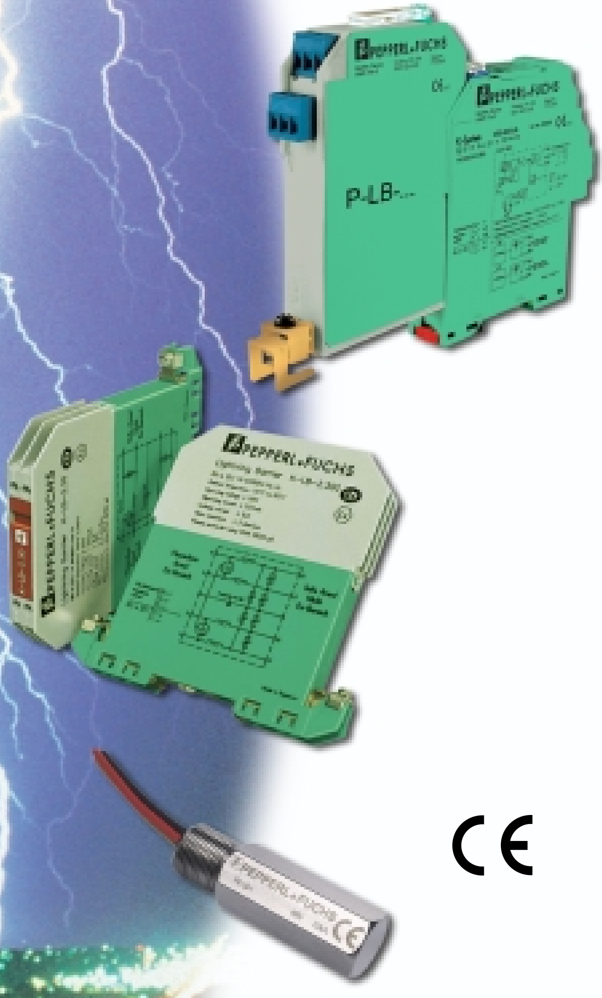
PROCESS AUTOMATION

MANUAL

SURGE PROTECTION BARRIERS



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With regard to the supply of products, the current issue of the following document is applicable:
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including the supplementary clause “Extended reservation of title”.

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Subject to reasonable modifications due to technical advances

1 Introduction

When Benjamin Franklin invented the lightning rod in 1752, he created the first protection against nature's most destructive force: lightning. More than 200 years later, lightning protections are designed to protect buildings, sensitive electrical systems and even lives.

In industrial organisations, the ever-increasing use of extremely sensitive computer controlled equipment makes inadequate attention to the destructive potential of lightning extremely expensive. Each year, millions of dollars are spent worldwide on damages due to lightning related causes.

Pepperl+Fuchs has been a world leader in intrinsic safety for over 30 years. Thousands of industries worldwide rely on Pepperl+Fuchs' components to transfer intrinsically safe signals. Pepperl+Fuchs' Surge Protection Barriers (SPBs) are a new addition to the process automation product range.

2 SPB product range overview

2.1 SPB for standard (non-hazardous) and Zener barrier (hazardous) applications

Field device (> 500 V isolated to earth)*	SPB for field device protection	SPB for PLC/DCS, Zener barrier protection	PLC/DCS, Zener barrier
Sensors, mechanical contacts Valves, LEDs, alarms	K-LB-1(2).30	K-LB-1(2).30G	Digital input Digital output
(SMART) transmitters (SMART) I/P converters, (SMART) positioners	K-LB-1(2).30 F*-LB-*	K-LB-1(2).30G	Analogue input Analogue output
RTDs, thermocouples, photocells	K-LB-1(2).6	K-LB-1(2).6G	Low voltage input

* *Field devices with a lower isolation voltage are protected via the non-isolated SPB: K-LB-*.*G. For further information, refer to Chapter 7.5.*

2.2 SPB for TIB (hazardous) applications

Field device (> 500 V isolated to earth)*	SPB for field device protection	SPB for TIB protection	TIB (> 500 V isolated to earth)*
Sensors, mechanical contacts Valves, LEDs, alarms	K-LB-1(2).30	K-LB-1(2).30	Digital input Digital output
(SMART) transmitters (SMART) I/P converters, (SMART) positioners	K-LB-1(2).30 F*-LB-*	K-LB-1(2).30	Analogue input Analogue output
RTDs, thermocouples, photocells	K-LB-1(2).6	K-LB-1(2).6	Low voltage input

* *Devices with a lower isolation voltage are protected via the non-isolated SPB: K-LB-*.*G. For further information, refer to Chapter 7.5.*

2.3 Snap-on for TIB applications

Snap-on	TIB types from Pepperl+Fuchs (further models upon request)	TIB function
P-LB-1.A	KF□□-SR2-/-ST2-Ex1* KFD2-CR-Ex1. □0200, KFD2-ST□1-/-ST □3-Ex1* KF□□-UFC-/-DWB-/-DU-/-PWC-(Ex)1*, KF□□-UFT-Ex2	Sensor input 2-wire current input Universal signal conditioners
P-LB-2.A	KF□□-SR2-/-ST2-Ex2* KFD2-ST □4-Ex2*	Sensor input 2-wire current/voltage input
P-LB-1.B	KFD □-SD-/-SL-/-SCD-/-CD-/-CC-/-CS-(Ex)1	Solenoid driver, Voltage/ Current repeater
P-LB-2.B	KFD□-SL2-/-CS-(Ex)2	Solenoid driver, Voltage/ Current repeater
P-LB-1.C	KF□□-FSU-/-IT-/-DW-Ex1* KFD2-CR-Ex1. □03□□, KF□□-CV-/-CRG-/-ST□4-(Ex)1* KFD0-T□ -(Ex)1	Universal signal conditioners 3-wire current/voltage input Temperature converter
P-LB-1.D	KFD2-UT-Ex1*	Temperature converter

*: *Types possibly with extensions*

2.4 Snap-on for RPI applications (Remote Process Interface)

Snap-on	Suitable for Pepperl+Fuchs RPI module	RPI function
P-LB-2.C	KSD2-BI-Ex2, KSD2-BO-Ex2*, KSD2-F1-(Ex)	Digital input, digital output, frequency converter
P-LB-1.E	KSD2-BO-Ex, KSD2-CO-(S)-(Ex)(H)	Digital output, current output
P-LB-1.C	KSD2-CI-S-(Ex)(H)	Current input
P-LB-2.D	KSD2-RO-(Ex)2, KSD2-C1-(Ex)2, KSD2-B1-(Ex)4*	Relay output, current input, digital input
P-LB-1.F	KSD2-TI-(Ex)	Temperature input
P-LB-1.B	KSD2-VI	Voltage input

*: *Types possibly with extensions*

2.5 Features

✓ For all measuring and control signals
✓ Suitable for mounting in the field and in the control room
✓ Sink of 10 kA (8/20 ms) in accordance to CCITT and IEC 60060-1 (Category C)
✓ Up to two channels in one housing
✓ Easy and fast installation
✓ Certified for IS loops, earth-free up to 500 V
✓ Self resetting and maintenance-free

Additional features of P-LB-...

✓ Space saving in the cabinet
✓ Less wiring
✓ Less cable trunks
✓ Less risk of errors
✓ Less installation time
✓ Safe, reliable connection
✓ Simple to apply

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3 Basic theory

3.1 Formation of lightning

- Separation of the electric charges in the cloud

During a storm, clouds become electrically charged and an electrically negative layer is formed at the bottom of the cloud. This negative charge causes the appearance of a positive electric charge on the surface of the ground below the cloud *(see Figure 1: Separation of the electric charges in the cloud).*

- Stepped leader

When the negatively-charged layer becomes strong enough to overcome air's resistance, electrons flow towards the ground in steps (approx. 10 meters per second) along a path of least resistance leaving a trail of ionised gas (the downward-flowing electrons collide with air molecules). This formation is called stepped leader. However this 'forked' path is not the actual lightning bolt that we see *(see Figure 2: Stepped leader).*

- Corona discharges

As the stepped leader approaches the earth, the positive charge on the ground's surface increases due to the ground electrons' repulsion. This positive charge called corona discharge moves up into the air through any conducting objects and reaches out for the approaching stepped leader. Until now the process is still invisible *(see Figure 3: Corona discharges).*

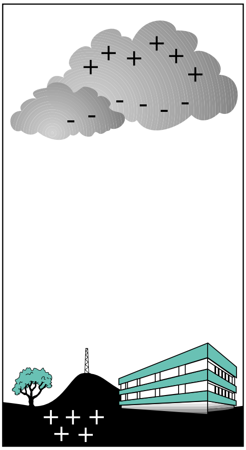

Figure 1: Separation of the electric charges in the cloud

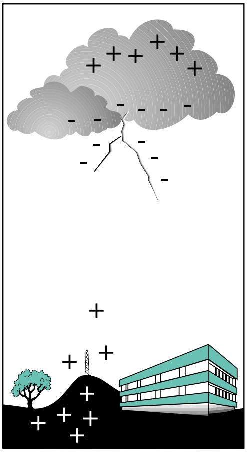

Figure 2: Stepped leader

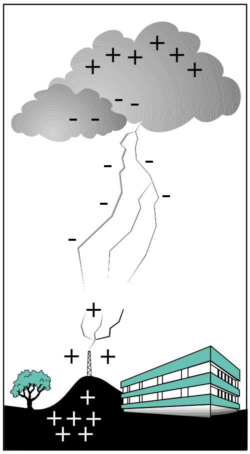

Figure 3: Corona discharges

- Arc channel

When the downward moving stepped leader connects with the corona discharge (of an altitude of around 100 meters), a continuous path between the cloud and the ground is formed (arc channel) and a powerful return strike is triggered. This extremely fast return strike (half the speed of light) progresses upwards from the ground to the cloud following the ionised trail of the stepped leader. The path as well as the 'branches' light up. This is the visible bright starting act of the lightning *(see Figure 4: Arc channel).*

- Dart leader

If the electric field in the cloud is still strong enough, the first return strike reaching the cloud generates a second discharge, which flows down the same path as the first return strike and forms a straight line. This phenomenon is called the dart leader. When this dart leader hits the ground, a second return strike is triggered. This activity is reproduced 3 or 4 times, sometimes even 20 times. The flash is usually not as bright as the first return strike but its repetition makes the lightning flash seem to flicker *(see Figure 5: Dart leader).*

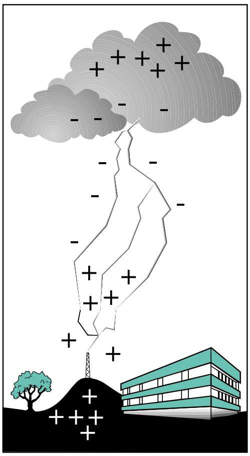

Figure 4: Arc channel

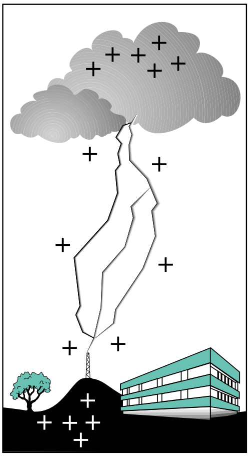

Figure 5: Dart leader

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3.2 Types of lightning

Lightning can occur in five ways: cloud-to-cloud, cloud-to-air, intra-cloud, cloud-to-ground and ground-to-cloud *(see Figure 6: Types of lightning).*

- Cloud-to-cloud (not very common).
- Cloud-to-air (not very common).
- Intra-cloud: Flashes are redistributing the charge within the cloud.
- Cloud-to-ground: These flashes are very common and are able to cause severe damages.
- Ground-to-cloud: These rare flashes originate from the ground, particularly from tall buildings.

