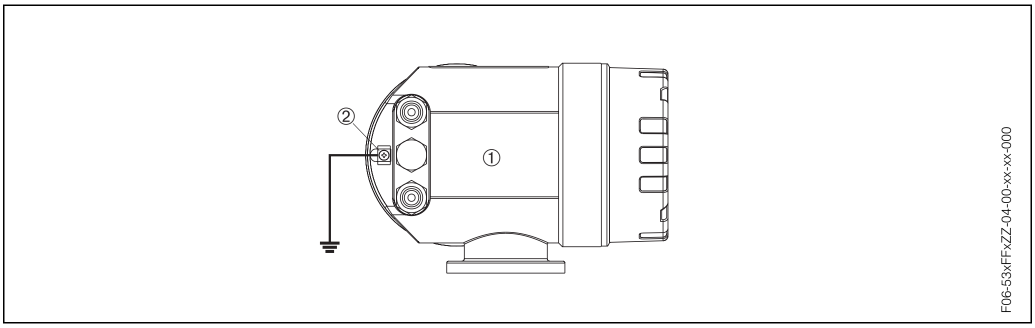


Fig. 2: Ground terminal for potential equalisation

Caution:
- The transmitter ① is to be securely connected to the potential equalization system using the screw terminal ② on the outside of the transmitter housing.

The table below contains the values that are identical for all versions, irrespective of the type code.

Transmitter Promag 53

Terminals	**1**	**2**	**3**
	L (+)	**N (–)**	
Designation	Power supply ①		Protective earth
Functional values	AC: U = 85...260 V or AC: U = 20...55 V or DC: U = 16...62 V Power consumption: 15 VA / 15 W		Caution: Follow ground network requirements for the facility
Intrinsically safe circuit	no		
U_{max} =	260 V AC		

Input/output circuit

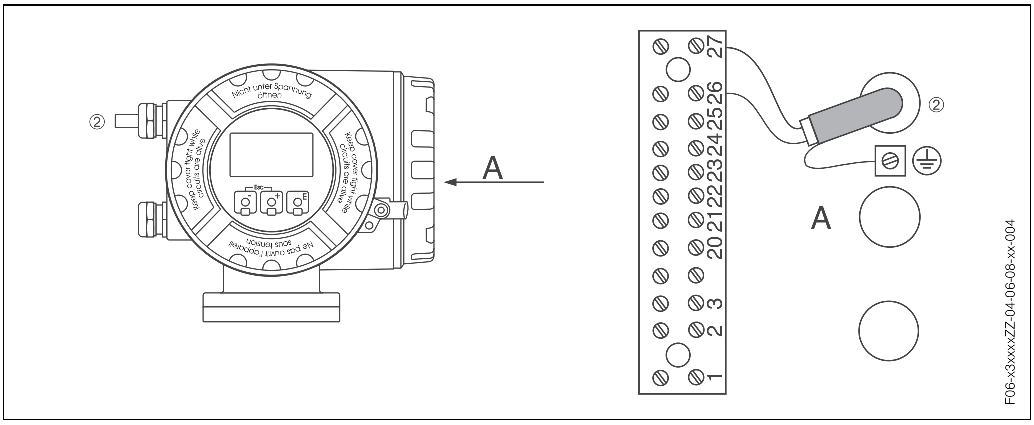


Fig. 3: ② = Bus cable (FOUNDATION Fieldbus)
A = View A

Note:
The table below contains the values which depend on the type code (type of device). Always remember to compare the type code in the table with the code on the nameplate of your device.

Transmitter Promag 53***-***********G

Terminals	20	21	22	23	24	25	26	27
	+	–	+	–	+	–	+	–
Designation							FOUNDATION Fieldbus ②	
Functional values							U_B = 9...32 V DC I_B = 12 mA	
Intrinsically safe circuit							EEx ia	
U_i =							30 V DC	
I_i =							500 mA	
P_i =							5.5 W	
L_i =							10 µH	
C_i =							5 nF	

Transmitter Promag 53***-***********K

Terminals	20	21	22	23	24	25	26	27
	+	–	+	–	+	–	+	–
Designation							FOUNDATION Fieldbus ②	
Functional values							U_B = 9...32 V DC I_B = 12 mA	
Intrinsically safe circuit							no	
U_{max} =							260 V AC	
I_{max} =							500 mA	

Service adapter

The service adapter is exclusively for connection to E+H approved service interfaces.

Warning:
It is not permissible to connect the service adapter in explosive atmospheres.

Device fuse

Warning:
Use only fuses of the following types; the fuses are installed on the power supply board:

- Voltage 20...55 V AC / 16...62 V DC:
  fuse 2.0 A slow-blow, disconnect capacity 1500 A
  (Schurter, 0001.2503 or Wickmann, Standard Type 181 2.0 A)

- Voltage 85...260 V AC:
  fuse 0.8 A slow-blow, disconnect capacity 1500 A
  (Schurter, 0001.2507 or Wickmann, Standard Type 181 0.8 A)

Cable entries

For number reference see the figure on Page 2.

③ *Cable entries for the transmitter terminal compartment (XP version)*
*power supply / bus cable: (Promag 53***-*****N******)*
Thread for cable entries ½" NPT.

Make sure that the XP cable entries are secured to prevent them from working loose.

Technical data

Dimensions wall-mount housing

Weight approx. 14.8 lbs

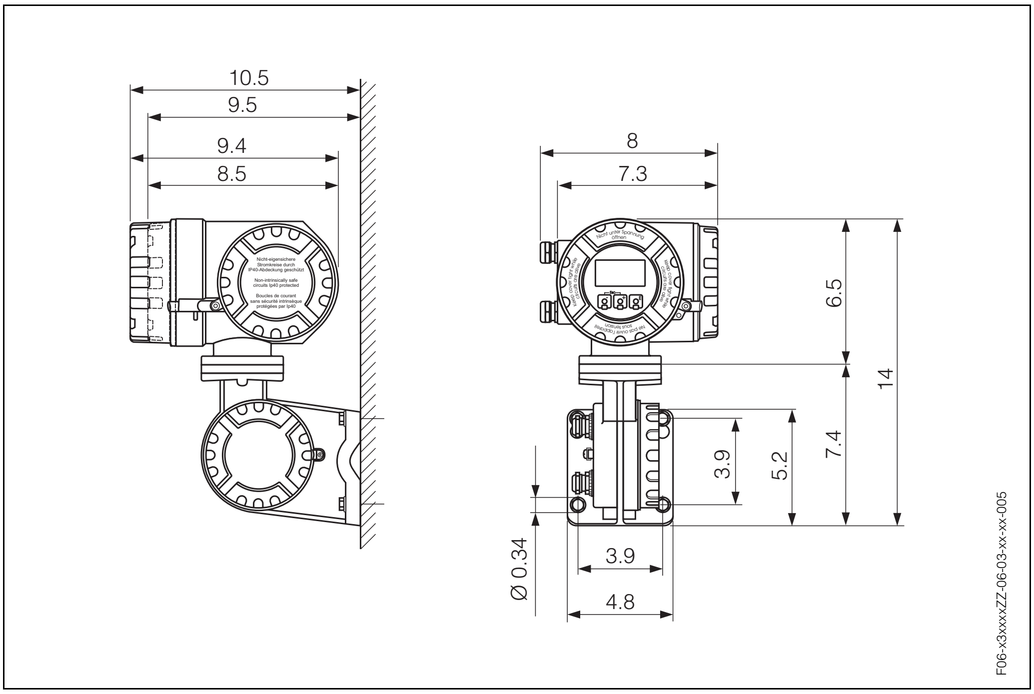


Fig. 4: Dimensions wall-mount housing

Bus cable for FOUNDATION Fieldbus

The Fieldbus FOUNDATION defines four different types of cable in the specification creating the physical transmission layer (FF-816) which is analogous to IEC 61158-2. A two-core cable is always specified.
The electrical data has not been specified but determines important characteristics of the design of the fieldbus, such as distances bridged, number of participants, electromagnetic compatibility, etc.

Two of the four cable types in the standard are specified in the following table.

	Cable type A (reference)	**Cable type B**
Cable construction	twisted pair, shielded	one or more twisted pairs, fully shielded
Core cross-section (nominal)	0.8 mm^2 (AWG 18)	0.32 mm^2 (AWG 22)
Loop resistance (direct current)	44 Ω/km	112 Ω/km
Impedance at 31.25 kHz	100 Ω ± 20%	100 Ω ± 30%
Attenuation constant at 39 kHz	3 dB/km	5 dB/km
Capacitive unsymmetry	2 nF/km	2 nF/km
Envelope delay distortion (7.9...39 kHz)	1.7 μs/km	**
Degree of voltage of shielding	90%	**
Max. bus segment length (inc. spur lines)	1900 m (6234 ft)	1200 m (3937 ft)

Tab. 1: Cable types

We recommend the use of cables meeting the minimum requirements of type A as transmission medium, particularly for the installation of new systems. The recommended network expansion is made up of the length of the main cable and the length of all spurs. The line between distribution box and field device is described as a spur. The maximum length of a spur depends on the number of spurs (>1 m [3 ft]). A maximum of four field devices can be connected to a spur.

Number of spurs	**1...12**	**13...14**	**15...18**	**19...24**	**25...32**
Max. length per spur	120 m (394 ft)	90 m (295 ft)	60 m (197 ft)	30 m (98 ft)	1 m (3 ft)

Tab. 2: Table of possible spur line lengths

The following table shows examples of FOUNDATION Fieldbus bus cables (type A) from various manufacturers.

Supplier	**Model**	**Order number**
Belden	3076	–
Kerpen	FB-02YS (St+C) Y-FL	74220001 (light blue) 74220004 (black)
Siemens	SIMATIC NET bus cable	6XV1830-5AH10 (light blue) 6XV1830-5BH10 (black)

Tab. 3: Possible cable suppliers

Bus termination
The start and end of each fieldbus segment are always to be terminated with a bus terminator.
- In the case of a branched bus segment the measuring device furthest from the segment connector represents the end of the bus.
- If the fieldbus is extended with a repeater then the extension must also be terminated at both ends.

Selecting and connecting components
The FOUNDATION Fieldbus allows several devices from different manufacturers to be generally connected to a bus segment. When selecting components for use in areas with an explosion risk only components marked as intrinsically safe, explosion-protected electrical equipment or as intrinsically safe associated electrical equipment may be used. When combining different fieldbus devices and fieldbus components, in addition to functional considerations, technical safety factors must be considered if explosion protection is to be ensured.

Implementation of intrinsic safety in the FOUNDATION Fieldbus H1

The FOUNDATION Fieldbus H1 can be made intrinsically safe for use in areas with an explosion risk (EEx i). To do this, according to the FOUNDATION Fieldbus specification a suitable safety component must be installed (FF-816) between the safe area and the area with an explosion risk. The intrinsically safe bus segment can be supplied either by a non-intrinsically safe power supply with a safety barrier downstream or by a fieldbus power supply with an intrinsically safe output.
It is recommended that the cable shielding be grounded at both ends (refer to Fig. 6, Page 14).

Installation example of a galvanic isolator with bus feed:

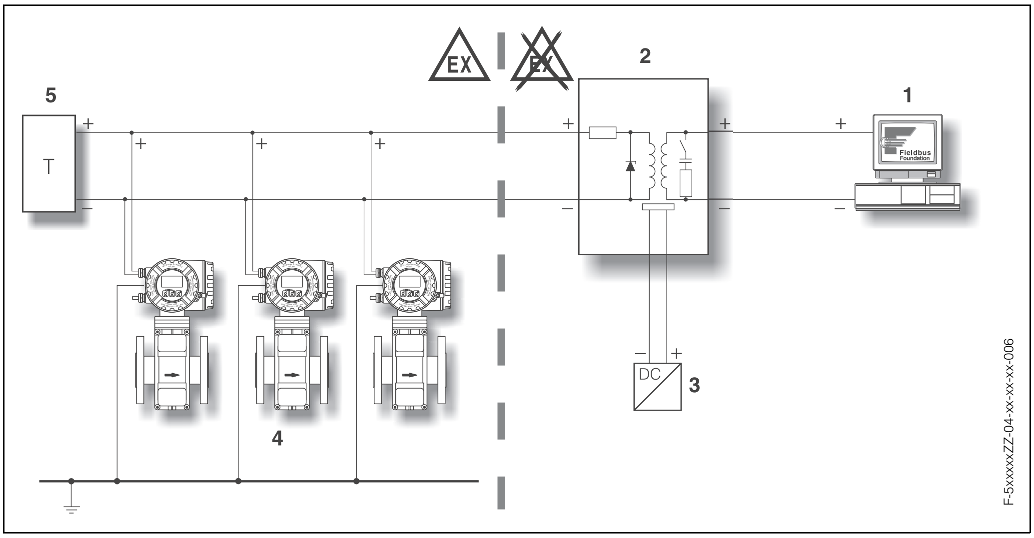


Fig. 5: Typical embodiment of a galvanic isolator including fieldbus power supply

1 = DCS with integrated FOUNDATION Fieldbus H1 interface card
2 = fieldbus power supply: galvanic isolator
3 = fieldbus power supply
4 = Promag 53 bus devices for hazardous area
5 = terminator (T) = bus termination

Proof of intrinsic safety

Proof of intrinsic safety for the intrinsically safe bus segment can be made by using one of the following models:
- Entity model
- FISCO model

Both models differ from one another by their consideration of the cable. While the FISCO model considers the transmission line as distributed inductance and capacitance, the basis of this consideration for the Entity model is concentrated inductance and capacitance. The result of this is that lower quantities of power can be transmitted with the Entity model into the Ex area, and that the number of field devices that can be operated on a power repeater is therefore lower than with the FISCO model.
In the case of failure, instruments from different manufacturers can be exchanged when their safety-relevant data is taken into consideration. This data is: electrical parameters, device group and category, and the temperature class.

Both these models are briefly described in the following.

The Entity model

The Entity model is based on the observation that the cable represents concentrated inductance and capacitance. The result is that less electrical power can be transmitted into the area subject to the risk of explosion when compared with the FISCO model.

The following conditions must be met in the safety according to the entity model considerations:

Field device **Hazardous area**	**Mandatory**	**Power supply** **Safe area**
Maximum voltage [U_i]	≥	Idle voltage of the safety element [U_o]
Maximum current [I_i]	≥	Short-circuit current [I_o]
Maximum power [P_i]	≥	[P_o]
Effective internal capacitance [C_i] + cable capacitance	≤	Maximum permitted external capacitance [C_o]
Effective internal inductance [L_i] + cable inductance	≤	Maximum permitted external inductance [L_o]

Tab. 4: General dependencies

In addition, the following measures must be taken:
- determine permissible explosion group for the bus segment
- determine all effective energy stores (L_i, C_i, capacitance and inductance per unit length)
- check locally supplied operating units for galvanic isolation
- harmonize temperature class and ambient temperature

Note:
Configuration example see Page 16

The FISCO model

The German Federal Physical-Technical Institute (PTB) has developed the FISCO model which was published in Report PTB-W-53 "Examination on Intrinsic Safety for Field Bus Systems".

The FISCO model makes possible the interconnection of intrinsically safe apparatus and one intrinsically safe associated apparatus, without having to have separate certification for respective connections.
The criteria for the intrinsic safety of an interconnection (bus segment) is given under the following interrelationships:

1. To transmit power and data, the bus system uses the physical configuration defined by IEC 61158-2. This is the case for FOUNDATION Fieldbus and the H1 bus.

2. Only one active source is permitted on a bus segment (here the power repeater). All other components work as passive current sinks.

3. The basic current consumption of a field device is at least 10 mA.

4. U_i, I_i and P_i of the bus device ≥ U_o, I_o and P_o of the associated equipment (bus power supply).

5. Each instrument must fulfill the following requirement: $C_i \leq 5$ nF, $L_i \leq 10$ μH

6. The permissible line length for EEx ia IIC applications is 1000 m (3280 ft).

7. The permissible spur length for Ex applications is 30 m (98 ft) per spur.

8. The transmission line that is used must conform to the following cable parameters:
   Resistor coating: 15 Ω/km < R' < 150 Ω/km
   Inductance coating: 0.4 mH/km < L' < 1 mH/km
   Capacitance coating: 80 nF/km < C' < 200 nF/km (including the shield)

9. The bus segment must be terminated on both ends of the line with a terminal bus resistor. A terminal resistor is integrated into the power repeater so that an external bus terminator is only required on the other end. According to the FISCO model the fieldbus terminator must conform to the following limits:
   – 90 Ω < R < 100 Ω
   – 0 μF < C < 2.2 μF

✎ Note:
Configuration example see Page 23

Potential equalisation with shielding grounded at both ends

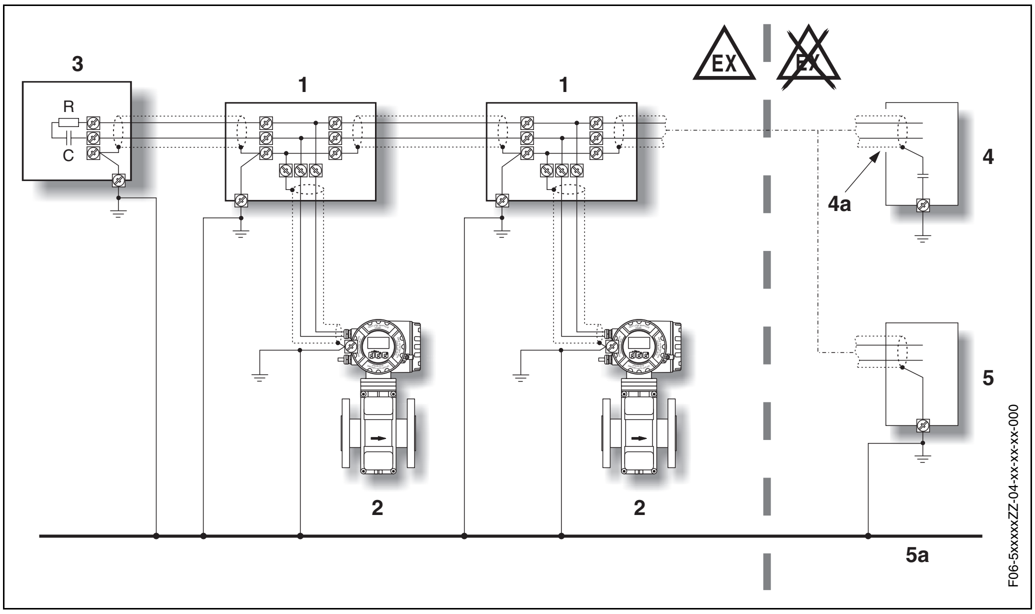


Fig. 6: Examples of the connection of potential equalisation lines

1 = distributor/T-box
2 = Promag 53 bus devices for hazardous area
3 = bus termination: R = 90...100 Ω, C = 0...2.2 µF
4 = fieldbus power supply variant 4a
4a = shielding connected via capacitor
5 = fieldbus power supply variant 5a
5a = potential equalisation line led out

Variant 4/4a:
With capacitive grounding of the shielding in the safe area the potential equalisation line does not need to be led out of the safe area.
Use small capacitors (e.g. 1 nF, 1500 V, dielectric strength, ceramic). The total capacitance connected at the shielding must not exceed 10 nF.

Variant 5/5a:
Potential equalisation line is led out of the safe area.

Network configuration for FOUNDATION Fieldbus H1

General remarks
Various aspects are to be considered when configuring a FOUNDATION Fieldbus H1 segment and these must essentially be checked by two general types of considerations:

Functional considerations
In the functional considerations, the characteristic of the technical function data laid down in IEC 61158-2 for the transmission technology of the FOUNDATION Fieldbus H1 and the physical network structure is checked. Here it must always be ensured that the total base currents of all bus participants does not exceed the maximum permissible feed current of the bus power supply and that the field devices are always supplied with a minimum bus voltage of 9 V.

Technical safety considerations
For use of the FOUNDATION Fieldbus H1 in an area with an explosion risk, proof of intrinsic safety is to be provided for the entire bus segment by means of the technical safety considerations. Proof of intrinsic safety for the intrinsically safe bus segment can be made by using one of the following models:

Entity model
The safety considerations correspond to those in a conventional 4...20 mA measuring circuit. The only exception is that here more than one field device is supplied by the power supply. The safety considerations must result in the knowledge that the fieldbus power supply does not exceed the safety parameters (P-, U-, I-values) of the field devices and that the inductance and capacitance are within the permissible limits (example see Page 16).

FISCO model
If proof of intrinsic safety is made according to the FISCO model, it is to be verified that all components connected to the bus segment (field instruments, bus power supplies, bus terminator) are laid out according to the FISCO model. If this is the case, it must be proven that for each bus component the values of U_i, I_i and P_i are greater or the same as the values of U_o, I_o and P_o for the associated equipment (bus power supply). Example see Page 23.

Configuration example for a FOUNDATION Fieldbus H1 segment
Based on the following example, the functional and safety-relevant considerations and calculations for the specification of a FOUNDATION Fieldbus H1 segment are carried out.

Configuration example Entity model

Fig. 7 shows the typical structure and the associated components. The field devices are operated on a segment with the type of protection EEx ia. A galvanic isolator is used for the transition to the area with explosion risk. Field devices with a lower power consumption, such as the Cerabar S pressure gauge, are supplied via the two-wire line. In contrast, the Promag 53 as a four-wire device must be supplied via an local power supply.

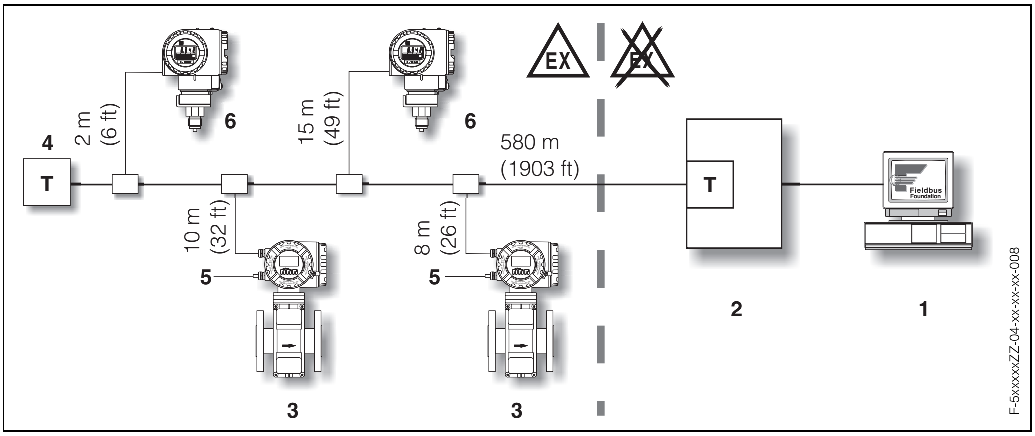


Fig. 7: Typical example of a bus connection with a fieldbus power supply of type MTL 5053

1 = DCS with integrated FOUNDATION Fieldbus H1 interface card
2 = fieldbus power supply, model MTL 5053
3 = Promag 53 bus devices for hazardous area
4 = terminator (T) = bus termination
5 = transducer supply
6 = Cerabar S bus devices for hazardous area

Functional considerations

Using the following procedure the functional considerations checks whether the desired segment structure meets the basic requirements for transmission to the physical layer in IEC 61158-2.

Step 1 – compilation of the functional characteristic values of the fieldbus components

- Fieldbus power supply MTL 5053:

U_S = 18.4 V
I_S = 80 mA
R_Q = 105 Ω (source impedance)

- Fieldbus line:

Cable type A
R_{WK} = 44 Ω/km (effective resistance per unit length)
max. permissible cable length $L_{perm.}$= 1900 m (6234 ft)

- Fieldbus device Promag 53:

I_B = 12 mA (basic current)
U_B = 9...32 V (perm. operating voltage)
I_{FDE} = 0 mA (fault current)
$I_{startup}$ = 0 (< I_B)

- Fieldbus device Cerabar S:

I_B = 10.5 mA (basic current)
U_B = 9...32 V (perm. operating voltage)
I_{FDE} = 0 mA (fault current)
$I_{startup}$ = 0 (< I_B)

Step 2 – calculation of cable length and checking of network structure

The maximum cable length is always determined by the type of cable used. The actual cable length, which is made up of the length of the main cable and the length of the spur lines, must not exceed this value. The spur lines are also to be checked (refer to Table 2, Page 10). The following restrictions apply to the specification of the cable length and network structure:

- Where cable type A is used the cable length $L_{perm.}$ may be max. 1900 m (6234 ft).
- Checking the spur line lengths (refer to Table 2, Page 10).

Calculation of actual cable length:

$$L_{SEG} = L_{main.} + \Sigma L_{spurs}$$
$$= 580\ \text{m}\ (1903\ \text{ft}) + 35\ \text{m}\ (115\ \text{ft})$$
$$= \underline{\underline{615\ \text{m}\ (2018\ \text{ft})}}$$

Checking the conditions

Consideration	Condition met?
$L_{SEG} < L_{perm.}$	✓ Yes
L_{spurs} < 120 m (394 ft)	✓ Yes

If one of the conditions is not met then the network structure must be revised.

Step 3 – current calculation

The number of field devices that can be connected to the H1 segment depends on the fieldbus power supply selected (supply voltage and supply current) and the current consumption of the field devices. Thus, the number of devices that can be connected is reduced if a field device consumes a basic current of more than 10 mA, e.g. 20 mA. By adding up the basic currents I_B of the field devices plus the response current in the event of a fault I_{FDE} for the FDE (**F**ault **D**isconnect **E**lectronics) and the current for the data modulation I_{MOD} (+9 mA) you can determine the minimum supply current that the fieldbus power supply must supply.

If, on switching on the device, the startup $I_{startup}$ current is greater than the basic current, then the startup current must be taken into consideration in the calculation. The response current for the FDE (I_{FDE}) is calculated for each field device from the difference between the maximum current in the event of a fault and the basic current. The field device with the greatest response current is taken into consideration in the current balance sheet.

Provided that no more than one FDE responds, the following condition must be taken into consideration in the calculation of the segment current I_{SEG}:

$$I_{Seff.} \geq I_{SEG}$$

where

$$I_{SEG} = \Sigma_{IB} + \max I_{FDE} + I_{MOD} + I_{startup}$$

In the example the calculation formula results in the following segment current consumption I_{SEG}, where $I_{FDE} = 0$, $I_{startup} = 0$, since the field devices used do not consume additional current in the event of a fault and the startup current is less than the bus current:

$$I_{SEG} = \Sigma I_B + \max.\ I_{FDE} + I_{MOD} + I_{startup}$$
$$= 45\ mA + 0\ mA + 9\ mA + 0\ mA$$
$$= \underline{\underline{54\ mA}}$$

The next step checks whether the current consumption I_{SEG} calculated is within the current limits of the fieldbus power supply. The maximum available supply current $I_{Seff.}$ is calculated taking into consideration the current drops caused by the source impedance R_Q of the fieldbus power supply and then by the effective resistance per unit of length of the fieldbus line. Also, the condition must be met that the supply voltage at the furthest field device must be at least 9 V. To make the overall considerations easier it is assumed that all the field devices FD (refer to Fig. 8) are connected at the end of the fieldbus line.

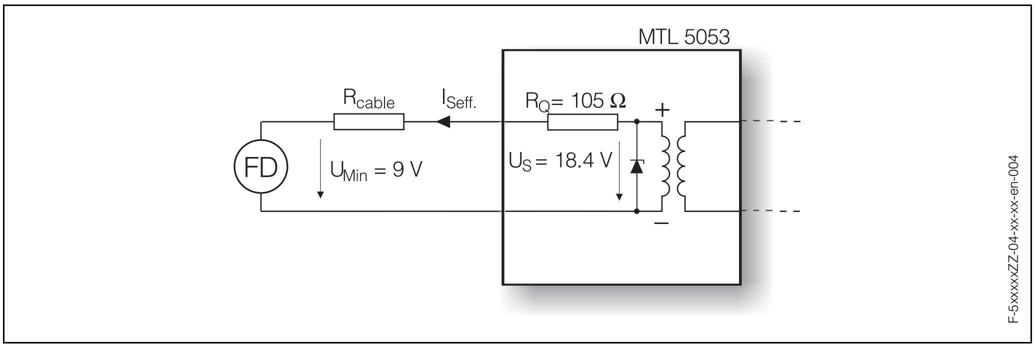


Fig. 8: Replacement circuit diagram

In order that the available supply current $I_{Seff.}$ can be calculated the resistance value for the fieldbus line R_{cable} must first be calculated:

$$R_{cable} = R_{WK} \times L_{SEG}$$
$$= 44\ \Omega/km \times 0.615\ km$$
$$= \underline{\underline{27\ \Omega}}$$

Calculation of the maximum available supply current $I_{Seff.}$ of the fieldbus power supply:

When calculating the maximum available supply current it must be ensured that a minimum supply voltage of 9 V is applied at the field devices:

$$I_{Seff.} = (U_S - 9\ V) / (R_Q + R_{cable})$$
$$= (18.4\ V - 9\ V) / (105\ \Omega + 27\ \Omega)$$
$$= \underline{\underline{71.2\ mA}}$$

Observing the conditions stated, a supply current of $I_{Seff.} = 71.2$ mA is available for the field devices on the bus segment. Since the actual current consumption of the segment is only 54 mA, from the point of view of the functional considerations proper functioning of the segment is ensured.

For reasons of satety the actual voltage $U_{FG\ eff.}$ of the furthest field device can be calculated as follows:

$$U_{FG\ eff.} = U_S - I_{SEG} \times (R_Q + R_{cable})$$
$$= 18.4\ V - 54\ mA \times (105\ \Omega + 27\ \Omega)$$
$$= 18.4\ V - 7.1\ V$$
$$= \underline{\underline{11.2\ V}}$$

Checking the conditions:

Consideration	Condition met?
$I_{seff} \geq I_{SEG}$ 71.2 mA ≥ 54 mA	✓ Yes
$U_{FG\ eff.} \geq 9$ V 11.2 V ≥ 9 V	✓ Yes

Final consideration:
From a purely functional point of view the bus segment shown in the example can be operated based on the positive results. Further optimization of the network with a view to connecting a greater number of field devices or realizing a longer line length can be achieved by selecting the right fieldbus power supply and cable type.

Technical safety considerations
using variant Promag 53***-***********G

Step 1 – compilation of technical values relevant to safety:

Bus power supply MTL 5053 (associated electrical apparatus)

- Nominal values:

U_o = 22 V
I_o = 216 mA
P_o = 1.2 W

	Explosion group		
	IIC	IIB	IIA
Capacitance C_o	0.165 µF	1.14 µF	4.20 µF
Inductance L_o	0.32 mH	3.00 mH	7.00 mH
L/R_{ratio}	31 µH/Ω	126 µH/Ω	242 µH/Ω

Tab. 5: External connection values of bus power supply MTL 5053 depending on temperature class

Promag 53 (explosion protected electrical apparatus with intrinsically safe FF output):

- Nominal values:

U_i = 30 V
I_i = 500 mA
P_i = 5.5 W
L_i = 10 µH
C_i = 5 nF

Cerabar S (explosion protected electrical apparatus with intrinsically safe FF output):

- Nominal values Entity:

U_i = 24 V
I_i = 250 mA
P_i = 1.2 W
L_i = 10 µH
C_i = 5 nF

Bus cable type 3076 from Belden (shielded bus cable):

- Nominal values:

R’	=	24 Ω/km (loop resistance)
C’	=	82 nF/km (capacitance per unit length between the two wires)
L’	=	623 µH/km (inductance per unit length of the two wires)
C'_{LS}	=	147 nF/km (capacitance per unit length wire against shielding)

Bus termination:

- Nominal values:

U_i	=	30 V
P_i	=	1.2 W
C_i	=	negligible

The effective capacitance of the bus line is derived first from the capacitance per unit length C’, which is effectively the capacitance between the two wires. In the case of the shielded wires the order of capacitance “wire against shielding” and “shielding against wire” must be observed. The total capacitance of the bus line is thus calculated as follows:

$$C'_{eff/cable} = (C' + 0.5 \times C'_{LS}) \times L_{SEG}$$

The total length of the bus line L_{SEG} is made up of the length of the main cable and the length of all spurs. Using the system structure illustrated in Fig. 8 the following data relevant to safety emerges for the bus line:

$$\begin{aligned} L_{SEG} &= L_{main} + \Sigma L_{spurs} \\ &= 580\ \text{m (1903 ft)} + 35\ \text{m (115 ft)} \\ &= \underline{\underline{615\ \text{m (2018 ft)}}} \end{aligned}$$

$$\begin{aligned} C'_{eff./cable} &= (C' + 0.5 \times C'_{LS}) \times L_{SEG} \\ &= (82\ \text{nF/km} + 0.5 \times 147\ \text{nF/km}) \times 0.615\ \text{km} \\ &= \underline{\underline{95.6\ \text{nF}}} \end{aligned}$$

$$\begin{aligned} L'_{eff./cable} &= L' \times L_{SEG} \\ &= 623\ \mu\text{H/km} \times 0.615\ \text{km} \\ &= \underline{\underline{383.1\ \mu\text{H}}} \end{aligned}$$

Step 2 – technical safety considerations

This step uses the existing data to check whether connecting the equipment is permissible from the point of view of technical safety. The conditions shown in Table 5 (Page 19) apply to these safety considerations. First the functional data of the equipment used is compared. In this consideration it is crucial that the maximum output voltage and output current of the bus power supply does not exceed the permitted maximum input voltage and input current of the individual field devices. Here we consider possible error behaviour by the bus power supply that could result in the stated maximum values on the intrinsically safe sides.