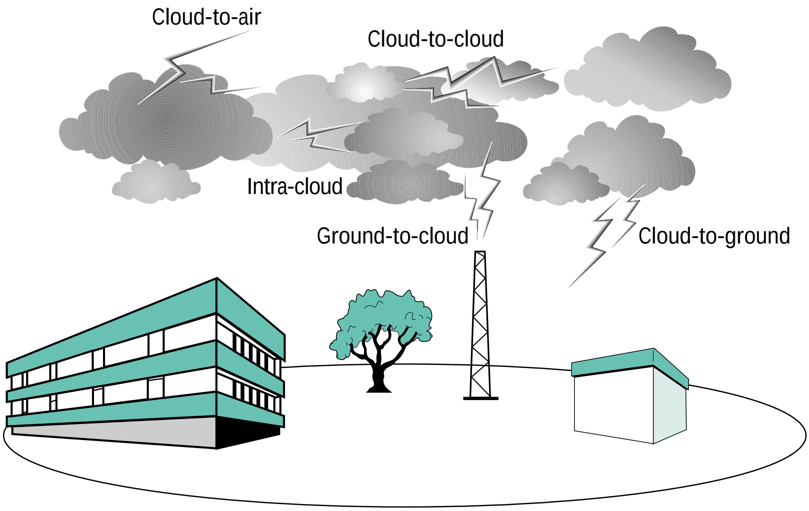

Figure 6: Types of lightning

3.3 Energy of a lightning strike

Power:	> 1 MW
Current (max):	up to 400 kA (200 kA accepted upper limit)
Current (rise time):	200 kA/µs
Current (average peak):	35 kA
Current (continuous):	93% of strikes are > 10 kA
Voltage (rise time):	12 kV/µs
Duration:	300 µs
Channel length:	5 km

The range of some of the above parameters can vary greatly.

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4 Impact of lightning

4.1 Damages

Lightning is the direct cause of losses exceeding hundreds of millions of dollars each year worldwide. Damages due to lightning include equipment loss, electronic component degradation, organisational disruption (data corruption, data loss), loss of operation as well as risk to personnel. This leads to tremendous costs, which include replacement of equipment, staff overtime, problem solving time, checking of security systems and recovery of lost or destroyed data. All of these ultimately lead to production delay and consequently customer dissatisfaction.

However, damages can be avoided if adequate protection against direct and indirect lightning effects on power or signal cables is installed. Direct strikes inject rapid-rising impulse currents of hundreds of kA into a structure. A portion of this power spike flows into the building through power and signal lines. The most common consequences of the damaging effect of direct strikes are resistive heating, arcing and burning. Even when lightning does not strike the structure directly, damages to equipment inside the building can occur. Due to coupling effects, lightning striking as far as 2-3 km away from the structure can still cause dangerously high transient voltages or surge currents on electrical systems.

Statistics show that indirect strikes are the main causes for damages, degradation or destruction of electrical systems. These damages are the direct consequences of the galvanic, inductive and capacitive coupling effects, described in Chapter 6.1.

4.2 Frequency of lightning

Professional weather observers are classifying the severity of convective activity using the frequency of thunderstorms. Globally, 2000 on-going thunderstorms cause approximately 10 billion flashes every year, which is about 100 lightning strikes to earth each second.

- Thunderstorms in the Asia-Pacific region

Number of thunderstorms per year in the Asia-Pacific region:

Indonesia	:	180 - 260
Malaysia	:	180 - 260
Singapore	:	160 - 220
China	:	100 - 160
Thailand	:	90 - 200
Philippines	:	90 - 140
India	:	50 - 150
Australia	:	5 - 80

The South East Asian region has the world's highest thunderstorm rate per year. Its proximity to the Equator results in a hot and humid climate all year around. These climatic conditions are favourable for the development of thunderclouds producing lightning.

Thunderstorms can occur throughout the year but they are most frequent during the North East Monsoons (April and May) and during the South West Monsoons (October and November). Over land, thunderstorms mainly develop in the afternoon and evening hours while over the sea, thunderstorms are more frequent at night.

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- Thunderstorms in America

Number of thunderstorms per year in the American continent:

Brazil	:	40 - 200
USA	:	20 - 100

The majority of lightning storms within the United States occurs within a 3-5 month span. Areas such as the Florida Peninsula, and the South Eastern plains of Colorado have the highest thunderstorm frequency in the United States.

In South America, countries closest to the Equator are the most prone to a high rate of severe thunderstorms.

- Thunderstorms in Europe

Number of thunderstorms per year in Europe:

Europe	:	5 - 50

The European continent has a low thunderstorm rate per year.

4.3 Zone concept

The international standard IEC 61312-1 defines a zone model to protect equipment against severe lightning damages *(see Figure 7: Zone concept)*. This model is used to control pulse parameters within each zone before passing them to the next zone. Surge protection devices are installed at each zone boundary, gradually reducing the pulse voltages and currents. Using the zone concept, direct lightning, indirect lightning and other effects like ESD (electrostatic discharges) can be reduced to acceptable levels. This decreases the risk of equipment damages.

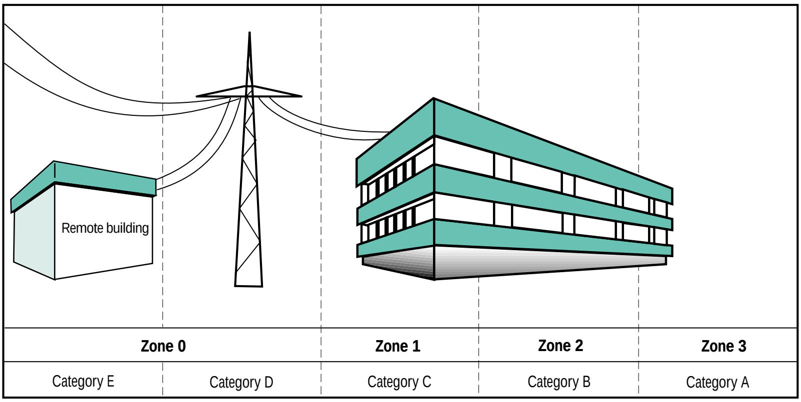

Figure 7: Zone concept

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- Zone 0 (Category D/E):

Zone 0 is found in rural or remote areas and includes cables' entries located outside the building. The typical surge current value is described by a 60 kA (10/350 µs) pulse. For further information regarding the surge current's waveform, refer to Chapter 8.4.

- Zone 1 (Category C):

Zone 1 locations also include the cables' entries outside the building but located in a less remote area. These points of entry can be the incoming main power supply cables, which are connected to the main power distribution panel. By placing a lightning protection device on each conductor, the incoming transient is reduced and is allowed to pass from Zone 0 to Zone 1.

For power lines the typical current pulse is lowered to 75 kA (10/350 µs), while a current pulse on signal lines is reduced to 10 kA (8/20 µs).

- Zone 2 (Category B):

Zone 2 locations are sub-circuits or circuits near the point of entry of power distribution systems and sub-distribution boards. Since some electrical equipment installed in Zone 2 are not able to withstand Zone 1 voltage or current pulses, an additional protection device called surge protection device is located on the border between Zone 1 and Zone 2.

For power lines the typical current pulse is reduced to 15 kA (8/20 µs), while a current pulse on signal lines is reduced to 3 kA (8/20 µs).

- Zone 3 (Category A):

Zone 3 locations are distributed circuits, power outlets and other circuits placed at a certain distance from the point of entry (more than 20 m to Zone 1). The ratings for the current pulses are similar to Zone 2.

Important: *Following the standards, an equipotential bonding network must exist between every zone crossover. In addition, shielded cables within the volume to be protected must be bonded at least at both ends and at the Lightning Protection Zone (LPZ) boundaries.*

5 Direct lightning protection

As our everyday lives become increasingly intertwined with electronic technology, it becomes more difficult to eliminate all the risk of lightning damages. Since lightning protection is necessary, a thorough analysis of the protection needs is required to determine the relative costs of providing protection against the probability of damages and the costs and consequences of such damages.

5.1 Direct strike

After a lightning strikes a structure, half of the total current will be discharged directly into the ground and the other half will choose a pass through the conductors or conduits of the building (power and signal lines or sewer, gas and water pipes) following the path of the lowest impedance. At the same time, a strong electromagnetic field builds up over these conductors.

For example, if a first strike has a current of 45 kA/µs and flows through a conductor with a typical inductance of 1 µH/m, the voltage will drop V = L x di/dt = 45 kV per meter. If a strike of 30 kA in 0.3 µs hits a conductor, the voltage drop will be 100 kV per meter. Therefore, after a lightning strike, extremely high potential voltages are expected between the lightning's point of entry and the earth point of the conductors.

Due to the direct link between cable conductors and other conduits (water, gas, or system pipes connected to the main earth) or to the potential of secondary lightning flashover, voltage potentials of these systems or structures can rise significantly.

The total voltage potential increase is calculated by adding the following voltages:

- The 'differential' voltage between two points of a conductor.
- The 'absolute' voltage to a common '0 V'-reference point.

To avoid dangerously high potential differences in adjacent structures or systems, a proper earth system must be installed as described in Chapter 7.

If the structure has inadequate direct lightning strike protection, the strike will hit any of the conductors inside the building. If one of the conductor's impedance is very high, the lightning will flashover to another conductor with a lower impedance. This secondary lightning flashover can generate an extreme temperature rise and often results in the meltdown of the conductor's insulation. In the worst case scenario, this will lead to fire.

Lightning does not need to directly strike a building to be dangerous. If lightning hits overhead power or signal cables that are linked to the building, most of the devastating current will travel to the ground as a result of the line-to-ground flashover effect. However, the remaining lightning surge current traveling along the conductors enters the building, and can damage connected electrical equipment.

5.2 Direct strike protection

Although 100% protection against lightning does not exist, to ensure the best possible level of protection against direct lightning the following four steps should be implemented:

- Step 1 ('catch' the lightning strike)

A few different direct lightning protection solutions exist. They include sharp (Franklin) rods, Faraday cages and air terminals. The air terminals are the latest technological

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development. They have a special shape designed to reproduce the effect of a natural upward streamer, which attracts lightning.

These external lightning protections have limitations, as there is always a possibility that lightning hits objects outside their zone of protection.

Important: *These solutions do not provide any protection against damages to electronic equipment resulting from indirect lightning effects.*

- Step 2 (downconductor)

With the installation of proper downconductors outside the building, the high current is safely diverted to the ground via a known path. These highly-insulated cables are designed to lower the occurrence of flashovers and other coupling effects by decreasing the intensity of the electromagnetic field.

- Step 3 (equipotential bonding)

By providing equipotential bonding between separated local grounds, the same potential level is ensured. If one of the local potentials is lifted up as a result of a lightning strike, the remaining will follow the rise and reach the same level almost instantly. The same concept applies to all metallic conductors entering the structure. This is why these conductors have to be bonded to the main earth system.