Intrinsically safe equipment	Condition	Associated equipment MTL 5053	Condition met?
Promag 53			
U_i = 30 V	≥	U_o = 22 V	✓ Yes
I_i = 500 mA	≥	I_o = 216 mA	✓ Yes
P_i = 5.5 W	≥	P_o = 1.2 W	✓ Yes
As a further condition galvanic isolation must be provided due to the local supply			✓ Yes
Cerabar S			
U_i = 24 V	≥	U_o = 22 V	✓ Yes
I_i = 250 mA	≥	I_o = 216 mA	✓ Yes
P_i = 1.2 W	≥	P_o = 1.2 W	✓ Yes
FBT1			
U_i = 30 V	≥	U_o = 22 V	✓ Yes
P_i = 1.2 W	≥	P_o = 1.2 W	✓ Yes

In addition to these values the limit values and the maximum permissible external capacitance C_o and inductance L_o must be observed for the supply circuit. To do this the sum of all effective inductance and capacitance in the hazardous area is formed (the internal capacitance of the bus termination is assumed to be 0). The resulting value must be less than the maximum permissible value specified by the fieldbus power supply.

The equivalent concentrated capacitance and inductance in the hazardous area is calculated as follows:

$$C_{eff.} = (C_{i/Promag\ 53} \times 2) + (C_{i/Cerabar\ S} \times 2) + C'_{eff./cable} + C_{i/bus\ termination}$$
$$= (5\ nF \times 4) + 95.6\ nF$$
$$= 115.6\ nF$$

$$L_{eff.} = (L_{i/Promag\ 53} \times 2) + (L_{i/Cerabar\ S} \times 2) + L'_{eff./cable}$$
$$= (10\ \mu H \times 4) + 383.1\ \mu H$$
$$= 423.1\ \mu H$$

Intrinsically safe equipment Promag 53	Condition	Associated equipment MTL 5053	Condition met?
Total capacitance $C_{eff.}$ = 115.6 nF	<	perm. capacitance for IIC C_o = 165 nF	✓ Yes
Total inductance $L_{eff.}$ = 423.1 µH	<	perm. inductance for IIC L_o = 320 µH	No

Tab. 6: Safety considerations (example)

If, in the example examined, the condition $L_{eff.} < L_o$ is met, then the demonstration of intrinsic safety with respect to the electrical parameters has a positive result. In this example, however, the condition was not met since the bus line selected is too long.

Possible solutions:

1. Reduce the main line by 175 m (574 ft) to 405 m (1329 ft) (this can be achieved by installing the barrier in the immediate vicinity of Explosion Zone 1, for example).
2. Check under what conditions the manufacturer of the safety barrier or segment connector allows the use of the L/R ratio for technical safety considerations.

Since all the users are permissible for explosion group IIC and the corresponding parameters have been taken into consideration, the bus segment can be used for gases in explosion group IIC.

The permissible ambient temperature may be considered either individually for each device at the respective place of installation, or specified uniformly for the bus segment as a whole. In the latter case the lowest value of the ambient temperature applies.

Required temperature class	Intrinsically safe equipment	Maximum ambient temperature
T6	Cerabar S	104 °F
T5	Promag 53	122 °F (at 176 °F medium temperature)

Configuration example FISCO model

Fig. 9 shows the typical structure and the associated components. The field devices are operated on a segment with the type of protection EEx ia. A galvanic isolator is used for the transition to the area with explosion risk. Field devices with a lower power consumption, such as the Cerabar S pressure gauge, are supplied via the two-wire line. In contrast, the Promag 53 as a four-wire device must be supplied via an local power supply.

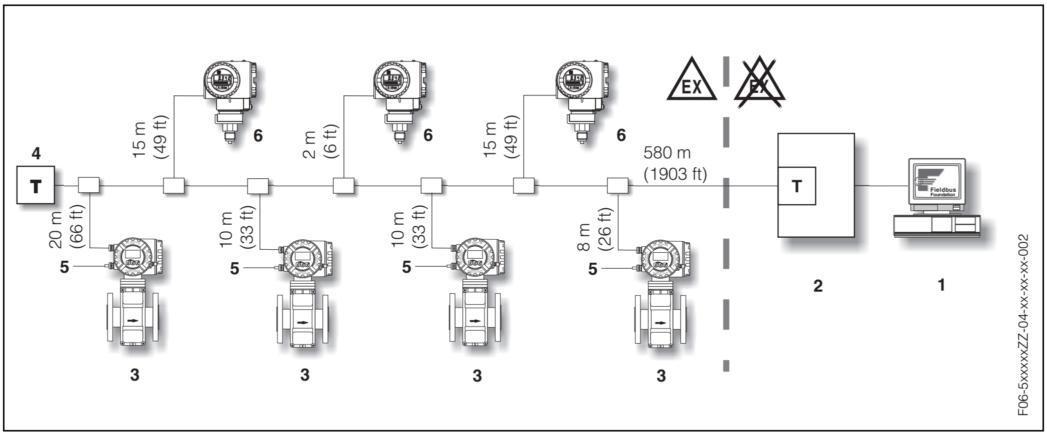


Fig. 9: Typical example of a bus connection with a fieldbus power supply Power Repeater KLD2-PR-Ex1.IEC1 (Pepperl+Fuchs)

1 = DCS with integrated FOUNDATION Fieldbus H1 interface card
2 = fieldbus power supply acc. FISCO model, Power Repeater KLD2-PR-Ex1.IEC1 (Pepperl+Fuchs)
3 = Promag 53 bus devices for hazardous area
4 = terminator (T) = bus termination
5 = transducer supply
6 = Cerabar S bus devices for hazardous area

Functional considerations
Using the following procedure the functional considerations checks whether the desired segment structure meets the basic requirements for transmission to the physical layer in IEC 61158-2.

Step 1 – compilation of the functional characteristic values of the fieldbus components

- Fieldbus power supply according FISCO model, Power Repeater KLD2-PR-Ex1.IEC1 (Pepperl+Fuchs):

U_S = 12.8 V (power supply voltage)
I_S = 100 mA (power supply current)

- Fieldbus line:

Cable type A
R_{WK} = 44 Ω/km (effective resistance per unit length)

- Fieldbus device Promag 53:

I_B = 12 mA (basic current)
U_B = 9...32 V (perm. operating voltage)
I_{FDE} = 0 mA (fault current)
$I_{startup}$ = 0 (< I_B)

- Fieldbus device Cerabar S:

I_B = 10.5 mA (basic current)
U_B = 9...32 V (perm. operating voltage)
I_{FDE} = 0 mA (fault current)
$I_{startup}$ = 0 (< I_B)

Step 2 – calculation of cable length and checking of network structure

An approved maximum length of 1000 meters (3280 ft) has been set with the FISCO model for EEx ia IIC applications in order that the inductance and capacitance of the fieldbus cable can be ignored when used in hazardous area applications. This length comprises the length of the main cable and the total length of the drop cables together. In addition, it must be taken into account that the approved maximum length of a drop cable is 30 m (98 ft).

Calculation of actual cable length L_{SEG}:

L_{SEG} = $L_{main.} + \Sigma L_{spurs}$
= 580 m (1903 ft) + 80 m (262 ft)
= 660 m (2165 ft)

Checking the conditions:

Consideration	Condition met?
L_{SEG} < 1000 m (3280 ft) 660 m (2165 ft) < 1000 m (3280 ft)	✓ Yes
L_{spurs} < 30 m (98 ft)	✓ Yes

If one of the conditions is not met then the network structure must be revised.

Step 3 – current calculation

The number of field devices that can be connected to the H1 segment depends on the fieldbus power supply selected (supply voltage and supply current) and the current consumption of the field devices. Thus, the number of devices that can be connected is reduced if a field device consumes a basic current of more than 10 mA, e.g. 20 mA. By adding up the basic currents I_B of the field devices plus the response current in the event of a fault I_{FDE} for the FDE (**F**ault **D**isconnect **E**lectronics) and the current for the data modulation I_{MOD} (+9 mA) you can determine the minimum supply current that the fieldbus power supply must supply.

If, on switching on the device, the startup $I_{startup}$ current is greater than the basic current, then the startup current must be taken into consideration in the calculation. The response current for the FDE (I_{FDE}) is calculated for each field device from the difference between the maximum current in the event of a fault and the basic current. The field device with the greatest response current is taken into consideration in the current balance sheet.

Provided that no more than one FDE responds, the following condition must be taken into consideration in the calculation of the segment current I_{SEG}:

I_{SEG} ≤ I_S
where
I_{SEG} = $\Sigma_{IB} + \max I_{FDE} + I_{MOD} + I_{startup}$

In the example the calculation formula results in the following segment current consumption I_{SEG}, where $I_{FDE} = 0$, $I_{startup} = 0$, since the field devices used do not consume additional current in the event of a fault and the startup current is less than the bus current. In addition, the modulation current I_{MOD} for the installed bus power supply KLD2-PR-Ex1.IEC1 by Pepperl+Fuchs need not be considered since the value of the supply current I_S already includes this.

$$I_{SEG} = \Sigma I_B = \underline{\underline{79.5 \text{ mA}}}$$

Checking the conditions:

Consideration	Condition met?
$I_{SEG} \leq I_S$ 79.5 mA ≤ 100 mA	✓ Yes

Step 4 – Voltage at the last instrument

The cable resistance causes a segment voltage drop, which is largest at the instrument farthest away from the bus power supply. For this reason it must be ensured that the minimum operating voltage of 9 V is available at this instrument.
To make the overall considerations easier it is assumed that all the field devices FD (refer to Fig. 10) are connected at the end of the fieldbus line.

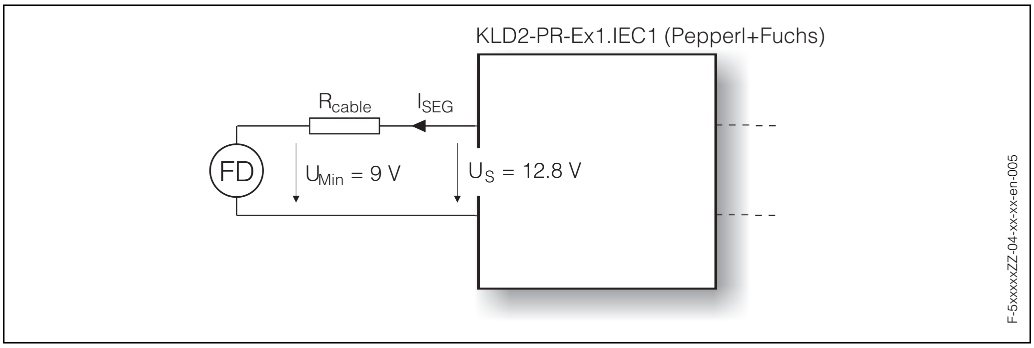


Fig. 10: Replacement circuit diagram

The resistance value R_{cable} must first be calculated in order to calculate the voltage drop caused by the fieldbus cable:

$$R_{cable} = R_{WK} \times L_{SEG} = 44\ \Omega/\text{km} \times 0.66\ \text{km} = \underline{\underline{29\ \Omega}}$$

Ohm's law is used to calculate the actual voltage $U_{FG\ eff.}$ at the last instrument:

$$U_{FG\ eff.} = U_S - (I_{SEG} \times R_{cable}) = 12.8\ \text{V} - (79.5\ \text{mA} \times 29\ \Omega) = 12.8\ \text{V} - 2.3\ \text{V} = \underline{\underline{10.5\ \text{V}}}$$

Checking the conditions:

Consideration	Condition met?
$U_{FG\ eff.} \geq 9$ V 10.5 V ≥ 9 V	✓ Yes

Final consideration:
From a purely functional point of view the bus segment shown in the example can be operated based on the positive results.

Technical safety considerations
using variant Promag 53***-***********G

Step 1 – compilation of technical values relevant to safety:

Fieldbus power supply (associated electrical apparatus)
FISCO Power Repeater KLD2-PR-Ex1.IEC1 (Pepperl+Fuchs):

- Nominal values:

U_o = 15 V
I_o = 207.2 mA
P_o = 1.93 W
Described in the test certificate as "associated equipment". Suitable for connection to a fieldbus system based on the FISCO model.

Promag 53 (explosion protected electrical apparatus with intrinsically safe FF output):

- Nominal values:

U_i = 30 V
I_i = 500 mA
P_i = 5.5 W
L_i = 10 μH
C_i = 5 nF
Suitable for connection to a fieldbus system based on the FISCO model.

Cerabar S (explosion protected electrical apparatus with intrinsically safe FF output):

- Nominal values FISCO:

U_i = 17.5 V
I_i = 500 mA
P_i = 5.5 W
L_i = 10 μH
C_i = 5 nF
Suitable for connection to a fieldbus system based on the FISCO model.

Bus cable type A (shielded bus cable):

- Nominal values:

R' = 24 Ω/km (loop resistance)
C' = 82 nF/km (capacitance per unit length)
L' = 623 μH/km (inductance per unit length)

Fieldbus connection KMD0-FT-Ex (Pepperl+Fuchs):

• Nominal values:
U_i = 24 V
I_i = 280 mA
P_i = 1.93 W
R = 100 Ω
C = 1 µF
Suitable for connection to a fieldbus system based on the FISCO model.

Step 2 – technical safety considerations acc. FISCO model

This step uses the existing data to check whether connecting the equipment is permissible from the point of view of technical safety. The conditions shown in the FISCO model apply to these safety considerations (see Page 13). First the functional data of the equipment used is compared. In this consideration it is crucial that the maximum output voltage and output current of the bus power supply does not exceed the permitted maximum input voltage and input current of the individual field devices. Here we consider possible error behaviour by the bus power supply that could result in the stated maximum values on the intrinsically safe sides.

Intrinsically safe equipment	Condition	Associated equipment FISCO Power Repeater KLD2-PR-Ex1.IEC1	Condition met?
Promag 53			
U_i = 30 V	≥	U_o = 15 V	✓ Yes
I_i = 500 mA	≥	I_o = 207.2 mA	✓ Yes
P_i = 5.5 W	≥	P_o = 1.93 W	✓ Yes
As a further condition galvanic isolation must be provided due to the local supply			✓ Yes
Cerabar S			
U_i = 17.5 V	≥	U_o = 15 V	✓ Yes
I_i = 500 mA	≥	I_o = 207.2 mA	✓ Yes
P_i = 5.5 W	≥	P_o = 1.93 W	✓ Yes
Fieldbus connection KMD0-FT-Ex			
U_i = 24 V	≥	U_o = 15 V	✓ Yes
I_i = 280 mA	≥	I_o = 207.2 mA	✓ Yes
P_i = 1.93 W	≥	P_o = 1.93 W	✓ Yes

Since all the users are permissible for explosion group IIC and the corresponding parameters have been taken into consideration, the bus segment can be used for gases in explosion group IIC.

The permissible ambient temperature may be considered either individually for each device at the respective place of installation, or specified uniformly for the bus segment as a whole. In the latter case the lowest value of the ambient temperature applies.

Required temperature class	Intrinsically safe equipment	Maximum ambient temperature
T6	Cerabar S	104 °F
T5	Promag 53	122 °F (at 176 °F medium temperature)

In the next step is the verification of whether the installed bus components fulfil the conditions and limit values set in the FISCO model. This is simplified by ensuring the bus components correspond to the FISCO model. A detailed consideration of the safety-relevant nominal values is then not necessary.

Do bus components correspond to the FISCO model?	Condition met?
Power Repeater KLD2-PR-Ex1.IEC1	✓ Yes
Promag 53	✓ Yes
Cerabar S	✓ Yes
Fieldbus connection KMD0-FT-Ex	✓ Yes

The following conditions have been applied to the bus cable and network structure:

Bus cable:

Values	Condition	Limits acc. FISCO model	Condition met?
R'	> <	15 Ω/km 150 Ω/km	
C'	> <	80 nF/km 200 nF/km	
L'	> <	400 μH/km 1000 μH/km	
Bus cable type A R' = 24 Ω/km C' = 82 nF/km L' = 623 μH/km			✓ Yes

Network structure:

Consideration	Condition	Limits acc. FISCO model	Condition met?
Cable length including drop cables	≤	1000 m (3280 ft)	
L_{SEG} = 660 m (2165 ft)	≤	1000 m (3280 ft)	✓ Yes
Drop cable length	≤	30 m (98 ft)	✓ Yes

Final consideration:
For the example shown, intrinsic safety according to the FISCO model can be proven.