Important: *For the bonding, exothermic (welded) connections are recommended.*

- Step 4 (earthing)

A low ground impedance path (for the high frequency peak current) and a low resistance path (for the lower frequency component of the follow-on current) for the lightning current are essential to dissipate the lightning energy into the earth mass with minimal rise in the ground potential. When a lightning strikes conductors, the ground becomes the target of the flowing charge. Consequently, the lightning current should be guided downwards over the shortest possible distance without using conduits or electrical installation systems. To achieve this, the downconductor should be linked to a ‘stand-alone’ lightning ground rod. A ‘crow-foot’ radial rod is recommended to allow lightning to diverge easily. This rod must be connected to the equipotential bonding system of the entire building.

Important: *All earth connections must be as short as possible.*

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6 Indirect lightning protection

Since electromagnetic fields cannot be eliminated by direct lightning protection, internal lightning protection is necessary to lower the risk of devastating induced transient voltage and surge current pulses.

6.1 Coupling mechanisms

Lightning-induced transient voltages and surge currents are caused by various coupling mechanisms.

6.1.1 Galvanic coupling

Near a localised lightning strikes entry point, the current transferred through the ground increases the voltage potential in the area surrounding the strike. This voltage potential decreases exponentially from the strike point. For instance, when local ground structures without equipotential bonding are only a few meters apart, galvanically coupled high transient voltages can occur. If lightning strikes, the surge current prefers to flow through electrical interconnections between equipment located on separate grounds than through the less conductive soil *(see Figure 8: Galvanic coupling).*

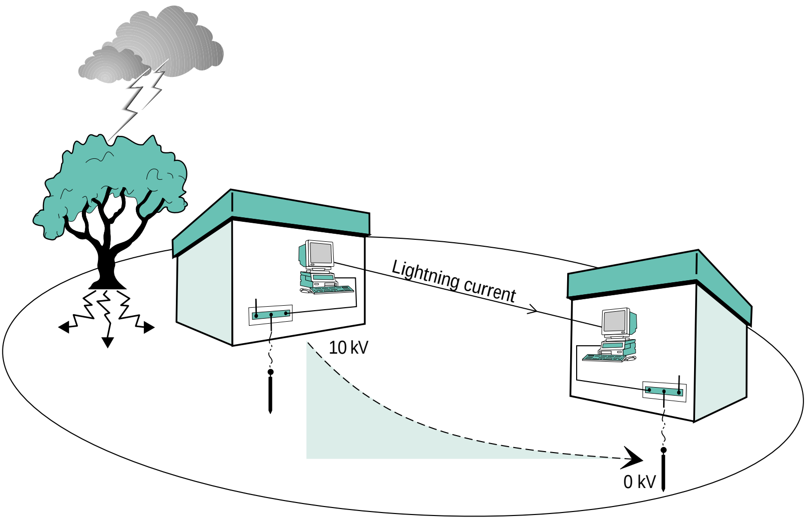

Figure 8: Galvanic coupling

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6.1.2 Inductive and capacitive coupling

Inductive and capacitive coupling can occur between two separate electrical conductors, when they are placed close to each other. The coupling takes place either over a mutual inductance or a coupling capacitance.

Current flowing through a conductor creates a magnetic and electrical field, which penetrates adjacent conductors *(see Figure 9: Inductive and capacitive coupling)*.

An alteration of the magnetic field causes an induced voltage on the adjacent conductor over the mutual inductance. This effect is called inductive coupling. An alteration of the electric field results in an equalised current to flow between the conductors through the coupling capacitance. This effect is called capacitive coupling.

Both coupling mechanisms are only applicable when current or voltage changes take place.

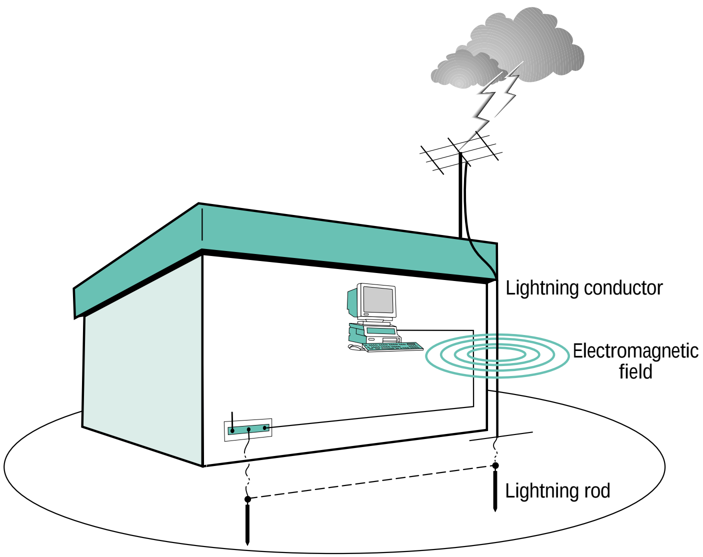

Figure 9: Inductive and capacitive coupling

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6.1.3 Electromagnetic coupling

In the case of electromagnetic coupling, the coupling is the result of electromagnetic wave transmission over empty space. The distance between the conductors is so large that the influence of the mutual inductance and coupling capacitance is negligible. The principle is comparable to receiving and transmitting signals over antennas. The lightning transmits an alternating electromagnetic field, which is captured by other conductors *(see Figure 10: Electromagnetic coupling).*

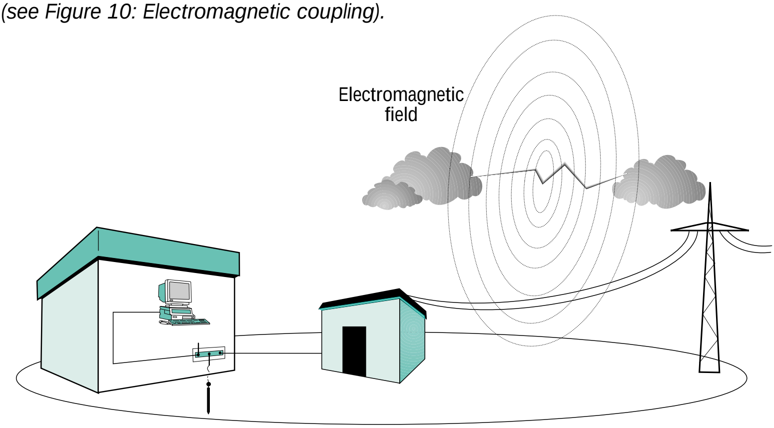

Figure 10: Electromagnetic coupling

6.2 Lightning protection for process plants

In today's industrial world, process plants are increasingly controlled by computerised systems. And the various power and signal cables entering and exiting a plant can influence each other. Conditions such as these can result in signals that can potentially damage electrical devices. In order to ensure a safe and uninterrupted process, a complete protection for all interconnected electrical equipment is necessary.

Various protection devices route surge currents to the local ground. To ensure an effective protection of the electrical equipment, the protection devices should be placed as close to the equipment as possible. This rule applies especially to the equipment responsible for the control of the main process. Any damages to this equipment would lead to breakdown times, resulting in production losses and unplanned costs. Damages to field devices installed in remote or high risk areas can also have disastrous consequences, since standard field devices are not designed to withstand lightning-induced transient voltages or surge currents. This is why proper surge protection for the remote field device should also be installed.

Since lightning-induced signals show pulse characteristics, standard circuit breakers or fuses are not able to sufficiently protect the electrical equipment. The Surge Protection Barrier (SPB) from Pepperl+Fuchs is the best solution possible. It can also be used for protection against other sources causing transient voltages like devices changing voltages or currents during switching events or exhibiting a non-linear behavior.

These other sources are energy storing inductive loads, such as transformers, motors and drives. They can induce high transient voltages and surge currents on conductors that can damage connected equipment.

Each electronic device in the loop should be protected with an SPB. The SPB is either installed on a separate mounting rail (if required in a field enclosure) or directly fitted (screwed) to the device.

Important: *The SPB is not able to withstand a direct lightning strike and will be damaged.*

6.2.1 Standard applications

A complete industrial or process plant comprises of various kinds of field devices and control room equipment. For instance, field devices can be used to measure physical variables and convert them into standardised electrical signals or vice versa. Standard field devices generally found in industrial processes include sensors, transmitters, RTDs, thermocouples, I/P converters and solenoid valves. These signals, used to measure, monitor or control process functions, are connected to indicators or I/O cards of PLC/ DCS systems, installed in the control room. In general, standard I/O cards handle digital input, digital output, analogue input and analogue output signals. The SPBs from Pepperl+Fuchs are specially designed for these signal types.

6.2.1.1 Analogue input signals

The illustration shows a standard (SMART) transmitter connected to an analogue input card of a PLC/DCS *(see Figure 11: Analogue input signals)*. In this situation the SPB protects the analogue input card. The most typical solution is to integrate the SPB into the electrical loop by locating it on a mounting rail in the control room close to the I/O card. The Pepperl+Fuchs SPB K-LB-1.30G should be used to protect the analogue input card since the circuit is rated 24 VDC at 4... 20 mA.

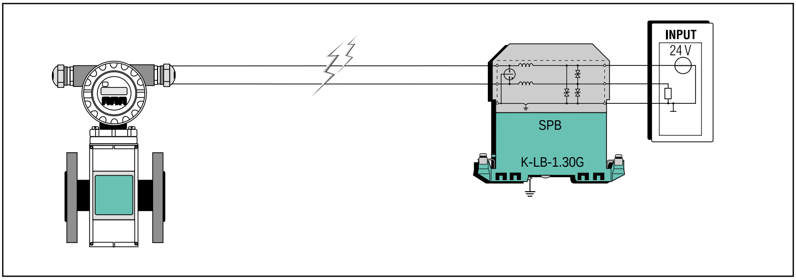

Figure 11: Analogue input signals

Important: *The supply voltage for the transmitter must be lower than the working voltage of the SPB to avoid leakage currents. The working voltage for the K-LB-1.30G is 30 V and is therefore suitable for this application.*

Protection should always be provided for field devices installed in remote or vulnerable areas, when they play a key role in the main process.

For the following applications, all the field devices are isolated > 500 V to earth. For the field devices with a lower isolation voltage, refer to Chapter 7.5.

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The SPB provides a preferential breakdown path between the signal lines (differential mode protection) and between the signal lines to earth (common mode protection). Any surge current will flow through this path rather than through the field device. Thus, damages are avoided.

Two options are available for the protection of the field device *(see Figure 12: Field device protection).*

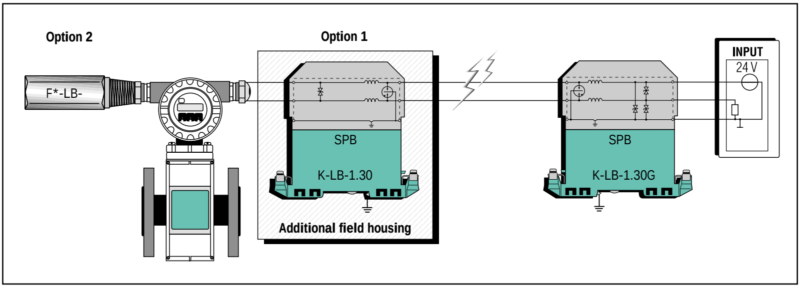

Figure 12: Field device protection

Option 1: The standard housing SPB K-LB-1.30 is located close to the field device. It should be placed within a field enclosure and mounted on a grounded rail. The SPB must be locally bonded to control the local potential between the signal cables and the structure.