Device identification

Promag 53 FOUNDATION Fieldbus transmitter and W/P/H sensor.

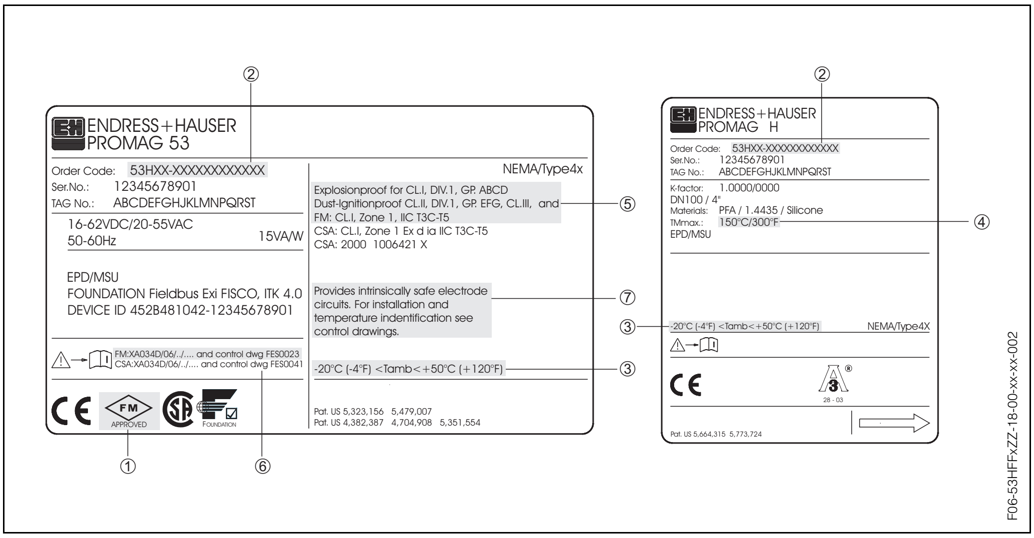


Fig. 11: Nameplate of transmitter and nameplate of sensor (example)

Key to nameplates (Figure 11)

No.	Meaning	No.	Meaning
①	Label of the notified body: Factory Mutual Research	⑤	Type of protection and explosion group for the Promag 53 FOUNDATION Fieldbus measuring system
②	Type code	⑥	Applicable Ex documentation
③	Ambient temperature range	⑦	Warning
④	Maximum medium temperature		

Control drawings

Endress+Hauser Reinach hereby declares that the product is in conformity with the requirements of the FACTORY MUTUAL standards.

Hazardous Locations
Class I Division 1 Groups ABCD or Class I Zone 1 Groups IIC
and Class II and III Division 1 Groups EFG

Promag 5. W / P

Promag 5. H

Keine Änderungen ohne vorherige Factory Mutual Genehmigung

WARNING: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.

PROMAG 5. W / P / H

XP / I / 1 / ABCD; DIP / II, III / 1 / EFG
AIS / I, II, III / 1 / ABCDEFG

FM Cl. I, Zone 1, Group IIC

Temperature table

Max. ambient temperature	Max. medium temperature depending temperature classes			
	T5	T4A	T4	T3C
50 °C / 122°F	50 °C / 122°F	110 °C / 230°F		
45 °C / 113°F	50 °C / 122°F	110 °C / 230°F	130 °C / 266°F	
40 °C / 104°F	50 °C / 122°F	110 °C / 230°F	130 °C / 266°F	150 °C / 302°F

Max. allowed medium temperature depending liner material

Liner material	Max. medium temperature
PU (polyurethan)	60 °C / 140°F
HG (hard rubber)	80 °C / 176 °F
PTFE	130 °C / 266°F
PFA	150 °C / 302°F

Communication Options	Control Drawing
I/O option = F,H,J	see FES 0023-0001
I/O option = G,K	see FES 0023-0002
I/O option = S,T	see FES 0023-0004

Notes:
1. Control room equipment shall not use or generate more than 250 V rms.
2. Caution: Use supply wires suitable for 5 °C above ambient temperature, but at least for 80 °C / 176°F.
3. Class II Group G: The surface temperature of the apparatus cannot exceed 165 °C / 329°F.
4. Install per NEC ANSI/NFPA 70 Article 500

Aenderungen:	A	03.12.01 / MDI	F		
	B		G		
	C		H		
	D		J		Ersteller: FES / **ID 1006**
	E		K		FILE: M:\ZEICHNG\FES0023\011203_aC.DOC

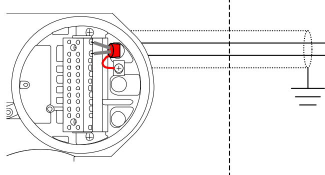
FM Control Drawing Div. 1 / Zone 1 Class I Zone 1 PROMAG 5x compact version	Gezeichnet	3.Dez.2001	MDI
	Geprüft		
	Ex-geprüft	3.Dez.2001	MDI
	Gesehen		

Flowtec AG, Kaegenstrasse 7, CH-4153 Reinach BL1, Postfach

FES0023

HAZARDOUS LOCATIONS
Cl. I Div. 1 Groups A,B,C,D
Cl. I Zone 1 Group IIC
Cl. I Div. 2 Group A,B,C,D
Cl. I Zone 2 Group IIC
Cl. II, III Div. 1 Group E,F,G

NON HAZARDOUS LOCATIONS



Entity Approved bus supply

Notes:

Intrinsically safe signal output:
1) Wire all intrinsically circuits per ISA RP 12.6. or in conduit per NEC ANSI/NFPA 70
2) **WARNING**: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
3) Control room equipment may not use or generate more than 250 Vrms.

PROMAG Type: 5*-***********G**
Terminals: 26, 27 (Foundation Fieldbus):
Iintrinsically safe circuit:

V_{max} / U_i	I_{max} / I_i	P_{max} / P_i	C_i	L_i
30 V	500 mA	5.5 W	≤ 5 nF	≤ 10 µH

Connect to entity approved associated apparatus with
I_{SC}, I_t or $I_O \leq$ Imax or I_i and
V_{OC}, V_t or $U_O \leq$ Vmax or U_i
($P_O \leq$ Pmax or P_i)
Cable parameters for Intrinsic Safety:
$C_{cable} \leq C_a / C_O - \Sigma C_i$
$L_{cable} \leq L_a / L_O - \Sigma L_i$ or
$L/R_{cable} \leq L/R_{Associated\ Apparatus}$ and Li of each I.S. apparatus ≤ 10 µH

Alternatively the intrinsically safe circuit (Fieldbus Foundation) can be connected according to the FISCO – Concept (see FES 0023-0003).

Keine Änderungen ohne vorherige Factory Mutual Genehmigung

Nonintrinsically safe signal output:
4) Transmitter circuit wiring in conduit in accordance with NEC ANSI/NFPA 70.
5) **WARNING**: EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 1.
6) Control room equipment may not use or generate over 250 Vrms.

PROMAG Type: 5***-***********K
Terminals 26,27 (FIELDBUS FOUNDATION NON I.S.)
V ≤ 32 V, I = 10 mA

Aenderungen:	A	03.12.01 / MDI	F		Alle gesetzlichen Urheberrechte vorbehalten.	Ersetzt durch:
	B		G		Diese Zeichnung darf ohne unsere	
	C		H		Genehmigung weder vervielfältigt werden noch	Ersatz für:
	D		J		dritten Personen und Konkurrenzfirmen	Ersteller: FES / **ID 1006**
	E		K		zugängig gemacht werden.	File: M:\ZEICHNG\FES0023\011203_aC.DOC

FM Control Drawing Div. 1 / Zone 1 PROMAG 5. W / P / H Fieldbus Foundation I.S. installation	Massstab %	Gezeichnet	3.Dez.2001	MDI
		Geprüft		
		Ex-geprüft	3.Dez.2001	MDI
		Gesehen		

Flowtec AG, Kaegenstrasse 7, CH-4153 Reinach BL1, Postfach

FES0023-0002

FISCO CONCEPT

The FISCO Concept allows interconnection of intrinsically safe apparatus to associated apparatus not specially examined in such combination. The criteria for interconnection is that the voltage (Ui or V_{max}), the current (Ii or I_{max}), and the power (Pi or P_{max}) which intrinsically safe apparatus can receive and remain intrinsically safe, considering faults, must be equal or greater than the voltage (Uo, Voc or Vt), the current (Io, Isc or It) and the power (Po or P_{max}) levels which can be delivered by the associated apparatus, considering faults and applicable factors. In addition, the maximum unprotected capacitance (Ci) and inductance (Li) of each apparatus (other than the termination) connected to the fieldbus must be less than or equal to 5 nF and 10 µH respectively.

In each segment only one active device, normally the associated apparatus, is allowed to provide the necessary energy for the fieldbus system. The voltage Uo (or Voc or Vt) of the associated apparatus is limited to a range of 14V to 24Vd.c. All other equipment connected to the bus cable has to be passive, meaning that they are not allowed to provide energy to the system, except a leakage current of 50µA for each connected device. Separatly powered equipment needs a galvanic isolation to assure that the intrinsically safe fieldbus circuit remains passive.

The cable used to interconnect the devices needs to have the parameter in the following range:

Loop Resistance R' :	15...150 Ohm/km
Inductance per unit length L' :	0.4...1 mH/km
Capacitance per unit length C' :	80...200 nF

C' = C' line/line + 0.5 C' line/screen, if both lines are floating, or
C' = C' line/line + C' line/screen, if the screen is connected to one line

Length of trunk cable:	≤ 1000 m
Length of spur cable:	≤ 30 m
Length of splice:	≤ 1 m

At each end of the trunk cable an approved infallible line termination with following parameters is suitable:

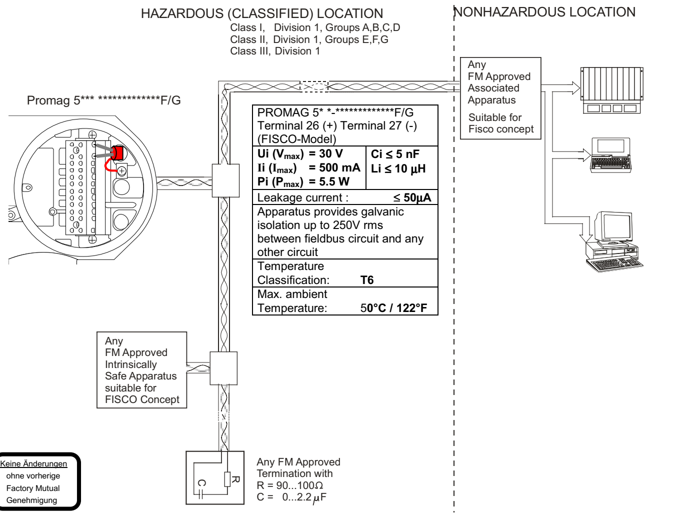
R = 90...100 Ohm C = 0...2.2 µF

One of the allowed terminations might already be integrated in the associated apparatus. The number of passive apparatus connected to the bus segment is not limited due to I. S. reasons. If the above rules are respected, up to a total lenght of 1000 m (sum of trunk and all spur cables), the inductance and the capacitance of the cable will not impair the intrinsic safety of the installation.

Notes:

Intrinsically safe Class I, Div.1, Groups A,B,C,D

1. Approved associated apparatus must be installed in accordance with manufacturers instructions.
2. FM approved associated apparatus must meet the following parameters: Uo or Voc or Vt ≤ Ui (V_{max}) and Io or Isc or It ≤ Ii (I_{max}) and Po or P_{max} ≤ Pi (P_{max})
3. The maximum non-hazardous area voltage must not exceed 250V
4. The installation must be in accordance with the National Electrical Code NFPA 70, and ANSI/ISA-Rp 12.6. (except chapter 5).
5. Multiple earthing of screen is allowed only, if high integrity equipotential system is realized between the points of bonding (see drawing No. FES 0014).
6. Caution: Use only supply wires suitable for 5°C above surrounding temperature.
7. Warning : Substitution of components may impair intrinsic safety.
8. The polarity for connection PA+ (26) and PA- (27) is of no importance due to an internal rectifier.



Aenderungen:	A	03.12.01	F		
	B		G		
	C		H		
	D		J		
	E		K		

Ersetzt durch:

Ersatz für:

Ersteller: FES / **ID 1006**

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FM Control Drawing Div. 1 / Zone 1
PROMAG 5. W / P / H
Intrinsically safe PROFIBUS PA, Fieldbus Foundation
FISCO-Concept

Massstab			
	Gezeichnet	3.Dez.2001	MDI
	Geprüft		
	Ex-geprüft	3.Dez.2001	MDI
	Gesehen		

FES0023-0003

Flowtec AG, Kaegenstrasse 7, CH-4153 Reinach BL1, Postfach

Supplementary documentation
TI 046D/06
TI 047D/06
TI 048D/06

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Endress+Hauser
The Power of Know How

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XA 034D/06/en/07.02
50098662
FM+SGML 6.0

PROline promag 53 Division 1

en

Ex documentation for the BA 051D and BA 052D operating instructions

according to CANADIAN STANDARDS ASSOCIATION

Example: **Class I, Division 1, Groups ABCD**

Canadian Standards Association

Class

I	Class I (Gas)
II	Class II (Dust)
III	Class III (Fibre)

Division

1	Division 1
2	Division 2

Group

CSC / NEC	Gases, vapours and dusts (Examples)	Min. ignition temperature [µJ]
A	Acetylene, carbon disulfide (Class I)	0.02
B	Hydrogen, ethyl nitrate (Class I)	0.02
C	Ethylene, isoprene (Class I)	0.06
D	Acetone, ethane, benzene (Class I)	0.18
E	Metallic powder (Class II)	
F	Coal dust (Class II)	
G	Grain dust (Class II)	
	Textile fibres (Class III)	

Type of Protection

	Explosionproof
	Intrinsically Safe Apparatus
	Associated Apparatus with Intrinsically Safe Connections
	Nonincendive Field Wiring Circuit
	Pressurized
	Associated Pressurization Systems/Components
	Nonincendive
	Dust-Ignitionproof
	Special Protection

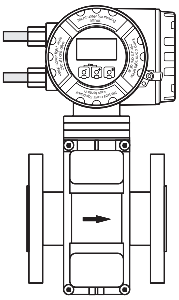
Temperature Class

CSA	Maximum surface temperature	
T1	450 °C	842 °F
T2	300 °C	572 °F
T2A	280 °C	536 °F
T2B	260 °C	500 °F
T2C	230 °C	446 °F
T2D	215 °C	419 °F
T3	200 °C	392 °F
T3A	180 °C	356 °F
T3B	165 °C	329 °F
T3C	160 °C	320 °F
T4	135 °C	275 °F
T4A	120 °C	248 °F
T5	100 °C	212 °F
T6	85 °C	185 °F

Endress+Hauser
The Power of Know How

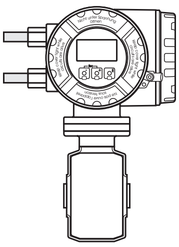
Hazardous area		Safe area
Division 1 / Zone 1	Division 2 / Zone 2	

Promag 53
P = DN 15...300
W = DN 25...300



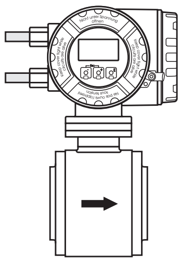
③

Promag 53
H = DN 2...25



③

Promag 53
H = DN 40...100



③

F06-53xxxxZZ-16-xx-xx-en-001

Division 1 / Zone 1	Division 2 / Zone 2	
Hazardous area		Safe area

- Promag 53 FOUNDATION Fieldbus flow measuring system in:
  Explosionproof and Dust-Ignitionproof for
  Class I, Groups ABCD or Class I, Zone 1, Group IIC
  Class II, Groups EFG
  Class III
- For ambient and fluid temperature ranges, and temperature class, see Page 3.