Option 2: The screw-in SPB F*-LB-* is directly screwed to the field device. Its spare cable entry can be used for this purpose. Three wires are connected in parallel to the field device's signals and earth line (see also the installation guide, Chapter 9.5.2). This will ensure a line to line and line to earth protection. For the various screw-in types available, refer to Chapter 9.2.

6.2.1.2 Analogue output signals

For applications using analogue output signals (for example (SMART) I/P converters, and (SMART) positioners), the K-LB-1.30G should be integrated in the electrical loop to protect the analogue output card. The additional protection of the field device can be easily achieved by installing one of the two options described above (*see Figure 13: Analogue output signals).*

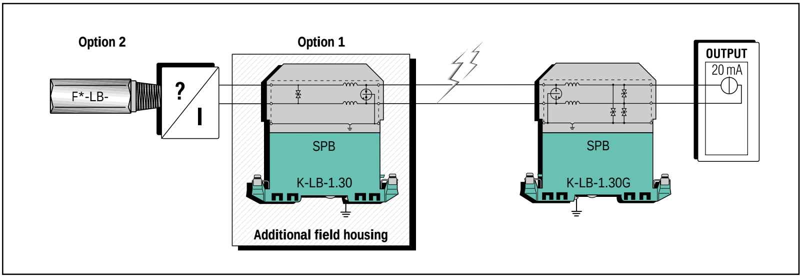

Figure 13: Analogue output signals

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6.2.1.3 *Low voltage analogue signals*

Some field devices generate particularly low analogue voltage signals. RTDs, thermocouples and photocells belong to this category. The suitable SPB for protecting the I/O card is the K-LB-1.6G with a 6 V working voltage *(see Figure 14: Low voltage analogue signals)*. For the additional protection in the field, the K-LB-1.6, placed in a field enclosure on a mounting rail, is located close to the device.

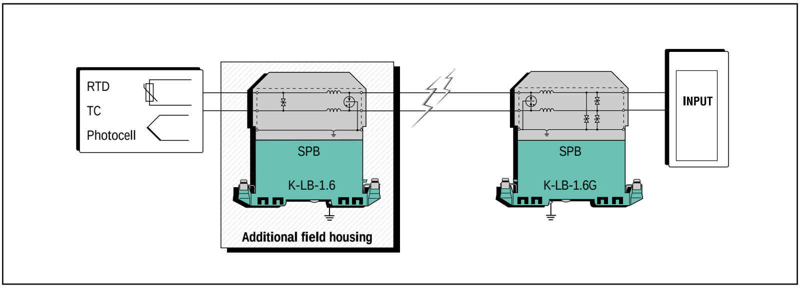

Figure 14: Low voltage analogue signals

6.2.1.4 *Digital input signals*

Proximity sensors or mechanical contacts are connected with the K-LB-1.30G to protect the digital input card. The device in the field can be protected by placing the K-LB-1.30 in a field enclosure on a mounting rail, close to the device *(see Figure 15: Digital input signals).*

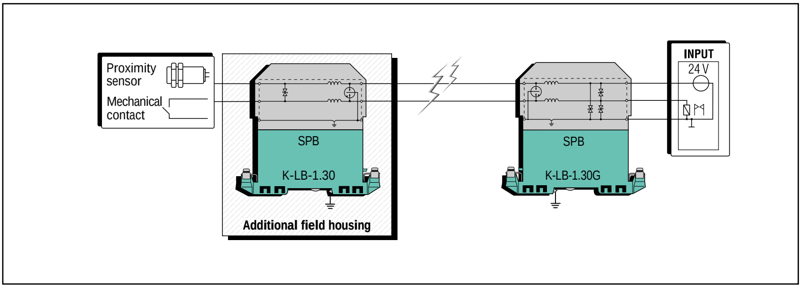

Figure 15: Digital input signals

6.2.1.5 Digital output signals

Solenoid valves, LEDs, alarms, etc. are triggered by digital output signals. For this type of application, the K-LB-1.30G should be integrated into the electrical loop to protect the digital output card. To protect the device in the field, the K-LB-1.30 should be placed on a mounting rail in a field enclosure close to the device *(see Figure 16: Digital output signals).*

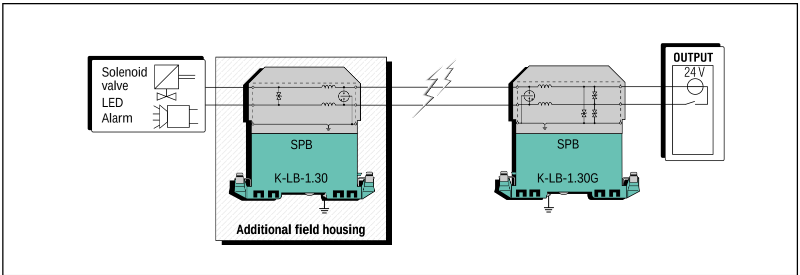

Figure 16: Digital output signals

6.2.2 Hazardous area applications

Explosive atmospheres are expected in hazardous areas and can be easily ignited if a high temperature or a spark is present. Under certain circumstances, lightning strikes are also able to ignite a gas and air mixture present in the hazardous area. Therefore appropriate safety precautions have to be taken. Protections should be used to shield remote equipment like storage tanks against lightning strike's flashover. A sufficient bonding method should also be applied between the remote equipment and the local remote earth creating links that will limit the impact of the lightning and therefore possible ignition.

Important: *The designation of Zone 0, 1 and 2 in the next several sections refers to the partition of hazardous areas regarding frequentness and duration of the presence of explosive atmosphere, according to IEC 60079-10. This should not be confused with the Zone classification discussed in Chapter 4.3, according to IEC 61312-1.*

6.2.2.1 The SPB as simple apparatus

Equipment installed in intrinsically safe loops must follow the standards described in EN 50020 (protection type EEx 'i', intrinsic safety). This equipment can only be included in intrinsically safe circuits and installed in hazardous areas if it is a certified intrinsically safe apparatus or a simple apparatus. Simple apparatus can be placed into hazardous areas with no additional third party certification.

Pepperl+Fuchs' SPBs contain gas discharge tubes, inductances and TVS diodes. They are classified as simple apparatus, because the inductance is the only energy-storing device and the line to line inductance is less than 200 µH.

However, the complete Pepperl+Fuchs' SPB product range has additional third party certifications allowing them to be installed in hazardous areas and to be included into intrinsically safe loops.

Important: *The SPB is not an intrinsically safe barrier on its own. Its basic purpose is the protection of the field device and the intrinsically safe barrier against damages caused by transient voltages and surge currents.*

6.2.2.2 Zone 1/Zone 2

For hazardous areas belonging to Zone 1 or Zone 2, it is rare to have a direct lightning or a lightning-induced voltage or surge current directly igniting the explosive atmosphere. The standard lightning pulse only exists for an extremely short period of time. Thus, the resulting heat or spark-energy is generally too low to ignite the explosive atmosphere in these areas. However, danger exists when transient voltages or surge currents induced by lightning strikes damage the devices installed in the hazardous area or in the control room.

Electrical loops in hazardous areas can be designed in accordance to the explosion protection type EEx ‘i’, intrinsic safety. These intrinsically safe loops consist of an integrated intrinsically safe barrier installed between the field device and the control equipment. This intrinsically safe barrier and the field device have a high risk to be damaged by induced surges produced by a lightning strike or other sources. Therefore, an SPB protection for both devices is necessary since faulty instrumentation can put the entire plant at risk.

Placing one SPB in the hazardous area close to the field device and one in the safe area close to the intrinsically safe barrier (separately located on a mounting rail) completes the full loop protection for hazardous areas applications.

Important: *A minimum distance of separation of at least 50 mm must exist between the hazardous and safe areas’ wires. When connecting SPBs, the relevant standards for explosion protection (e.g. EN 50020, IEC 60079-14) must be taken into account.*

6.2.2.3 Zone 0

An explosive atmosphere is always present in Zone 0. This is why, compared to Zone 1 and Zone 2, a higher level of safety precaution should be implemented.

Zone 0 is most frequently found inside tanks and process vessels. Their shape and bonding form a type of “Faraday” cage eliminating any significant potential differences. However, an over-voltage and resulting spark in any of the attached field devices can disrupt this protection and ignite the explosive atmosphere. An additional SPB installed to protect the field device in the hazardous area can eliminate this risk.

Important: *The SPB must be located as close to the field device as possible, but outside Zone 0.*

6.2.2.4 Application example with Zener barriers

In this example again a (SMART) transmitter is used. This 2-wire intrinsically safe 4…20 mA level transmitter is attached to a tank, partially operated within Zone 0 area (see Figure 17: Ex application with Zener barrier).

The intrinsic safety of the electrical loop is ensured by the Zener barrier. For the protection of the transmitter the two options described in chapter 6.2.1.1 can be used.

Important: *Since isolation between intrinsic safe circuits and earthed equipment must withstand a minimum of 500 V, the types K-LB-*.*G can’t be used to protect the field instrument; see chapter 7.7.*

For the protection of the Zener barrier in the control room a SPB K-LB-1.30G is used.

SPB type K-LB-1.6(G) can be used with low voltage analogue signals, with nominal operating voltage of less than 6V.

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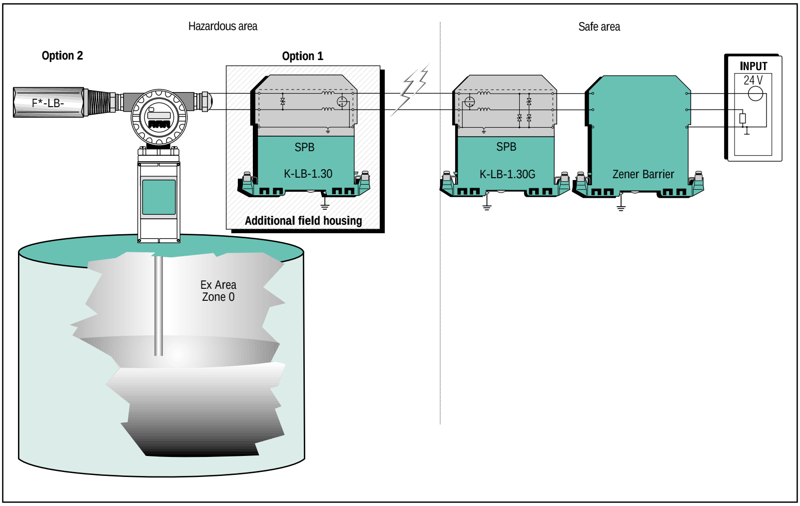

Figure 17: Ex application with Zener barrier

6.2.2.5 *Application example with K-System TIB (Transformer Isolated Barrier) or RPI (Remote Process Interface)*

The application with TIBs or modules of the Pepperl+Fuchs RPI product family is different from the Zener application in two ways:

- For the protection of the transmitter and the TIB, two isolated SPBs are integrated into the intrinsically safe loop (see Figure 18a: Ex application with TIB or RPI, K-LB-* SPBs). The main advantage of this isolated SPB solution is that the entire galvanically isolated measurement loop is isolated 500 V from earth, which is in accordance to the intrinsically safe (IS) Entity concept.
- For most TIBs and the modules of the RPI product family, Pepperl+Fuchs offers the new space saving P-LB-*.* family of surge protection barriers. Contrary to the K-LB types which are mounted on a separate DIN rail, the P-LB SPB is simply snapped-on to the TIB or RPI modules and fixed with a screw on an earth rail (see Figure 18b: Ex application with TIB or RPI, Snap-on SPBs).

To protect the transmitter, again the two options described in chapter 6.2.1.1 can be used.

Using P-LB SPBs has the following advantages:

- Space saving in the cabinet
- Less wiring
- Less cable trunks
- Less risk of errors
- Less installation time
- Safe, reliable connection
- Simple to apply

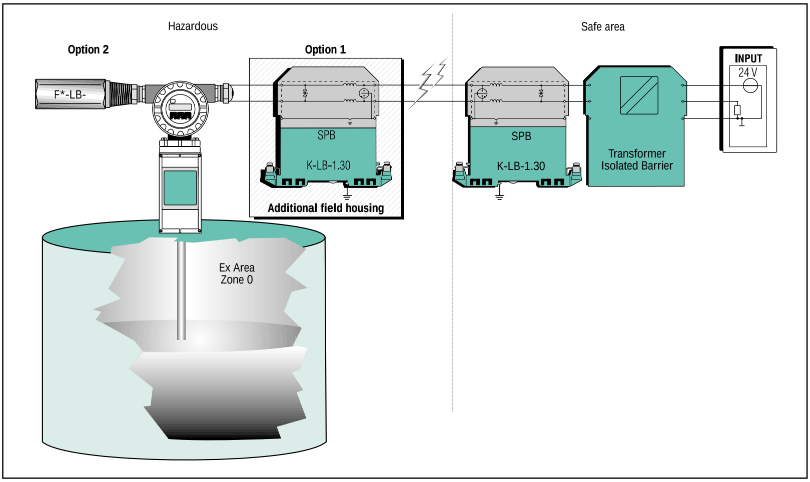

Figure 18a: Ex application with TIB or RPI, K-LB- SPBs*

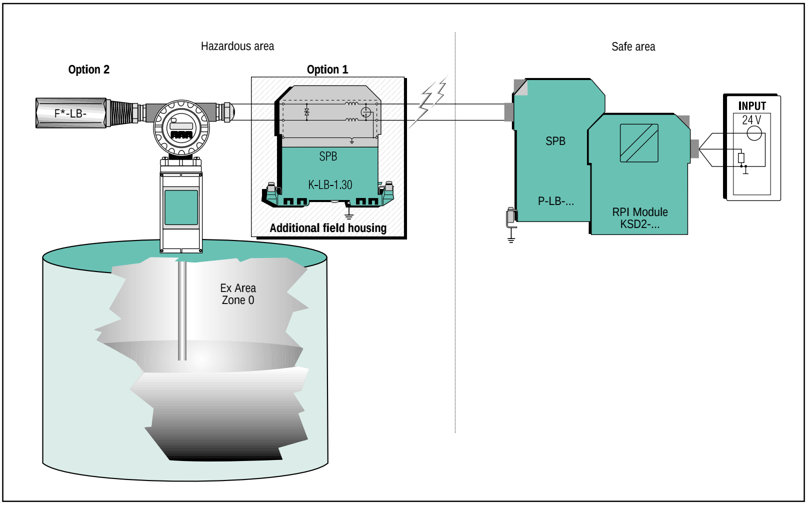

Figure 18b: Ex application with TIB or RPI, Snap-on SPBs

To protect a TIB or RPI module the P-LB type SPB is directly plugged into it. As the terminal connections vary from module to module, Pepperl+Fuchs offers different types of P-LB to match each module.

A detailed list of available SPBs is provided in chapter 9.

7 Earthing

Earthing connections between all the various electrical equipment and the bonding to the mechanical structures are critical points to consider when designing a plant system. Each country has its own rules and regulations but in general the earthing should be arranged in such a way that all the different local earth connections are at the same potential (at least under faulty conditions) and earth loops avoided.

Important: *In the following chapters, the term 'ground' represents the planet's surface while the 0 Volt reference for the electrical system is called 'earth'.*

For electrical equipment installed in cabinets, the busbar, located at the bottom, is usually the common earth reference point. This busbar is linked over the main earth to the plant system earth.

Local remote earth reference points are established by placing various types of earth rods into the local ground. Adequate earthing is necessary to ensure electrical safety and reduce electrical noises as well as eliminating earth loops.

After a lightning strike, extremely high current pulses pass through all types of cables. Therefore, the proper path to the ground will decrease the danger of damages to the electrical equipment. Without several important rules regarding earth connections, even the best lightning protection device for electrical equipment will be ineffective.

7.1 The star point earth connection

Galvanic couplings can be suppressed by connecting the electrical equipment to the system earth using one cable path for each electrical circuit. This method, called star-point connection, ensures that the potential of all connected equipment is at the same level as the earth potential at all times *(see Figure 19: The star point earth connection)*. However, the amount and length of cable used in this method increases the capacitive and inductive coupling effects.

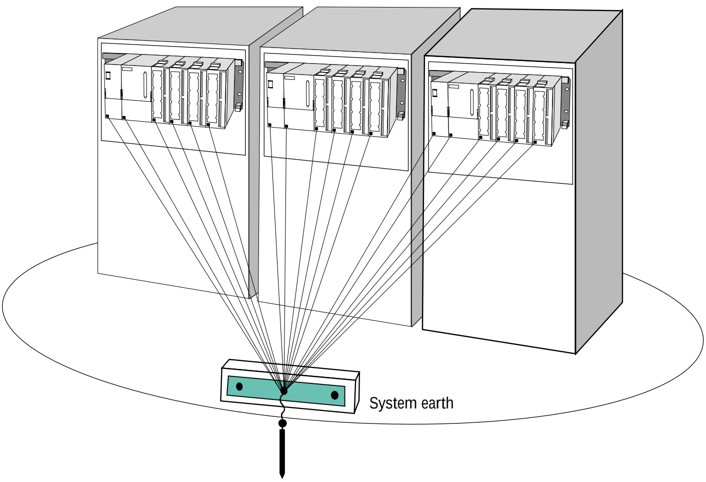

Figure 19: The star point earth connection

A more practical solution would be to build various hierarchy levels into the system and set-up a star point structure at every level *(see Figure 20: The practical star point earth connection).*

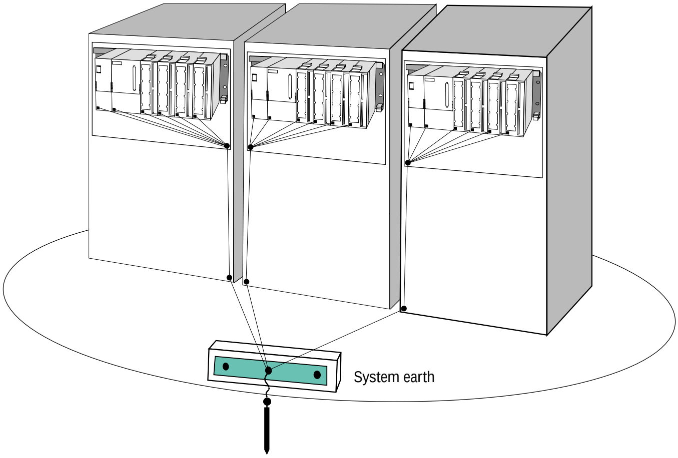

Figure 20: The practical star point earth connection

7.2 Surge Protection Barriers (SPBs)

The SPB integrated into the system will not change the general philosophy of proper earthing.

Establishing separate grounds for the SPB and the protected equipment should be avoided *(see Figure 21: Separated SPB and equipment earth connection).*

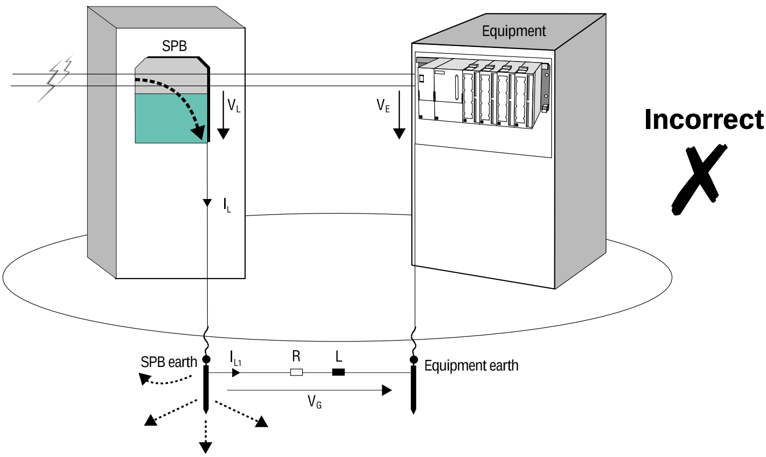

Figure 21: Separated SPB and equipment earth connection

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After the SPB diverts the surge current to the ground, a portion of it (I_{L1}), for example 200 A, flows radially from the earth rod through the ground to the equipment earth. The soil impedance is approximately 10 Ohm per meter. The voltage V_G developed across 1 m of ground will be 2000 V. The SPB K-LB-*.30* is restricting the voltage V_L across the SPB to 45 V, therefore the equipment at 1 m to the SPB must be able to withstand the resulting voltage $V_E = V_L + V_G = 2045$ V. In general, the equipment is not able to withstand this voltage and damages occur. This is why the system should be in accordance to the above mentioned star point connection *(see Figure 22: SPB star point earth connection).*

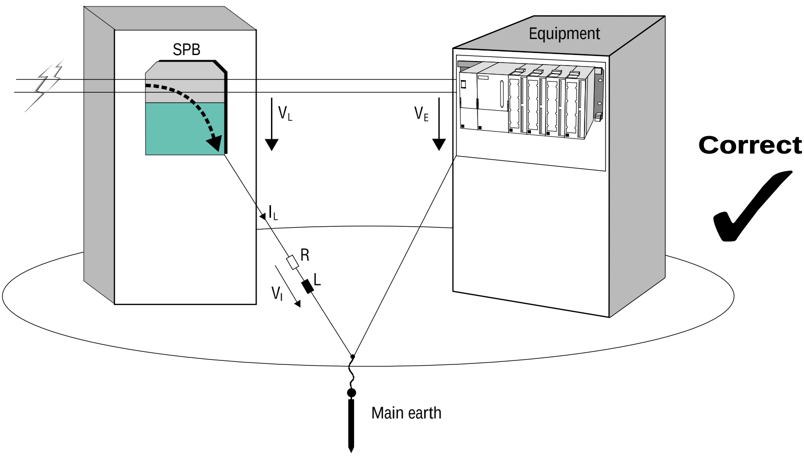

Figure 22: SPB star point earth connection

However, while applying this system, the impedance of the earth cables must be taken into consideration.
The SPB diverts the high surge current to ground. This develops a transient voltage V_I over the cable between the SPB earth connection point and the system earth star point due to its impedance. The equipment is subjected to the voltage $V_E = V_I + V_L$, the transient voltage V_I added to the SPB's clamping voltage V_L. If V_E reaches critical values, the equipment can be damaged.

The impedance of a cable is the sum of the resistance R and the complex inductive reactance jwL. The voltage drop over the cable is calculated by $V_I = R \times I_L + L \times di_L/dt$. Since lightning-induced surges show pulse characteristics, the inductance L is more relevant than the resistance R. To keep the transient voltage V_I to a minimum, the inductance should be as low as possible. This can be achieved by using very short earth cables (recommended less than 1 m) connected to the main earth busbar with a minimum conductor cross section of either 4 mm^2 (for copper cable, at least one conductor) or 1.5 mm^2 (for copper cable, at least two separated conductors).