③ Transmitter terminal compartment power supply/bus cable

Temperature tables

Measuring system Promag 53 (compact version)

at T_a = 40 °C			Max. medium temperature [°C] in					
			T5	**T4A**	**T4**	**T3C**	**T2**	**T1**
Promag H	DN 2...100		50	110	130	150	150	150
Promag P	DN 25...200	(PFA lining)	50	110	130	150	150	150
Promag P	DN 15...300	(PTFE lining)	50	110	130	130	130	130
Promag W	DN 25...300	(polyurethan lining)	50	60	60	60	60	60
Promag W	DN 65...300	(hard-rubber lining)	50	80	80	80	80	80

at T_a = 45 °C			Max. medium temperature [°C] in					
			T5	**T4A**	**T4**	**T3C**	**T2**	**T1**
Promag H	DN 2...100		50	110	130	130	130	130
Promag P	DN 25...200	(PFA lining)	50	110	130	130	130	130
Promag P	DN 15...300	(PTFE lining)	50	110	130	130	130	130
Promag W	DN 25...300	(polyurethan lining)	50	60	60	60	60	60
Promag W	DN 65...300	(hard-rubber lining)	50	80	80	80	80	80

at T_a = 50 °C			Max. medium temperature [°C] in					
			T5	**T4A**	**T4**	**T3C**	**T2**	**T1**
Promag H	DN 2...100		50	110	110	110	110	110
Promag P	DN 25...200	(PFA lining)	50	110	110	110	110	110
Promag P	DN 15...300	(PTFE lining)	50	110	110	110	110	110
Promag W	DN 25...300	(polyurethan lining)	50	60	60	60	60	60
Promag W	DN 65...300	(hard-rubber lining)	50	80	80	80	80	80

Note:
At the specified medium temperatures, the equipment is not subjected to temperatures impermissible for the temperature class in question.

Approvals

No. / approval type	Description
160686-1006421 (See Page 5 for notes on special conditions)	for the electric flow measuring system Promag 53 FOUNDATION Fieldbus Identification: **Explosionproof and Dust-Ignitionproof for Class I, Groups ABCD; Class I, Zone 1, Group IIC Class II, Groups EFG Class III**

Measuring system Promag 53 FOUNDATION Fieldbus (compact version)

Promag 53***-***********.	G = FOUNDATION Fieldbus, intrinsically safe K = FOUNDATION Fieldbus

Promag 53 H	DN 2...100	
Promag 53 P	DN 15...600:	**see description above**
Promag 53 W	DN 25...300:	

Notified body

The Promag measuring system was tested for approval by the following named entity:

CSA: Canadian Standards Association

Special conditions

1. Install per Canadian Electrical Code.

2. Control room equipment shall not use or generate more than 250 V rms.

3. The specified temperature class in conjunction with the ambient temperature and the medium temperature must be in compliance with the tables on Page 3.

4. Use of the devices is restricted to mediums against which the process-wetted materials are adequately resistant.

5. Use supply wires suitable for 5 °C above ambient temperature, but at least for 80 °C.

6. Devices connected to terminals Nos. 20 to 27 of the Promag 53 FOUNDATION Fieldbus transmitter must be rated for U_m = 260 V and I_m = 500 mA: it is impermissible to connect devices with higher ratings to these terminals.
   (Does not apply to Promag 53***-***********G with intrinsically safe output circuit).

General warnings

Warning:
- Installation, connection to the electricity supply, commissioning and maintenance of the devices must be carried out by qualified specialists trained to work on Ex-rated devices.

- Compliance with national regulations relating to the installation of devices in potentially explosive atmospheres is mandatory, if such regulations exist.

- Open the device only when it is de-energized (and after a delay of at least 10 minutes following shutdown of the power supply).

- The housing of the Ex-rated transmitter can be turned in 90° steps. Whereas the non-Ex version has a bayonet adapter, however, the Ex version has a thread. Recesses for centering the worm screw are provided to prevent inadverted movement ot the transmitter housing.
  It is permissible to turn the transmitter housing through a maximum of 180° during operation (in either direction), without compromising explosion protection.
  After turning the housing the worm screw must be fastened again.

- The screw cap has to be removed before the local display can be turned, and this must be done with the device de-energized (and after a delay of at least 10 minutes following shutdown of the power supply).

Electrical connections

Power supply connection

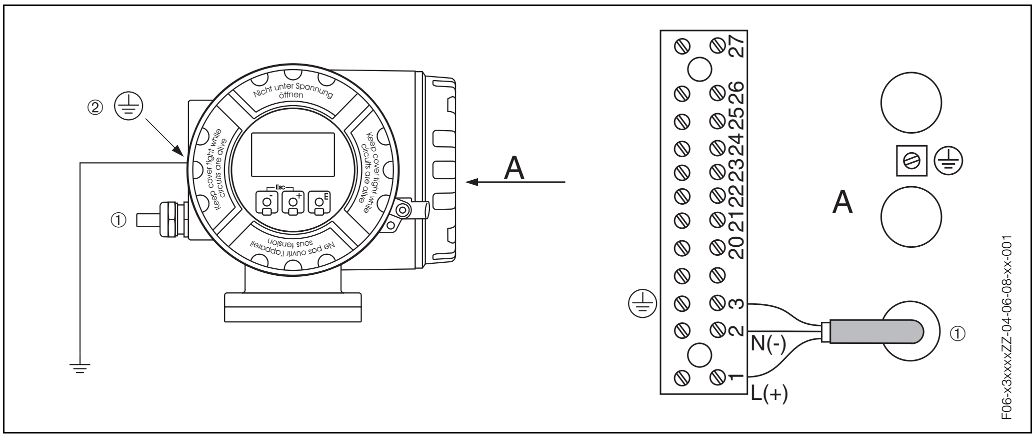


Fig. 1: *① = Power supply cable*
② = Ground terminal for potential equalisation
A = View A

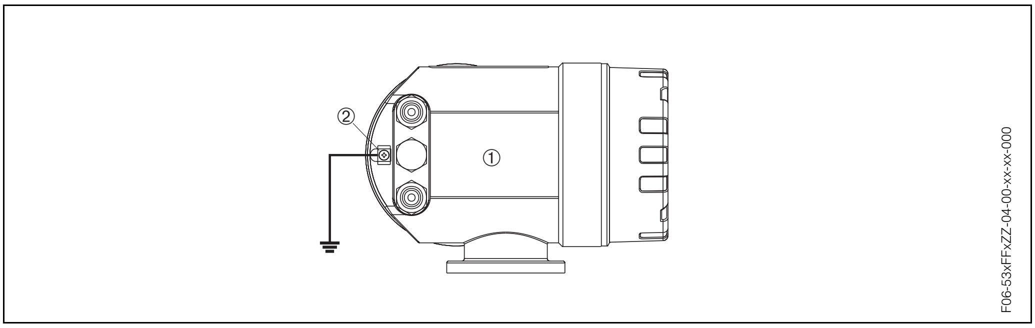


Fig. 2: *Ground terminal for potential equalisation*

Caution:
- The transmitter ① is to be securely connected to the potential equalization system using the screw terminal ② on the outside of the transmitter housing.

The table below contains the values that are identical for all versions, irrespective of the type code.

Transmitter Promag 53

Terminals	1	2	3
	L (+)	N (–)	
Designation	Power supply ①		Protective earth
Functional values	AC: U = 85...260 V or AC: U = 20...55 V or DC: U = 16...62 V Power consumption: 15 VA / 15 W		Caution: Follow ground network requirements for the facility
Intrinsically safe circuit	no		
U_{max} =	260 V AC		

Input/output circuit

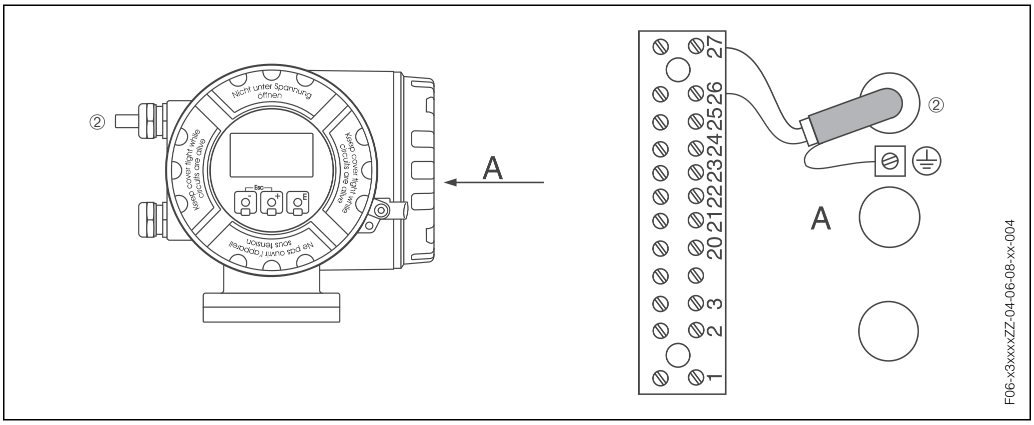


Fig. 3: ② = Bus cable (FOUNDATION Fieldbus)
A = View A

Note:
The table below contains the values that are not identical for all versions, in other words which depend on the type code (type of device).
Always remember to compare the type code in the table with the code on the nameplate of your device.

Transmitter Promag 53***-***********G

Terminals	20	21	22	23	24	25	26	27
	+	–	+	–	+	–	+	–
Designation							FOUNDATION Fieldbus ②	
Functional values							U_B = 9...32 V DC I_B = 12 mA	
Intrinsically safe circuit							EEx ia	
U_i =							30 V DC	
I_i =							500 mA	
P_i =							5.5 W	
L_i =							10 µH	
C_i =							5 nF	

Transmitter Promag 53***-***********K

Terminals	20	21	22	23	24	25	26	27
	+	–	+	–	+	–	+	–
Designation							FOUNDATION Fieldbus ②	
Functional values							U_B = 9...32 V DC I_B = 12 mA	
Intrinsically safe circuit							no	
U_{max} =							260 V AC	
I_{max} =							500 mA	

Service adapter

The service adapter is exclusively for connection to E+H approved service interfaces.

Warning:
It is not permissible to connect the service adapter in explosive atmospheres.

Device fuse

Warning:
Use only fuses of the following types; the fuses are installed on the power supply board:

- Voltage 20...55 V AC / 16...62 V DC:
  fuse 2.0 A slow-blow, disconnect capacity 1500 A
  (Schurter, 0001.2503 or Wickmann, Standard Type 181 2.0 A)

- Voltage 85...260 V AC:
  fuse 0.8 A slow-blow, disconnect capacity 1500 A
  (Schurter, 0001.2507 or Wickmann, Standard Type 181 0.8 A)

Cable entries

For number reference see the figure on Page 2.

③ *Cable entries for the transmitter terminal compartment power supply / bus cable: (Promag 53***-*****N******)*
Thread for cable entries ½" NPT.

Make sure that the cable entries are secured to prevent them from working loose.

Technical data

Dimensions wall-mount housing

Weight approx. 6.7 kg

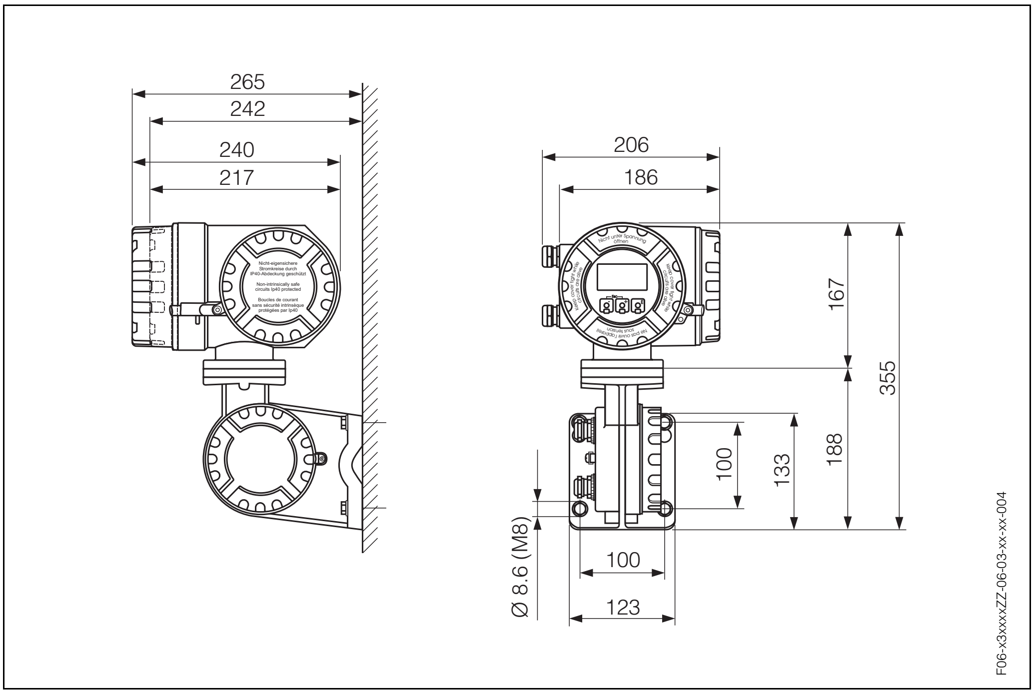


Fig. 4: Dimensions wall-mount housing

Bus cable for FOUNDATION Fieldbus

The Fieldbus FOUNDATION defines four different types of cable in the specification creating the physical transmission layer (FF-816) which is analogous to IEC 61158-2. A two-core cable is always specified.
The electrical data has not been specified but determines important characteristics of the design of the fieldbus, such as distances bridged, number of participants, electromagnetic compatibility, etc.

Two of the four cable types in the standard are specified in the following table.

	Cable type A (reference)	**Cable type B**
Cable construction	twisted pair, shielded	one or more twisted pairs, fully shielded
Core cross-section (nominal)	0.8 mm^2 (AWG 18)	0.32 mm^2 (AWG 22)
Loop resistance (direct current)	44 Ω/km	112 Ω/km
Impedance at 31.25 kHz	100 Ω ± 20%	100 Ω ± 30%
Attenuation constant at 39 kHz	3 dB/km	5 dB/km
Capacitive unsymmetry	2 nF/km	2 nF/km
Envelope delay distortion (7.9...39 kHz)	1.7 µs/km	**
Degree of voltage of shielding	90%	**
Max. bus segment length (inc. spur lines)	1900 m	1200 m

Tab. 1: Cable types

We recommend the use of cables meeting the minimum requirements of type A as transmission medium, particularly for the installation of new systems. The recommended network expansion is made up of the length of the main cable and the length of all spurs. The line between distribution box and field device is described as a spur. The maximum length of a spur depends on the number of spurs (>1 m). A maximum of four field devices can be connected to a spur.

Number of spurs	**1...12**	**13...14**	**15...18**	**19...24**	**25...32**
Max. length per spur	120 m	90 m	60 m	30 m	1 m

Tab. 2: Table of possible spur line lengths

The following table shows examples of FOUNDATION Fieldbus bus cables (type A) from various manufacturers.

Supplier	**Model**	**Order number**
Belden	3076	–
Kerpen	FB-02YS (St+C) Y-FL	74220001 (light blue) 74220004 (black)
Siemens	SIMATIC NET bus cable	6XV1830-5AH10 (light blue) 6XV1830-5BH10 (black)

Tab. 3: Possible cable suppliers

Bus termination
The start and end of each fieldbus segment are always to be terminated with a bus terminator.

- In the case of a branched bus segment the measuring device furthest from the segment connector represents the end of the bus.
- If the fieldbus is extended with a repeater then the extension must also be terminated at both ends.

Selecting and connecting components
The FOUNDATION Fieldbus allows several devices from different manufacturers to be generally connected to a bus segment. When selecting components for use in areas with an explosion risk only components marked as intrinsically safe, explosion-protected electrical equipment or as intrinsically safe associated electrical equipment may be used. When combining different fieldbus devices and fieldbus components, in addition to functional considerations, technical safety factors must be considered if explosion protection is to be ensured.

Implementation of intrinsic safety in the FOUNDATION Fieldbus H1

The FOUNDATION Fieldbus H1 can be made intrinsically safe for use in areas with an explosion risk (EEx i). To do this, according to the FOUNDATION Fieldbus specification a suitable safety component must be installed (FF-816) between the safe area and the area with an explosion risk. The intrinsically safe bus segment can be supplied either by a non-intrinsically safe power supply with a safety barrier downstream or by a fieldbus power supply with an intrinsically safe output.
It is recommended that the cable shielding be grounded at both ends (refer to Fig. 6, Page 14).