To maximise the safety, the contact made between the main earth busbar and the earth cable has to follow general earthing connection standards. First, the possibility of rising contact resistance due to corrosion, greasy film layers, etc. should be avoided. Secondly, it is advisable to use flat cable conductors because of their lower impedance compared to the equivalent round cable types.

7.3 Main control station

If the proper earth connections have been established in a control room, electrical safety, intrinsic safety (for hazardous area applications) and electrical noise reduction are ensured *(see Figure 23: Main control station).*

The shielded lightning downconductor is directly bonded to the lightning earth rod and the building's structure. Over an equipotential bonding network the lightning system earth is linked to the main system earth. The incoming power supply is protected by a

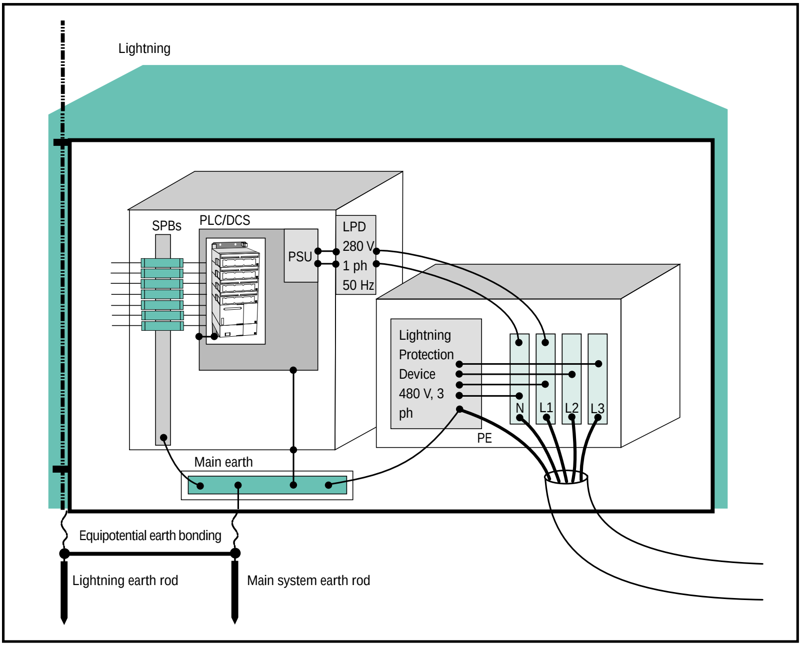

Figure 23: Main control station

power distribution protection system. The main earth busbar, being the reference point, is bonded to the main system earth and connected to the device's earth cables inside the building. This design follows the star point connection method.

Important: *For an adequate electrical equipment protection, both, the surge protection barriers (SPBs) for signal lines and the lightning protection devices (LPDs) for power supply lines have to be installed.*

The SPBs are placed on a mounting rail and their earth connection is directly linked to the main earth busbar as well as the process system equipment earth.

Important: *The connection of the relevant earth cables to the main earth busbar needs to be as short as possible.*

7.4 Installation of SPBs

The correct installation of the SPB is very important. It must be assured that the unprotected wiring does not influence the wiring on the protected side. Proper cable routing should ensure a sufficient cable distance between wires of the unprotected, earth connected and protected side *(see Figure 24: Wiring)*.

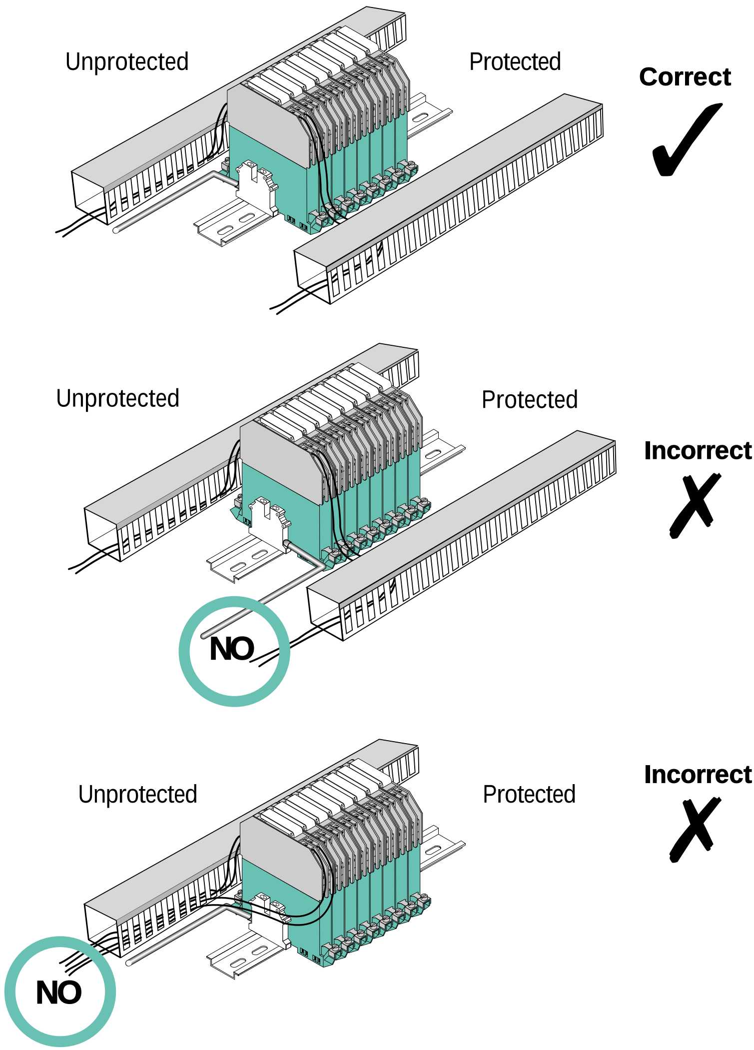

Figure 24: Wiring

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7.5 SPB types

Pepperl+Fuchs' SPB range includes two types of SPBs: the non-isolated and the isolated SPB.

- Non-isolated type, K-LB-*.*G (standard housing)

The breakdown voltage (line to earth) for the non-isolated type is 90 V. This type is usually used for applications where the protected equipment is not isolated from earth (e.g. standard I/O cards, Zener barriers).

The 'G' in the identification code and the grey top easily identify this non-isolated SPB.

- Isolated type, K-LB-*.* (standard housing), F*-LB-* (screw-in), P-LB-*.*(Snap-on)

The breakdown voltage for the isolated SPB type is 500 V. This type is used to protect electrical equipment, which is isolated at least 500 V from earth. The screw-in and Snap-on SPBs are always isolated types. Since most field instruments are isolated at least 500 V from earth they should be protected by isolated SPBs. This includes applications involving Transformers Isolated Barriers (TIBs) and intrinsically safe field devices.

The red top of the standard housing SPB identifies the isolated type.

For the different colour codes, refer to Chapter 9.1.

7.6 Remote process areas

Remote stations are usually provided with local ground rods (*see Figure 25: Remote process areas).*

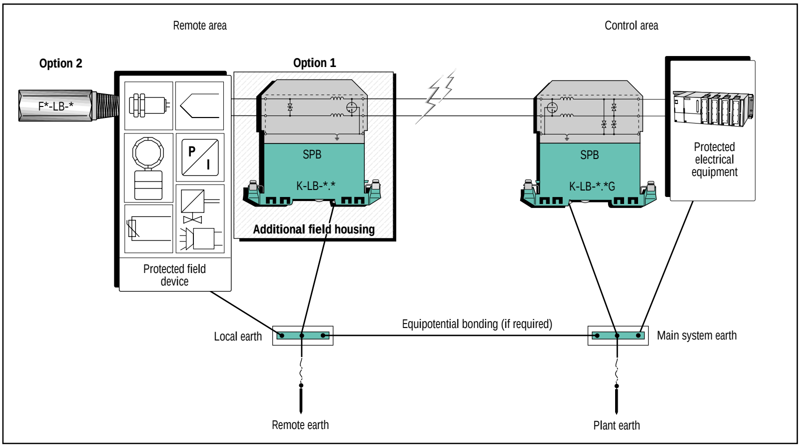

Figure 25: Remote process areas

Equipotential bonding regulations differ from country to country and from industry to industry. Some allow multiple earth systems while others specify that an equipotential bonding network between the main plant earth and the local earth should be established. When establishing an equipotential bonding, minimum cross sections for various bonding materials have to be followed:

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- 10 mm² for copper
- 16 mm² for aluminium
- 50 mm² for steel

If the SPB is placed in the remote site, it will protect electrical equipment located in these areas. It can be either placed on a grounded mounting rail in a field enclosure, or screwed to the field device. Since for these standard applications the field devices are isolated at least 500 V from earth, they should be protected via the isolated SPB.

In a cabinet, the SPBs are placed on a separate mounting rail. Generally, the earth connections of 16 SPBs are grouped at one point via a group terminal clamp and linked directly to the cabinet's earth busbar. These earth connections should be laid on the unprotected side of the SPB. The shield of the incoming multicore cable should be properly bonded directly to the cabinet's earth busbar *(see Figure 26: Cabinet layout for standard applications).*

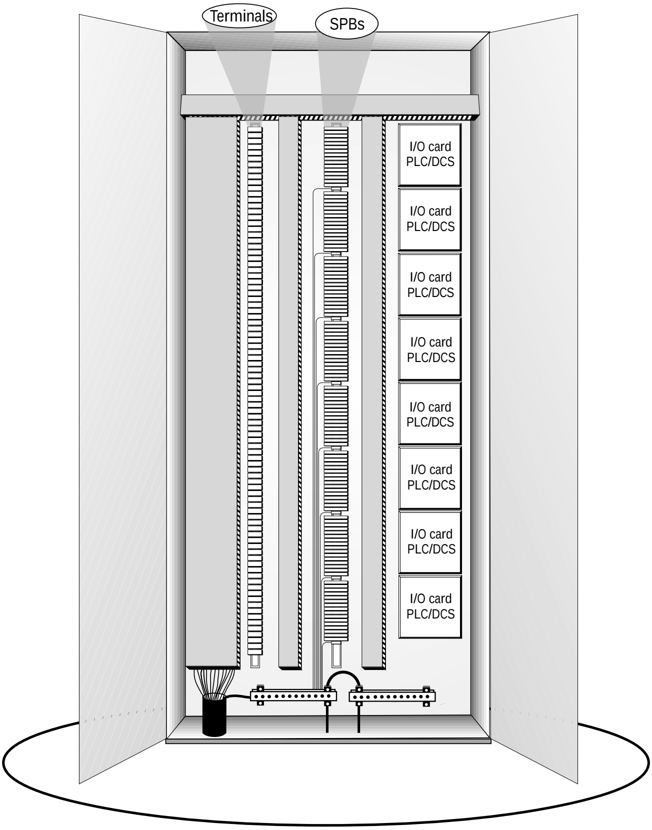

Figure 26: Cabinet layout for standard applications

When mounting several SPBs adjacent to one another, it must be assured that the wires of the protected side are clearly separated from the wires of the unprotected side *(see Figure 27: Positioning of adjacent SPBs).*

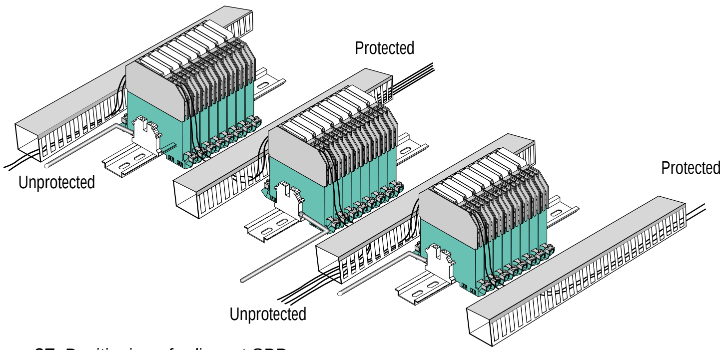

Figure 27: Positioning of adjacent SPBs

7.7 Hazardous areas

To protect the electrical equipment in both the control room and the hazardous area, two SPBs must be integrated into the intrinsically safe circuit loop. Following the international standard EN 60079-14 standard, intrinsically safe circuits can be either connected "at one point to the equipotential bonding system if this exists over the whole area in which the intrinsically safe circuits are installed" or "isolated from earth".

International Standard EN 60079-14:1997 states "if intrinsically safe apparatus (field devices, SPBs and intrinsically safe barriers) do not withstand the electrical strength test with at least 500 V from earth, a connection to earth at the apparatus is to be assumed".

7.7.1 One point earth connection

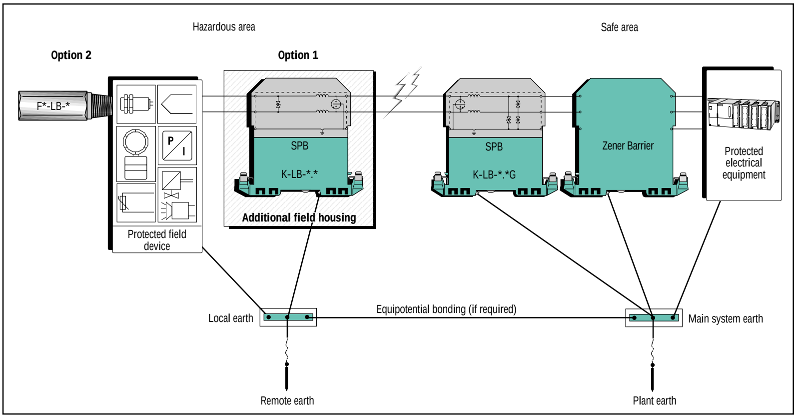

Figure 28: One point earth connection

The intrinsically safe circuit is connected at one point to the equipotential bonding system or to a high-integrity earth point. The intrinsically safe barrier is a shunt (Zener) diode type, without galvanic isolation. Following intrinsically safe standards, an appropriate earth link must be established between the Zener barrier and the main power system earth and the total cable resistance of the Zener barrier earth connection must not exceed 1 Ohm. To protect the Zener barrier, a non-isolated, separately mounted SPB must be installed and connected to the intrinsically safe side of the Zener barrier. The SPB's earth connection is made, following the described guidelines, to the main system earth in parallel to the equipment and Zener barrier earth cable.

Important: *Since the non-isolated SPB and the Zener barrier earth connection establish the maximum allowed 'one point' link to the earth system, an isolated SPB must protect the intrinsically safe field device.*

7.7.2 The galvanically isolated measurement loop

The entire intrinsically safe circuit is isolated from earth *(see Figure 29: The galvanically isolated measurement loop).* The intrinsically safe barrier is a galvanically isolated Transformer Isolated Barrier (TIB) and no connection to the main system earth is necessary. To maintain the intrinsically safe measurement loop galvanically isolated from earth, an isolated SPB must be installed at both ends of the loop. This must be close to the TIB, connected to its intrinsically safe side, in the safe area and close to the field device in the hazardous area, but outside Zone 0.

The isolated SPB's earth connection is linked directly to the main system and local earth, parallel to the equipment and the field device's earth cable.

The combination of using TIBs with isolated SPBs is in accordance to the IS entity concept and maintains all the benefits of a galvanically isolated control and measurement loop.

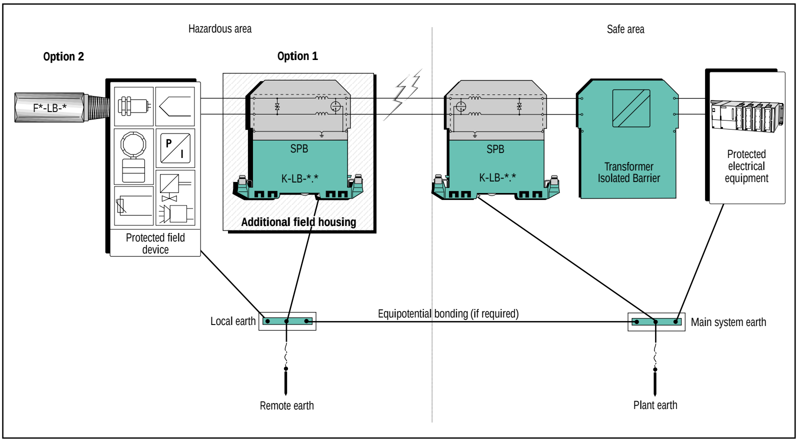

Figure 29: The galvanically isolated measurement loop

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For the intrinsically safe (IS) cabinet layout, the isolated SPBs are placed on a mounting rail. The earth connections of the group of 16 SPBs are directly linked over group terminal clamps to the cabinet's earth busbar. The shield of the incoming multicore cable is bonded directly to the cabinet's busbar *(see Figure 30: Cabinet layout EEx 'i' applications).*

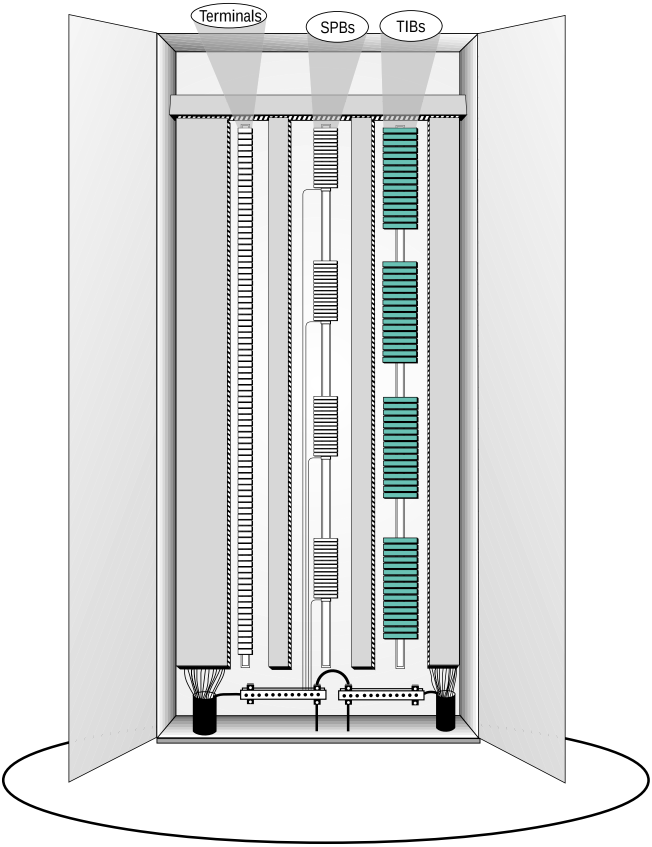

Figure 30: Cabinet layout EEx 'i' applications

Important: *To ensure the minimum required distance between hazardous and safe area circuits, which is 50 mm, the SPBs and the intrinsically safe (IS) barriers (Zener barriers or TIBs) should be placed on separate mounting rails, as shown in the cabinet layout.*

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7.8 Cable shielding

For low frequency signal lines, shielded twisted pair (STP) cables are preferred in order to avoid stray electric fields' influences. Including SPBs into the electrical loop does not change the general cable shielding rules *(see Figure 31: Cable shielding).* Following the International Standard IEC 61312-1: "where shielded cables within the volume to be protected are used, their shields shall be bonded at least at both ends, as well as at the LPZ (Lightning Protection Zone) boundaries", a shielded cable between the SPBs should be connected to earth at both ends. As an option, a shielded cable between the SPB and the equipment to be protected can be used. This 'surge link' must be connected to earth at both ends. In this case, to avoid the creation of earth loops, the SPB's earth cable should be laid as close as possible to the 'surge link'.

For hazardous area applications, the cable shield is preferably connected to earth only at one end between two SPBs.

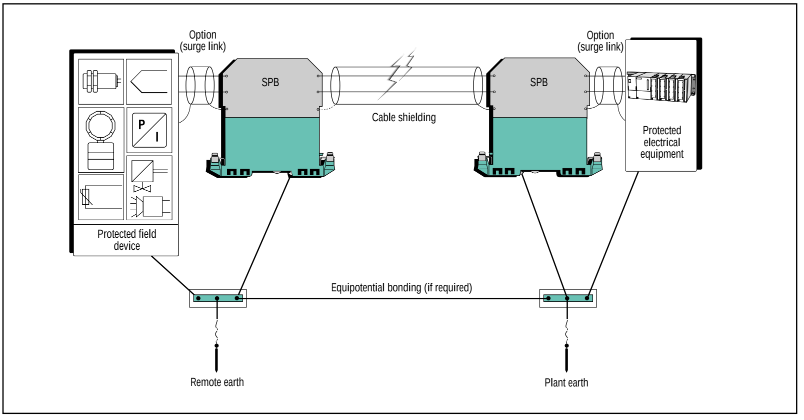

Figure 31: Cable shielding

8 Hybrid circuit protection

The main purpose of the surge protection barrier is to limit induced transient voltages across sensitive electrical equipment and to safely divert the surge current to ground. The surge protection barrier incorporates the line to line (differential mode) and line to earth (common mode) protection. This is achieved by integrating suitable ‘switching’ elements into the surge protection device and guaranteeing a proper connection to ground. The protection device must be able to respond extremely fast on high impulse voltages and currents. Since a single ‘switching’ element is unable to fulfil this requirement, several stages are included in the device. This network is called ‘hybrid circuit’ protection. Gas Discharge Tubes represent the first switching stage. They are able to clamp high voltages and divert high currents, but their slow response time still allows dangerously high energy levels to pass through. Therefore, a second ‘switching’ element, must be implemented to control the remaining energy. This silicon avalanche transient voltage suppressor (TVS) diode type responds to lower voltage and current levels extremely fast, clamps the voltages to non-damaging levels, and diverts the surge currents to ground.

Both protection stages are decoupled via inductance *(see Figure 32: Hybrid circuit protection)*.

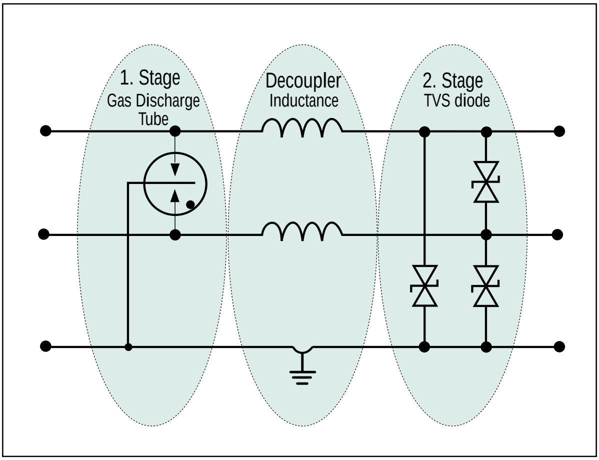

Figure 32: Hybrid circuit protection

8.1 Gas Discharge Tube

Gas Discharge Tubes can reduce surge currents of up to 40 kA. When the incoming surge voltage is below the gas discharge tube’s spark-over voltage, the device acts as a high impedance and no current flows between its electrodes. The gas (argon/hydrogen mixture) ignites when the tube’s spark-over voltage is exceeded, which causes the resistance between the electrodes to drop to less than 1 Ohm. Consequently, a high discharge current flows through the tube to ground. When the voltage decreases, the current will drop accordingly. Falling below a specific minimum current value, the gas tube extinguishes and returns automatically to the original high-impedance stage.