Installation example of a galvanic isolator with bus feed:

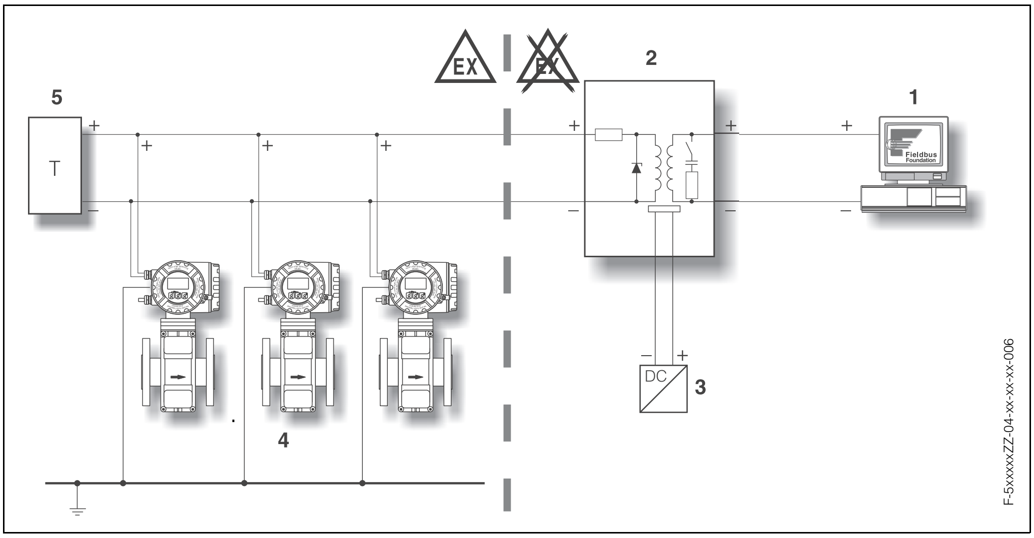


Fig. 5: Typical embodiment of a galvanic isolator including fieldbus power supply

1 = DCS with integrated FOUNDATION Fieldbus H1 interface card
2 = fieldbus power supply: galvanic isolator
3 = fieldbus power supply
4 = Promag 53 bus devices for hazardous area
5 = terminator (T) = bus termination

Proof of intrinsic safety

Proof of intrinsic safety for the intrinsically safe bus segment can be made by using one of the following models:
- Entity model
- FISCO model

Both models differ from one another by their consideration of the cable. While the FISCO model considers the transmission line as distributed inductance and capacitance, the basis of this consideration for the Entity model is concentrated inductance and capacitance. The result of this is that lower quantities of power can be transmitted with the Entity model into the Ex area, and that the number of field devices that can be operated on a power repeater is therefore lower than with the FISCO model.
In the case of failure, instruments from different manufacturers can be exchanged when their safety-relevant data is taken into consideration. This data is: electrical parameters, device group and category, and the temperature class.

Both these models are briefly described in the following.

The Entity model

The Entity model is based on the observation that the cable represents concentrated inductance and capacitance. The result is that less electrical power can be transmitted into the area subject to the risk of explosion when compared with the FISCO model.

The following conditions must be met in the safety according to the entity model considerations:

Field device **Hazardous area**	**Mandatory**	**Power supply** **Safe area**
Maximum voltage [U_i]	≥	Idle voltage of the safety element [U_o]
Maximum current [I_i]	≥	Short-circuit current [I_o]
Maximum power [P_i]	≥	[P_o]
Effective internal capacitance [C_i] + cable capacitance	≤	Maximum permitted external capacitance [C_o]
Effective internal inductance [L_i] + cable inductance	≤	Maximum permitted external inductance [L_o]

Tab. 4: General dependencies

In addition, the following measures must be taken:
- determine permissible explosion group for the bus segment
- determine all effective energy stores (L_i, C_i, capacitance and inductance per unit length)
- check locally supplied operating units for galvanic isolation
- harmonize temperature class and ambient temperature

Note:
Configuration example see Page 16

The FISCO model

The German Federal Physical-Technical Institute (PTB) has developed the FISCO model which was published in Report PTB-W-53 “Examination on Intrinsic Safety for Field Bus Systems”.

The FISCO model makes possible the interconnection of intrinsically safe apparatus and one intrinsically safe associated apparatus, without having to have separate certification for respective connections.
The criteria for the intrinsic safety of an interconnection (bus segment) is given under the following interrelationships:

1. To transmit power and data, the bus system uses the physical configuration defined by IEC 61158-2. This is the case for FOUNDATION Fieldbus and the H1 bus.

2. Only one active source is permitted on a bus segment (here the power repeater). All other components work as passive current sinks.

3. The basic current consumption of a field device is at least 10 mA.

4. U_i, I_i and P_i of the bus device ≥ U_o, I_o and P_o of the associated equipment (bus power supply).

5. Each instrument must fulfill the following requirement: $C_i \leq 5$ nF, $L_i \leq 10$ µH

6. The permissible line length for EEx ia IIC applications is 1000 m.

7. The permissible spur length for Ex applications is 30 m per spur.

8. The transmission line that is used must conform to the following cable parameters:
   Resistor coating: 15 Ω/km < R' < 150 Ω/km
   Inductance coating: 0.4 mH/km < L' < 1 mH/km
   Capacitance coating: 80 nF/km < C' < 200 nF/km (including the shield)

9. The bus segment must be terminated on both ends of the line with a terminal bus resistor. A terminal resistor is integrated into the power repeater so that an external bus terminator is only required on the other end. According to the FISCO model the fieldbus terminator must conform to the following limits:
   – 90 Ω < R < 100 Ω
   – 0 µF < C < 2.2 µF

Note:
Configuration example see Page 23

Potential equalisation with shielding grounded at both ends

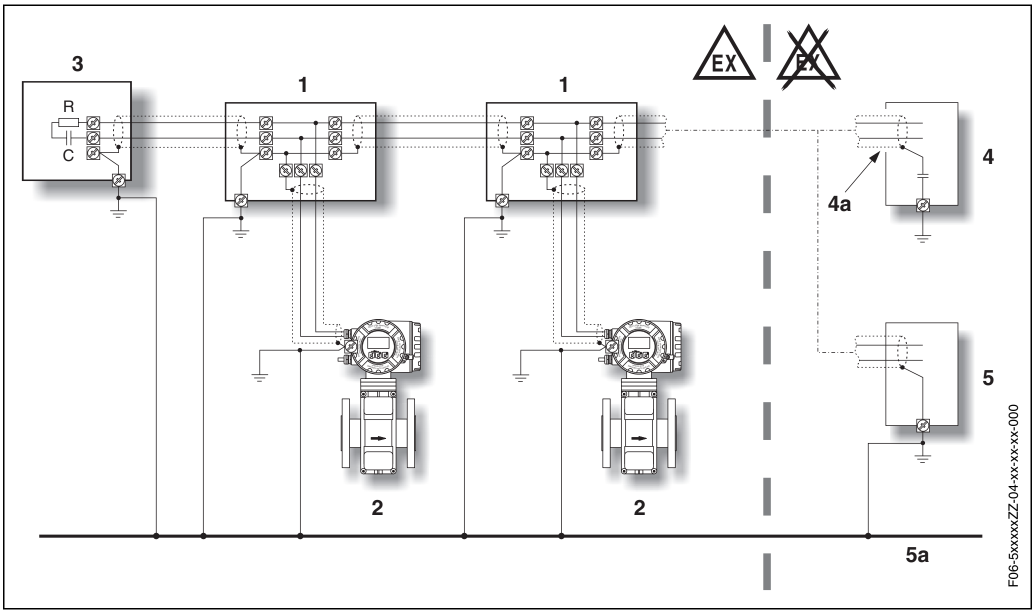


Fig. 6: Examples of the connection of potential equalisation lines

1 = distributor/T-box
2 = Promag 53 bus devices for hazardous area
3 = bus termination: R = 90...100 Ω, C = 0...2.2 µF
4 = fieldbus power supply variant 4a
4a = shielding connected via capacitor
5 = fieldbus power supply variant 5a
5a = potential equalisation line led out

Variant 4/4a:
With capacitive grounding of the shielding in the safe area the potential equalisation line does not need to be led out of the safe area.
Use small capacitors (e.g. 1 nF, 1500 V, dielectric strength, ceramic). The total capacitance connected at the shielding must not exceed 10 nF.

Variant 5/5a:
Potential equalisation line is led out of the safe area.

Network configuration for FOUNDATION Fieldbus H1

General remarks

Various aspects are to be considered when configuring a FOUNDATION Fieldbus H1 segment and these must essentially be checked by two general types of considerations:

Functional considerations

In the functional considerations, the characteristic of the technical function data laid down in IEC 61158-2 for the transmission technology of the FOUNDATION Fieldbus H1 and the physical network structure is checked. Here it must always be ensured that the total base currents of all bus participants does not exceed the maximum permissible feed current of the bus power supply and that the field devices are always supplied with a minimum bus voltage of 9 V.

Technical safety considerations

For use of the FOUNDATION Fieldbus H1 in an area with an explosion risk, proof of intrinsic safety is to be provided for the entire bus segment by means of the technical safety considerations. Proof of intrinsic safety for the intrinsically safe bus segment can be made by using one of the following models:

Entity model

The safety considerations correspond to those in a conventional 4...20 mA measuring circuit. The only exception is that here more than one field device is supplied by the power supply. The safety considerations must result in the knowledge that the fieldbus power supply does not exceed the safety parameters (P-, U-, I-values) of the field devices and that the inductance and capacitance are within the permissible limits (example see Page 16).

FISCO model

If proof of intrinsic safety is made according to the FISCO model, it is to be verified that all components connected to the bus segment (field instruments, bus power supplies, bus terminator) are laid out according to the FISCO model. If this is the case, it must be proven that for each bus component the values of U_i, I_i and P_i are greater or the same as the values of U_o, I_o and P_o for the associated equipment (bus power supply). Example see Page 23.

Configuration example for a FOUNDATION Fieldbus H1 segment

Based on the following example, the functional and safety-relevant considerations and calculations for the specification of a FOUNDATION Fieldbus H1 segment are carried out.

Configuration example Entity model

Fig. 7 shows the typical structure and the associated components. The field devices are operated on a segment with the type of protection EEx ia. A galvanic isolator is used for the transition to the area with explosion risk. Field devices with a lower power consumption, such as the Cerabar S pressure gauge, are supplied via the two-wire line. In contrast, the Promag 53 as a four-wire device must be supplied via an local power supply.

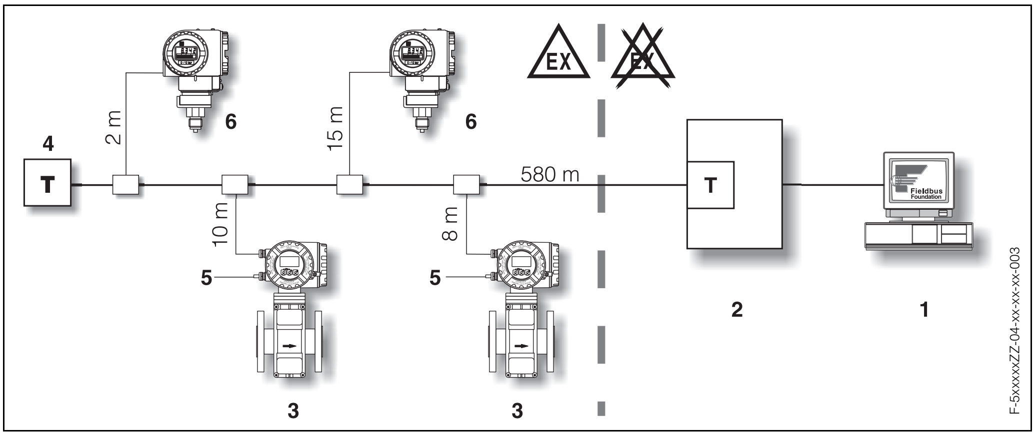


Fig. 7: Typical example of a bus connection with a fieldbus power supply of type MTL 5053

1 = DCS with integrated FOUNDATION Fieldbus H1 interface card
2 = fieldbus power supply, model MTL 5053
3 = Promag 53 bus devices for hazardous area
4 = terminator (T) = bus termination
5 = transducer supply
6 = Cerabar S bus devices for hazardous area

Functional considerations

Using the following procedure the functional considerations checks whether the desired segment structure meets the basic requirements for transmission to the physical layer in IEC 61158-2.

Step 1 – compilation of the functional characteristic values of the fieldbus components

- Fieldbus power supply MTL 5053:

U_S = 18.4 V
I_S = 80 mA
R_Q = 105 Ω (source impedance)

- Fieldbus line:

Cable type A
R_{WK} = 44 Ω/km (effective resistance per unit length)
max. permissible cable length $L_{perm.}$= 1900 m

- Fieldbus device Promag 53:

I_B = 12 mA (basic current)
U_B = 9...32 V (perm. operating voltage)
I_{FDE} = 0 mA (fault current)
$I_{startup}$ = 0 (< I_B)

- Fieldbus device Cerabar S:

I_B = 10.5 mA (basic current)
U_B = 9...32 V (perm. operating voltage)
I_{FDE} = 0 mA (fault current)
$I_{startup}$ = 0 (< I_B)

Step 2 – calculation of cable length and checking of network structure

The maximum cable length is always determined by the type of cable used. The actual cable length, which is made up of the length of the main cable and the length of the spur lines, must not exceed this value. The spur lines are also to be checked (refer to Table 2, Page 10). The following restrictions apply to the specification of the cable length and network structure:

- Where cable type A is used the cable length $L_{perm.}$ may be max. 1900 m.
- Checking the spur line lengths (refer to Table 2, Page 10).

Calculation of actual cable length:

$$L_{SEG} = L_{main.} + \Sigma L_{spurs} = 580\text{ m} + 35\text{ m} = \underline{\underline{615\text{ m}}}$$

Checking the conditions

Consideration	Condition met?
$L_{SEG} < L_{perm.}$	✓ Yes
$L_{spurs} < 120$ m	✓ Yes

If one of the conditions is not met then the network structure must be revised.

Step 3 – current calculation

The number of field devices that can be connected to the H1 segment depends on the fieldbus power supply selected (supply voltage and supply current) and the current consumption of the field devices. Thus, the number of devices that can be connected is reduced if a field device consumes a basic current of more than 10 mA, e.g. 20 mA. By adding up the basic currents I_B of the field devices plus the response current in the event of a fault I_{FDE} for the FDE (**F**ault **D**isconnect **E**lectronics) and the current for the data modulation I_{MOD} (+9 mA) you can determine the minimum supply current that the fieldbus power supply must supply.

If, on switching on the device, the startup $I_{startup}$ current is greater than the basic current, then the startup current must be taken into consideration in the calculation. The response current for the FDE (I_{FDE}) is calculated for each field device from the difference between the maximum current in the event of a fault and the basic current. The field device with the greatest response current is taken into consideration in the current balance sheet.

Provided that no more than one FDE responds, the following condition must be taken into consideration in the calculation of the segment current I_{SEG}:

$$I_{Seff.} \geq I_{SEG}$$

where

$$I_{SEG} = \Sigma_{IB} + \max I_{FDE} + I_{MOD} + I_{startup}$$

In the example the calculation formula results in the following segment current consumption I_{SEG}, where I_{FDE} = 0, $I_{startup}$ = 0, since the field devices used do not consume additional current in the event of a fault and the startup current is less than the bus current:

$$I_{SEG} = \Sigma I_B + \max. I_{FDE} + I_{MOD} + I_{startup}$$
$$= 45\ mA + 0\ mA + 9\ mA + 0\ mA$$
$$= \underline{\underline{54\ mA}}$$

The next step checks whether the current consumption I_{SEG} calculated is within the current limits of the fieldbus power supply. The maximum available supply current $I_{Seff.}$ is calculated taking into consideration the current drops caused by the source impedance R_Q of the fieldbus power supply and then by the effective resistance per unit of length of the fieldbus line. Also, the condition must be met that the supply voltage at the furthest field device must be at least 9 V. To make the overall considerations easier it is assumed that all the field devices FD (refer to Fig. 8) are connected at the end of the fieldbus line.

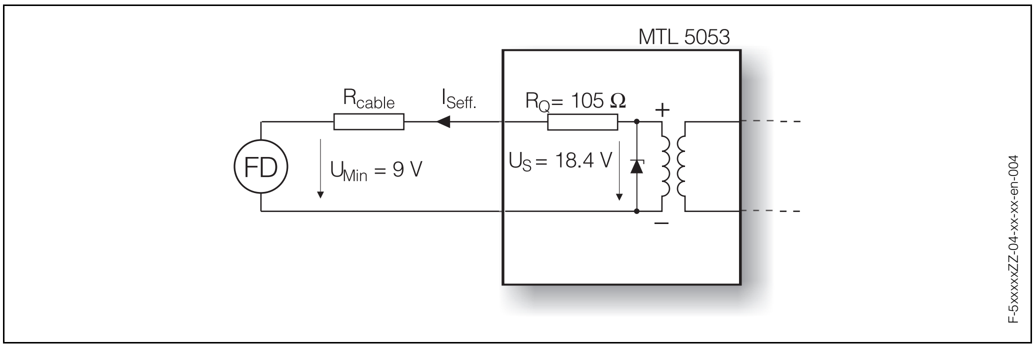


Fig. 8: Replacement circuit diagram

In order that the available supply current $I_{Seff.}$ can be calculated the resistance value for the fieldbus line R_{cable} must first be calculated:

$$R_{cable} = R_{WK} \times L_{SEG}$$
$$= 44\ \Omega/km \times 0.615\ km$$
$$= \underline{\underline{27\ \Omega}}$$

Calculation of the maximum available supply current $I_{Seff.}$ of the fieldbus power supply:

When calculating the maximum available supply current it must be ensured that a minimum supply voltage of 9 V is applied at the field devices:

$$I_{Seff.} = (U_S - 9\ V) / (R_Q + R_{cable})$$
$$= (18.4\ V - 9\ V) / (105\ \Omega + 27\ \Omega)$$
$$= \underline{\underline{71.2\ mA}}$$

Observing the conditions stated, a supply current of $I_{Seff.}$ = 71.2 mA is available for the field devices on the bus segment. Since the actual current consumption of the segment is only 54 mA, from the point of view of the functional considerations proper functioning of the segment is ensured.

For reasons of satety the actual voltage $U_{FG\ eff.}$ of the furthest field device can be calculated as follows:

$$U_{FG\ eff.} = U_S - I_{SEG} \times (R_Q + R_{cable})$$
$$= 18.4\ V - 54\ mA \times (105\ \Omega + 27\ \Omega)$$
$$= 18.4\ V - 7.1\ V$$
$$= \underline{\underline{11.2\ V}}$$

Checking the conditions:

Consideration	Condition met?
$I_{seff} \geq I_{SEG}$ 71.2 mA ≥ 54 mA	✓ Yes
$U_{FG\ eff.} \geq 9$ V 11.2 V ≥ 9 V	✓ Yes

Final consideration:
From a purely functional point of view the bus segment shown in the example can be operated based on the positive results. Further optimization of the network with a view to connecting a greater number of field devices or realizing a longer line length can be achieved by selecting the right fieldbus power supply and cable type.

Technical safety considerations
using variant Promag 53***-***********G

Step 1 – compilation of technical values relevant to safety:

Bus power supply MTL 5053 (associated electrical apparatus)

- Nominal values:

U_o = 22 V
I_o = 216 mA
P_o = 1.2 W

	Explosion group		
	IIC	IIB	IIA
Capacitance C_o	0.165 µF	1.14 µF	4.20 µF
Inductance L_o	0.32 mH	3.00 mH	7.00 mH
L/R_{ratio}	31 µH/Ω	126 µH/Ω	242 µH/Ω

Tab. 5: External connection values of bus power supply MTL 5053 depending on temperature class

Promag 53 (explosion protected electrical apparatus with intrinsically safe FF output):

- Nominal values:

U_i = 30 V
I_i = 500 mA
P_i = 5.5 W
L_i = 10 µH
C_i = 5 nF

Cerabar S (explosion protected electrical apparatus with intrinsically safe FF output):

- Nominal values Entity:

U_i = 24 V
I_i = 250 mA
P_i = 1.2 W
L_i = 10 µH
C_i = 5 nF

Bus cable type 3076 from Belden (shielded bus cable):

- Nominal values:

R’	=	24 Ω/km (loop resistance)
C’	=	82 nF/km (capacitance per unit length between the two wires)
L’	=	623 µH/km (inductance per unit length of the two wires)
C'_{LS}	=	147 nF/km (capacitance per unit length wire against shielding)

Bus termination:

- Nominal values:

U_i	=	30 V
P_i	=	1.2 W
C_i	=	negligible

The effective capacitance of the bus line is derived first from the capacitance per unit length C’, which is effectively the capacitance between the two wires. In the case of the shielded wires the order of capacitance “wire against shielding” and “shielding against wire” must be observed. The total capacitance of the bus line is thus calculated as follows:

$$C'_{eff/cable} = (C' + 0.5 \times C'_{LS}) \times L_{SEG}$$

The total length of the bus line L_{SEG} is made up of the length of the main cable and the length of all spurs. Using the system structure illustrated in Fig. 8 the following data relevant to safety emerges for the bus line:

$$\begin{aligned} L_{SEG} &= L_{main} + \Sigma L_{spurs} \\ &= 580\text{ m} + 35\text{ m} \\ &= \underline{\underline{615\text{ m}}} \end{aligned}$$

$$\begin{aligned} C'_{eff./cable} &= (C' + 0.5 \times C'_{LS}) \times L_{SEG} \\ &= (82\text{ nF/km} + 0.5 \times 147\text{ nF/km}) \times 0.615\text{ km} \\ &= \underline{\underline{95.6\text{ nF}}} \end{aligned}$$

$$\begin{aligned} L'_{eff./cable} &= L' \times L_{SEG} \\ &= 623\ \mu\text{H/km} \times 0.615\text{ km} \\ &= \underline{\underline{383.1\ \mu\text{H}}} \end{aligned}$$

Step 2 – technical safety considerations

This step uses the existing data to check whether connecting the equipment is permissible from the point of view of technical safety. The conditions shown in Table 5 (Page 19) apply to these safety considerations. First the functional data of the equipment used is compared. In this consideration it is crucial that the maximum output voltage and output current of the bus power supply does not exceed the permitted maximum input voltage and input current of the individual field devices. Here we consider possible error behaviour by the bus power supply that could result in the stated maximum values on the intrinsically safe sides.

Intrinsically safe equipment	Condition	Associated equipment MTL 5053	Condition met?
Promag 53			
U_i = 30 V	≥	U_o = 22 V	✓ Yes
I_i = 500 mA	≥	I_o = 216 mA	✓ Yes
P_i = 5.5 W	≥	P_o = 1.2 W	✓ Yes
As a further condition galvanic isolation must be provided due to the local supply			✓ Yes
Cerabar S			
U_i = 24 V	≥	U_o = 22 V	✓ Yes
I_i = 250 mA	≥	I_o = 216 mA	✓ Yes
P_i = 1.2 W	≥	P_o = 1.2 W	✓ Yes
FBT1			
U_i = 30 V	≥	U_o = 22 V	✓ Yes
P_i = 1.2 W	≥	P_o = 1.2 W	✓ Yes

In addition to these values the limit values and the maximum permissible external capacitance C_o and inductance L_o must be observed for the supply circuit. To do this the sum of all effective inductance and capacitance in the hazardous area is formed (the internal capacitance of the bus termination is assumed to be 0). The resulting value must be less than the maximum permissible value specified by the fieldbus power supply.

The equivalent concentrated capacitance and inductance in the hazardous area is calculated as follows:

$$C_{eff.} = (C_{i/Promag\ 53} \times 2) + (C_{i/Cerabar\ S} \times 2) + C'_{eff./cable} + C_{i/bus\ termination}$$
$$= (5\ nF \times 4) + 95.6\ nF$$
$$= 115.6\ nF$$

$$L_{eff.} = (L_{i/Promag\ 53} \times 2) + (L_{i/Cerabar\ S} \times 2) + L'_{eff./cable}$$
$$= (10\ \mu H \times 4) + 383.1\ \mu H$$
$$= 423.1\ \mu H$$

Intrinsically safe equipment Promag 53	Condition	Associated equipment MTL 5053	Condition met?
Total capacitance $C_{eff.}$ = 115.6 nF	<	perm. capacitance for IIC C_o = 165 nF	✓ Yes
Total inductance $L_{eff.}$ = 423.1 µH	<	perm. inductance for IIC L_o = 320 µH	No

Tab. 6: Safety considerations (example)

If, in the example examined, the condition $L_{eff.} < L_o$ is met, then the demonstration of intrinsic safety with respect to the electrical parameters has a positive result. In this example, however, the condition was not met since the bus line selected is too long.

Possible solutions:

1. Reduce the main line by 175 m to 405 m (this can be achieved by installing the barrier in the immediate vicinity of Explosion Zone 1, for example).
2. Check under what conditions the manufacturer of the safety barrier or segment connector allows the use of the L/R ratio for technical safety considerations.

Since all the users are permissible for explosion group IIC and the corresponding parameters have been taken into consideration, the bus segment can be used for gases in explosion group IIC.

The permissible ambient temperature may be considered either individually for each device at the respective place of installation, or specified uniformly for the bus segment as a whole. In the latter case the lowest value of the ambient temperature applies.

Required temperature class	Intrinsically safe equipment	Maximum ambient temperature
T6	Cerabar S	40 °C
T5	Promag 53	50 °C (at 80 °C medium temperature)

Configuration example FISCO model

Fig. 9 shows the typical structure and the associated components. The field devices are operated on a segment with the type of protection EEx ia. A galvanic isolator is used for the transition to the area with explosion risk. Field devices with a lower power consumption, such as the Cerabar S pressure gauge, are supplied via the two-wire line. In contrast, the Promag 53 as a four-wire device must be supplied via an local power supply.

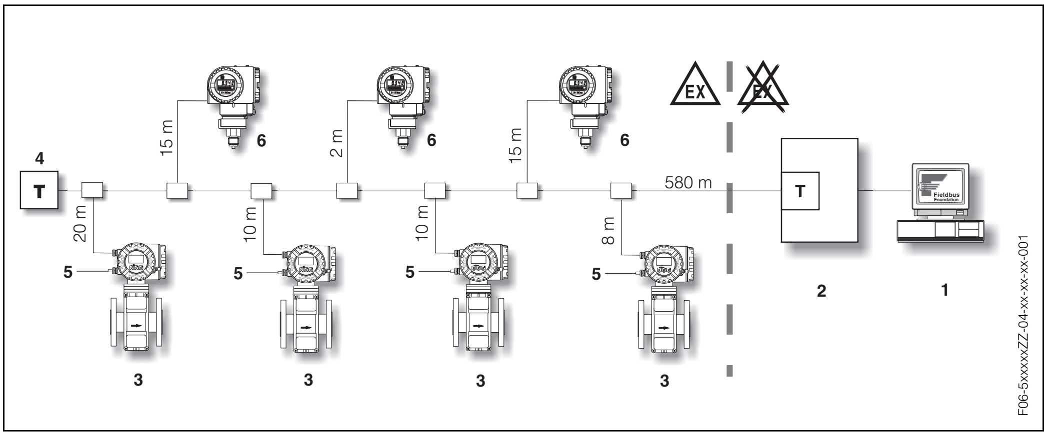


Fig. 9: Typical example of a bus connection with a fieldbus power supply Power Repeater KLD2-PR-Ex1.IEC1 (Pepperl+Fuchs)

1 = DCS with integrated FOUNDATION Fieldbus H1 interface card
2 = fieldbus power supply acc. FISCO model, Power Repeater KLD2-PR-Ex1.IEC1 (Pepperl+Fuchs)
3 = Promag 53 bus devices for hazardous area
4 = terminator (T) = bus termination
5 = transducer supply
6 = Cerabar S bus devices for hazardous area

Functional considerations

Using the following procedure the functional considerations checks whether the desired segment structure meets the basic requirements for transmission to the physical layer in IEC 61158-2.

Step 1 – compilation of the functional characteristic values of the fieldbus components

- Fieldbus power supply according FISCO model, Power Repeater KLD2-PR-Ex1.IEC1 (Pepperl+Fuchs):

U_S = 12.8 V (power supply voltage)
I_S = 100 mA (power supply current)

- Fieldbus line:

Cable type A
R_{WK} = 44 Ω/km (effective resistance per unit length)

- Fieldbus device Promag 53:

I_B = 12 mA (basic current)
U_B = 9...32 V (perm. operating voltage)
I_{FDE} = 0 mA (fault current)
$I_{startup}$ = 0 ($< I_B$)

- Fieldbus device Cerabar S:

I_B = 10.5 mA (basic current)
U_B = 9...32 V (perm. operating voltage)
I_{FDE} = 0 mA (fault current)
$I_{startup}$ = 0 (< I_B)

Step 2 – calculation of cable length and checking of network structure

An approved maximum length of 1000 meters has been set with the FISCO model for EEx ia IIC applications in order that the inductance and capacitance of the fieldbus cable can be ignored when used in hazardous area applications. This length comprises the length of the main cable and the total length of the drop cables together. In addition, it must be taken into account that the approved maximum length of a drop cable is 30 m.

Calculation of actual cable length L_{SEG}:

$$L_{SEG} = L_{main.} + \Sigma L_{spurs} = 580\text{ m} + 80\text{ m} = \underline{\underline{660\text{ m}}}$$

Checking the conditions:

Consideration	Condition met?
L_{SEG} < 1000 m 660 m < 1000 m	✓ Yes
L_{spurs} < 30 m	✓ Yes

If one of the conditions is not met then the network structure must be revised.

Step 3 – current calculation

The number of field devices that can be connected to the H1 segment depends on the fieldbus power supply selected (supply voltage and supply current) and the current consumption of the field devices. Thus, the number of devices that can be connected is reduced if a field device consumes a basic current of more than 10 mA, e.g. 20 mA. By adding up the basic currents I_B of the field devices plus the response current in the event of a fault I_{FDE} for the FDE (**F**ault **D**isconnect **E**lectronics) and the current for the data modulation I_{MOD} (+9 mA) you can determine the minimum supply current that the fieldbus power supply must supply.

If, on switching on the device, the startup $I_{startup}$ current is greater than the basic current, then the startup current must be taken into consideration in the calculation. The response current for the FDE (I_{FDE}) is calculated for each field device from the difference between the maximum current in the event of a fault and the basic current. The field device with the greatest response current is taken into consideration in the current balance sheet.

Provided that no more than one FDE responds, the following condition must be taken into consideration in the calculation of the segment current I_{SEG}:

$$I_{SEG} \leq I_S$$

where

$$I_{SEG} = \Sigma_{IB} + \max I_{FDE} + I_{MOD} + I_{startup}$$

In the example the calculation formula results in the following segment current consumption I_{SEG}, where $I_{FDE} = 0$, $I_{startup} = 0$, since the field devices used do not consume additional current in the event of a fault and the startup current is less than the bus current. In addition, the modulation current I_{MOD} for the installed bus power supply KLD2-PR-Ex1.IEC1 by Pepperl+Fuchs need not be considered since the value of the supply current I_S already includes this.

$$I_{SEG} = \Sigma I_B = \underline{\underline{79.5\ mA}}$$

Checking the conditions:

Consideration	Condition met?
$I_{SEG} \leq I_S$ 79.5 mA ≤ 100 mA	✓ Yes

Step 4 – Voltage at the last instrument

The cable resistance causes a segment voltage drop, which is largest at the instrument farthest away from the bus power supply. For this reason it must be ensured that the minimum operating voltage of 9 V is available at this instrument.
To make the overall considerations easier it is assumed that all the field devices FD (refer to Fig. 10) are connected at the end of the fieldbus line.

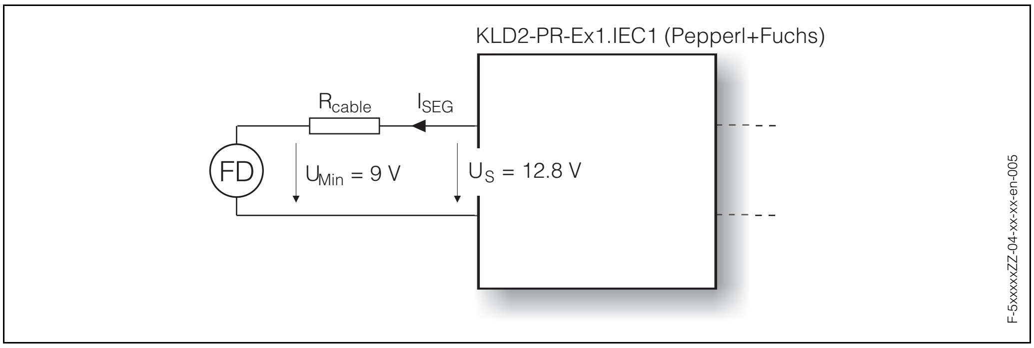


Fig. 10: Replacement circuit diagram

The resistance value R_{cable} must first be calculated in order to calculate the voltage drop caused by the fieldbus cable:

$$R_{cable} = R_{WK} \times L_{SEG} = 44\ \Omega/km \times 0.66\ km = \underline{\underline{29\ \Omega}}$$

Ohm's law is used to calculate the actual voltage $U_{FG\ eff.}$ at the last instrument:

$$U_{FG\ eff.} = U_S - (I_{SEG} \times R_{cable}) = 12.8\ V - (79.5\ mA \times 29\ \Omega) = 12.8\ V - 2.3\ V = \underline{\underline{10.5\ V}}$$

Checking the conditions:

Consideration	Condition met?
$U_{FG\ eff.} \geq 9$ V 10.5 V ≥ 9 V	✓ Yes

Final consideration:
From a purely functional point of view the bus segment shown in the example can be operated based on the positive results.

Technical safety considerations
using variant Promag 53***-***********G

Step 1 – compilation of technical values relevant to safety:

Fieldbus power supply (associated electrical apparatus)
FISCO Power Repeater KLD2-PR-Ex1.IEC1 (Pepperl+Fuchs):

- Nominal values:

U_o = 15 V
I_o = 207.2 mA
P_o = 1.93 W
Described in the test certificate as “associated equipment”. Suitable for connection to a fieldbus system based on the FISCO model.

Promag 53 (explosion protected electrical apparatus with intrinsically safe FF output):

- Nominal values:

U_i = 30 V
I_i = 500 mA
P_i = 5.5 W
L_i = 10 µH
C_i = 5 nF
Suitable for connection to a fieldbus system based on the FISCO model.

Cerabar S (explosion protected electrical apparatus with intrinsically safe FF output):

- Nominal values FISCO:

U_i = 17.5 V
I_i = 500 mA
P_i = 5.5 W
L_i = 10 µH
C_i = 5 nF
Suitable for connection to a fieldbus system based on the FISCO model.

Bus cable type A (shielded bus cable):

- Nominal values:

R’ = 24 Ω/km (loop resistance)
C’ = 82 nF/km (capacitance per unit length)
L’ = 623 µH/km (inductance per unit length)

Fieldbus connection KMD0-FT-Ex (Pepperl+Fuchs):

• Nominal values:
U_i = 24 V
I_i = 280 mA
P_i = 1.93 W
R = 100 Ω
C = 1 µF
Suitable for connection to a fieldbus system based on the FISCO model.

Step 2 – technical safety considerations acc. FISCO model

This step uses the existing data to check whether connecting the equipment is permissible from the point of view of technical safety. The conditions shown in the FISCO model apply to these safety considerations (see Page 13). First the functional data of the equipment used is compared. In this consideration it is crucial that the maximum output voltage and output current of the bus power supply does not exceed the permitted maximum input voltage and input current of the individual field devices. Here we consider possible error behaviour by the bus power supply that could result in the stated maximum values on the intrinsically safe sides.

Intrinsically safe equipment	Condition	Associated equipment FISCO Power Repeater KLD2-PR-Ex1.IEC1	Condition met?
Promag 53			
U_i = 30 V	≥	U_o = 15 V	✓ Yes
I_i = 500 mA	≥	I_o = 207.2 mA	✓ Yes
P_i = 5.5 W	≥	P_o = 1.93 W	✓ Yes
As a further condition galvanic isolation must be provided due to the local supply			✓ Yes
Cerabar S			
U_i = 17.5 V	≥	U_o = 15 V	✓ Yes
I_i = 500 mA	≥	I_o = 207.2 mA	✓ Yes
P_i = 5.5 W	≥	P_o = 1.93 W	✓ Yes
Fieldbus connection KMD0-FT-Ex			
U_i = 24 V	≥	U_o = 15 V	✓ Yes
I_i = 280 mA	≥	I_o = 207.2 mA	✓ Yes
P_i = 1.93 W	≥	P_o = 1.93 W	✓ Yes

Since all the users are permissible for explosion group IIC and the corresponding parameters have been taken into consideration, the bus segment can be used for gases in explosion group IIC.

The permissible ambient temperature may be considered either individually for each device at the respective place of installation, or specified uniformly for the bus segment as a whole. In the latter case the lowest value of the ambient temperature applies.

Required temperature class	Intrinsically safe equipment	Maximum ambient temperature
T6	Cerabar S	40 °C
T5	Promag 53	50 °C (at 80 °C medium temperature)

In the next step is the verification of whether the installed bus components fulfil the conditions and limit values set in the FISCO model. This is simplified by ensuring the bus components correspond to the FISCO model. A detailed consideration of the safety-relevant nominal values is then not necessary.

Do bus components correspond to the FISCO model?	Condition met?
Power Repeater KLD2-PR-Ex1.IEC1	✓ Yes
Promag 53	✓ Yes
Cerabar S	✓ Yes
Fieldbus connection KMD0-FT-Ex	✓ Yes

The following conditions have been applied to the bus cable and network structure:

Bus cable:

Values	Condition	Limits acc. FISCO model	Condition met?
R’	> <	15 Ω/km 150 Ω/km	
C’	> <	80 nF/km 200 nF/km	
L’	> <	400 µH/km 1000 µH/km	
Bus cable type A R’ = 24 Ω/km C’ = 82 nF/km L’ = 623 µH/km			✓ Yes

Network structure:

Consideration	Condition	Limits acc. FISCO model	Condition met?
Cable length including drop cables	≤	1000 m	
L_{SEG} = 660 m	≤	1000 m	✓ Yes
Drop cable length	≤	30 m	✓ Yes

Final consideration:
For the example shown, intrinsic safety according to the FISCO model can be proven.

Device identification

Promag 53 FOUNDATION Fieldbus transmitter and W/P/H sensor

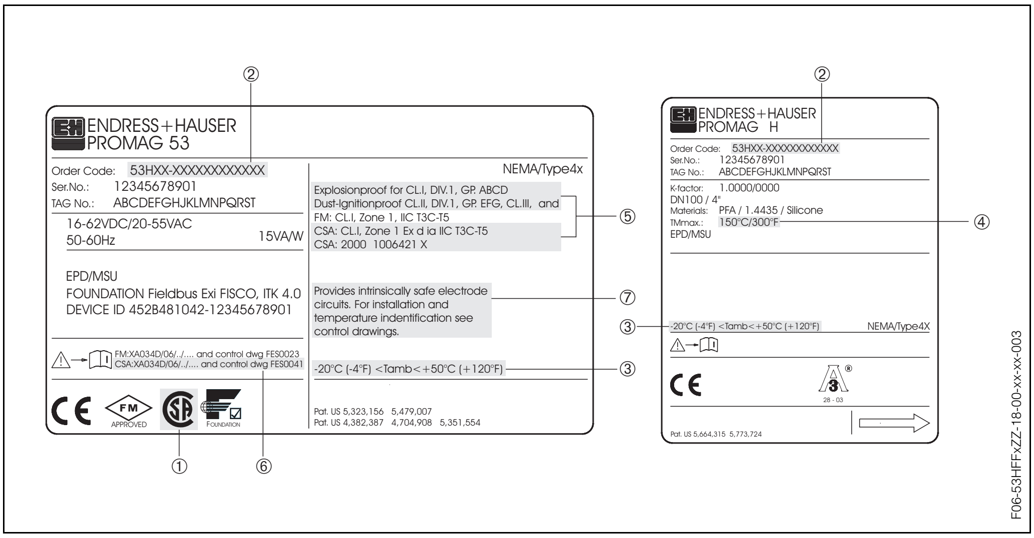


Fig. 11: Nameplate of transmitter and nameplate of sensor (example)

Key to nameplates (Figure 11)

No.	Meaning	No.	Meaning
①	Label of the notified body: Canadian Standards Association	⑤	Type of protection and explosion group for the Promag 53 FOUNDATION Fieldbus measuring system
②	Type code	⑥	Applicable Ex documentation
③	Ambient temperature range	⑦	Warning
④	Maximum medium temperature		

Control drawings

Endress+Hauser Reinach hereby declares that the product is in conformity with the requirements of the CADADIAN STANDARDS ASSOCIATION.

Hazardous Locations
Class I Division 1 Groups ABCD or Class I Zone 1 Groups IIC
and Class II and III Division 1 Groups EFG

PROMAG 5. W / P / H

Promag 5. W / P

Promag 5. H

Temperature table

Max. ambient temperature	Max. medium temperature depending temperature classes			
	T5	T4A	T4	T3C
50 °C / 122°F	50 °C / 122°F	110 °C / 230°F		
45 °C / 113°F	50 °C / 122°F	110 °C / 230°F	130 °C / 266°F	
40 °C / 104°F	50 °C / 122°F	110 °C / 230°F	130 °C / 266°F	150 °C / 302°F

Max. allowed medium temperature depending liner material

Liner material	Max. medium temperature
PU (polyurethan)	60 °C / 140°F
HG (hard rubber)	80 °C / 176 °F
PTFE	130 °C / 266°F
PFA	150 °C / 302°F

Communication Options	**Control Drawing**
I/O option = F,H,J	See FES 0041 – 0001
I/O option = G,K	See FES 0041 – 0002
I/O option = S,T	See FES 0041 – 0004

WARNING: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.

Notes:
1. Control room equipment shall not use or generate more than 250 V rms.
2. Caution: Use supply wires suitable for 5 °C above ambient temperature, but at least for 80 °C / 176°F.
3. Class II Group G: The surface temperature of the apparatus cannot exceed 165 °C / 329°F.
4. Install per Canadian Electrical Code

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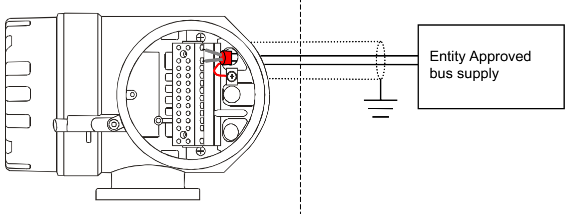
CSA Control Drawing Div. 1 / Zone 1 Class I Zone 1 PROMAG 5x compact version			
	Gezeichnet	03.12.01	MDI
	Geprüft		
	Ex-geprüft	03.12.01	MDI
	Gesehen		

Flowtec AG, Kaegenstrasse 7, CH-4153 Reinach BL1, Postfach

FES0041

HAZARDOUS LOCATIONS
Cl. I Div. 1 Groups A,B,C,D
Cl. I Zone 1 Group IIC
Cl. I Div. 2 Group A,B,C,D
Cl. I Zone 2 Group IIC
Cl. II, III Div. 1 Group E,F,G

NON HAZARDOUS LOCATIONS



Notes:

Intrinsically safe signal output:

1) Wire all intrinsically circuits per ISA RP 12.6. or in conduit per Canadian Electrical Code Part I
2) **WARNING**: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.
3) Control room equipment may not use or generate more than 250 Vrms.

PROMAG Type: 5**-***********G**

Terminals: 26, 27 (Foundation Fieldbus):
Iintrinsically safe circuit:

V_{max} / U_i	I_{max} / I_i	P_{max} / P_i	C_i	L_i
30 V	500 mA	5.5 W	≤ 5 nF	≤ 10 µH

Connect to entity approved associated apparatus with
I_{SC} or $I_O \leq$ Imax or I_i and
V_{OC} or $U_O \leq$ Vmax or U_i
($P_O \leq$ Pmax or P_i)
Cable parameters for Intrinsic Safety:
$C_{cable} \leq C_a / C_O - \Sigma C_i$
$L_{cable} \leq L_a / L_O - \Sigma L_i$ or
$L/R_{cable} \leq L/R_{Associated\ Apparatus}$ and Li of each I.S. apparatus ≤ 10 µH

Alternatively the intrinsically safe circuit (Fieldbus Foundation) can be connected according to the FISCO – Concept (see 0041-0003).

Nonintrinsically safe signal output:

4) Transmitter circuit wiring in accordance with Canadian Electrical Code.
5) **WARNING**: EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 1 OR CLASS I, ZONE 1.
6) Control room equipment may not use or generate over 250 Vrms.

PROMAG Type: 5****-***********K
Terminals 26,27 (FIELDBUS FOUNDATION NON I.S.)
V ≤ 32 V, I = 10 mA

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CSA Control Drawing Div. 1 / Zone 1 PROMAG 5. W / P / H Fieldbus Foundation I.S. installation			
	Gezeichnet	03.12.01	MDI
	Geprüft		
	Ex-geprüft	03.12.01	MDI
	Gesehen		

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FES0041 - 0002

FISCO CONCEPT

The FISCO Concept allows interconnection of intrinsically safe apparatus to associated apparatus not specially examined in such combination. The criteria for interconnection is that the voltage (Ui or V_{max}), the current (Ii or I_{max}), and the power (Pi or P_{max}) which intrinsically safe apparatus can receive and remain intrinsically safe, considering faults, must be equal or greater than the voltage (Uo or Voc), the current (Io or Isc) and the power (Po or P_{max}) levels which can be delivered by the associated apparatus, considering faults and applicable factors. In addition, the maximum unprotected capacitance (Ci) and inductance (Li) of each apparatus (other than the termination) connected to the fieldbus must be less than or equal to 5 nF and 10 µH respectively.

In each segment only one active device, normally the associated apparatus, is allowed to provide the necessary energy for the fieldbus system. The voltage Uo or Voc of the associated apparatus is limited to a range of 14V to 24Vd.c. All other equipment connected to the bus cable has to be passive, meaning that they are not allowed to provide energy to the system, except a leakage current of 50µA for each connected device. Separatly powered equipment needs a galvanic isolation to assure that the intrinsically safe fieldbus circuit remains passive.

The cable used to interconnect the devices needs to have the parameter in the following range:

Loop Resistance R' :	15...150 Ohm/km
Inductance per unit length L' :	0.4...1 mH/km
Capacitance per unit length C' :	80...200 nF

C' = C' line/line + 0.5 C' line/screen, if both lines are floating, or
C' = C' line/line + C' line/screen, if the screen is connected to one line

Length of trunk cable:	≤ 1000 m
Length of spur cable:	≤ 30 m
Length of splice:	≤ 1 m

At each end of the trunk cable an approved infallible line termination with following parameters is suitable:

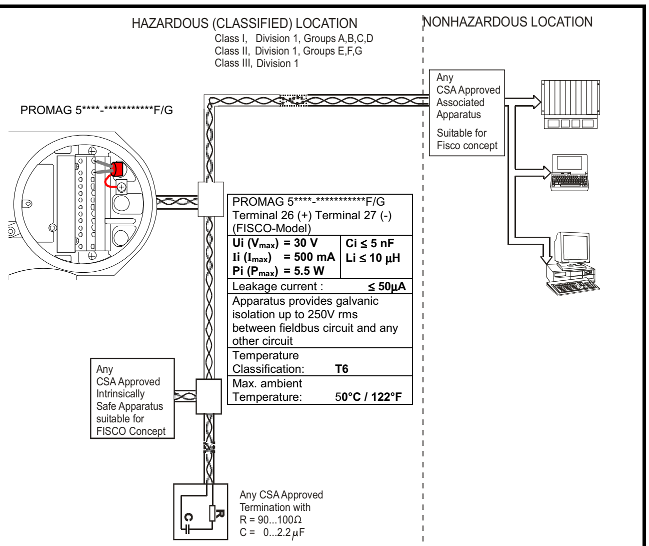
R = 90...100 Ohm C = 0...2.2 µF

One of the allowed terminations might already be integrated in the associated apparatus. The number of passive apparatus connected to the bus segment is not limited due to I. S. reasons. If the above rules are respected, up to a total lenght of 1000 m (sum of trunk and all spur cables), the inductance and the capacitance of the cable will not impair the intrinsic safety of the installation.

Notes:

Intrinsically safe Class I, Div.1, Groups A,B,C,D

1. Approved associated apparatus must be installed in accordance with manufacturers instructions.
2. CSA approved associated apparatus must meet the following parameters: Uo or Voc ≤ Ui (V_{max}) and Io or Isc ≤ Ii (I_{max}) and Po or P_{max} ≤ Pi (P_{max})
3. The maximum non-hazardous area voltage must not exceed 250V
4. The installation must be in accordance with the Canadian Electrical Code
5. Multiple earthing of screen is allowed only, if high integrity equipotential system is realized between the points of bonding (see drawing No. FES 0014).
6. Caution: Use only supply wires suitable for 5°C above surrounding temperature.
7. Warning : Substitution of components may impair intrinsic safety.
8. The polarity for connection PA+ (26) and PA- (27) is of no importance due to an internal rectifier.



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CSA Control Drawing Div. 1 / Zone 1 PROMAG 5. W / P / H Intrinsically safe PROFIBUS PA FISCO-Concept	Gezeichnet	03.12.01	MDI
	Geprüft		
	Ex-geprüft	03.12.01	MDI
	Gesehen		

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FES0041 - 0003

Supplementary documentation
TI 046D/06
TI 047D/06
TI 048D/06

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