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Pepperl+Fuchs' SPBs include 3-electrode Gas Discharge Tube arresters to achieve the optimum protection for signal lines *(see Figure 33: Gas Discharge Tube).*

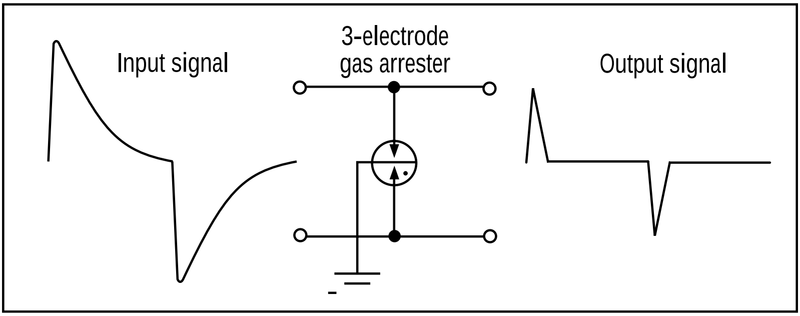

Figure 33: *Gas Discharge Tube*

8.2 TVS diode

Transient Voltage Suppressor (TVS) diodes are specifically designed to clamp lower voltages to non-damaging levels for electrical equipment. The TVS diode acts as a parallel protection element to the Gas Discharge Tube, effectively suppressing the incoming transient voltage. Under normal conditions, the diode acts as a high impedance. By exceeding the breakthrough voltage of the TVS diode, it becomes a low impedance path for the surge current to divert to earth. Consequently, the current does not flow through the protected equipment and the voltage is restricted to the clamping voltage of the TVS diode. Once the transient voltage has passed, the TVS diode returns to its high impedance stage. An important feature of the TVS diode is its extremely fast reaction time of less than 1 pico second. The low clamping voltage and fast response time represents an ideal second stage in a hybrid circuit protection device *(see Figure 34: TVS diode)*.

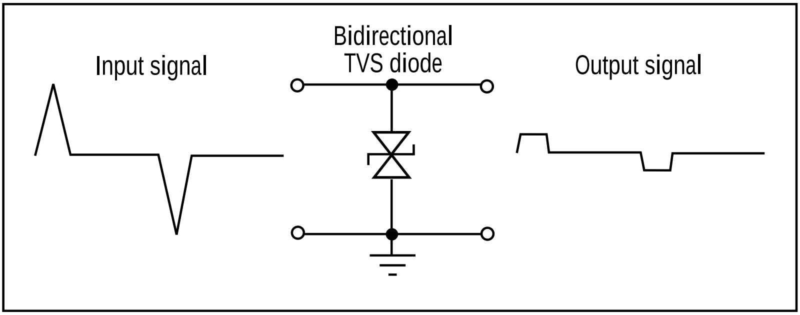

Figure 34: *TVS diode*

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8.3 Features

An evaluation of various protective components is shown in the table below:

Protection component	Response time	Power handling	Evaluation
Fuse	Very slow	Very high	+ Very effective against overcurrents - Replacement after operation
Circuit breaker	Slow	Very high	+ Effective for power systems - Ineffective against transient surges
Surge relay	Slow	High	+ Stability of operating level & sensitivity - Maintenance
Air gap	Fast	High	Outdated
Carbon gap	Fast	High	Outdated
Gas Discharge Tube	Fast	High	+ Self-restoring + Low capacitance + High insulation voltage + High spark-over voltage
Metal Oxide Varistor	Very fast	High	- Deterioration - High leakage current - Suitable only for AC load protection
TVS diode	Very fast	Low	+ Self-restoring + Low clamping voltage

Important: *Pepperl+Fuchs' SPBs comprise of Gas Discharge Tubes and TVS diodes. Since these protective components are self-restoring, Pepperl+Fuchs' SPBs are self-resetting and maintenance-free.*

8.4 Test pulse

Surge protection barriers must be able to withstand test pulses described in the international lightning standard IEC 60060-1.

IEC 60060-1 states that the test current pulse “has a shape increasing from zero to peak value in a short period of time, and then decreases to zero either exponentially or in the manner of a heavily-damped sine curve.” According to IEC standards, surge protection barriers should withstand exponentially type current test pulses *(see Figure 35: Lightning current test pulse)*.

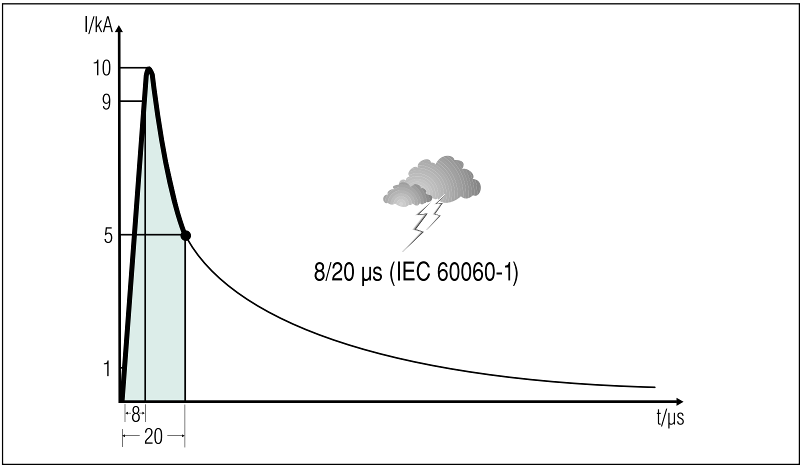

Figure 35: Lightning current test pulse

Following IEC 60060-1, SPBs for signal lines must be able to divert at least 10 test current pulses of 10 kA (8/20 µs) safely to ground, without damaging the transition contacts to earth, the internal circuitry and the SPB.

Important: *Pepperl+Fuchs’ SPBs are in accordance to IEC 60060-1 and CCITT with a nominal discharge current of 10 kA (8/20 µs) per lead.*

9 SPB product range

9.1 Standard housing type, K-LB-*.**

Type code:	Mechanical features:
K-LB-□.□ □ G - Non-isolated type 30 - 30 V working voltage 6 - 6 V working voltage 1: 1 channel 2: 2 channels	Design: Terminal housing modules made of Makrolon, flammability class UL: 94 V-0. Mounting: Snap-on to 35 mm standard rail per DIN EN 50 022. Connection: Self-piercing terminals, max. cross sectional area 2 x 2.5 mm^2.

- Standard (non-hazardous) application.

The suitable SPB for field device and PLC/DCS protection:

Field device (> 500 V isolated to earth)*	SPB for field device protection	SPB for PLC/DCS protection	PLC/DCS
Sensors, mechanical contacts Valves, LEDs, alarms	K-LB-1(2).30	K-LB-1(2).30G	Digital input Digital output
(SMART) transmitters (SMART) I/P converters, (SMART) positioners	K-LB-1(2).30	K-LB-1(2).30G	Analogue input Analogue output
RTDs, thermocouples, photocells	K-LB-1(2).6	K-LB-1(2).6G	Low voltage input

** : Field devices with a lower isolation voltage are protected via the non-isolated SPB: K-LB-*.*G.*

- Zener Barrier (hazardous) application.

The suitable SPB for field device and Zener barrier protection:

Field device (> 500 V isolated to earth)*	SPB for field device protection	SPB for Zener barrier protection	Zener barrier
Sensors, mechanical contacts Valves, LEDs, alarms	K-LB-1(2).30	K-LB-1(2).30G	Digital input Digital output
(SMART) transmitters (SMART) I/P converters, (SMART) positioners	K-LB-1(2).30	K-LB-1(2).30G	Analogue input Analogue output
RTDs, thermocouples, photocells	K-LB-1(2).6	K-LB-1(2).6G	Low voltage input

** : Field devices with a lower isolation voltage are protected via the non-isolated SPB: K-LB-*.*G.*

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- TIB (hazardous) application.

Preferably a P-LB-*.* SPB should be used for TIBs. Suitable P-LB SPBs can be selected from the table in chapter 9.3.

If the cabinet layout or other reasons does not allow the use of P-LB, the other suitable SPBs for the field device and the TIB protection are:

Field device (> 500 V isolated to earth)*	SPB for field device protection	SPB for TIB protection	TIB (> 500 V isolated to earth)*
Sensors, mechanical contacts Valves, LEDs, alarms	K-LB-1(2).30	K-LB-1(2).30	Digital input Digital output
(SMART) transmitters (SMART) I/P converters, (SMART) positioners	K-LB-1(2).30	K-LB-1(2).30	Analogue input Analogue output
RTDs, thermocouples, photocells	K-LB-1(2).6	K-LB-1(2).6	Low voltage input

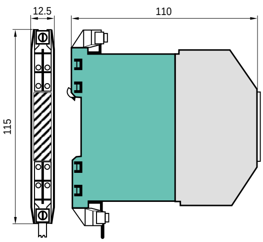
** : Devices with a lower isolation voltage are protected via the non-isolated SPB: K-LB-*.*G.*

The SPB for the DCS/PLC, Zener barrier or TIB protection is installed in the control room on a separate mounting rail.

The SPB for the field device protection is installed in the remote (hazardous) area on a mounting rail in a field enclosure.

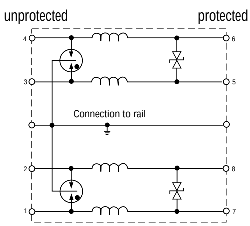
Approvals/certifications: EEx ia IIC T4; Class I, Division 1, Groups A-D (Intrinsic safety)

Mechanical dimensions:

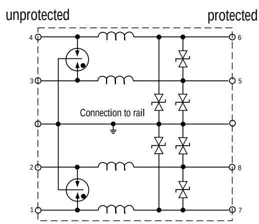


Circuit diagram (2 channels):

Isolated:



Non Isolated:



The non-isolated and isolated SPB can be easily identified via the following colour code:
Non-isolated, K-LB-*.*G: Top cover is grey.
Isolated, K-LB-*.*: Top cover is red.

9.2 Screw-in type, F*-LB-*

Type code:	Mechanical features:
F□ -LB-□ I - Intrinsic safety EEx 'i' D - Flameproof EEx 'd' ND - Explosion Proof EEx 'd' (US) Thread type: S - M20 x 1.5 P - Pg 13.5 N - 1/2" NPT	Design: ANSI 316 stainless steel hexagonal barstock, male thread, potential free housing; weight 175 g. Mounting: Screwed into the spare cable entry of field device or terminal junction box. Connections: Three flying leads; red (+), black (–), yellow/green (GND), length 300 mm, cross-section 1 mm² (16 AWG).

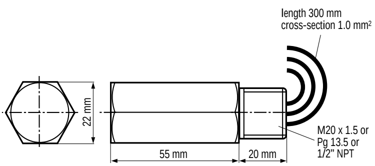
- Standard or hazardous area application:

The screw-in type SPB for field device protection:

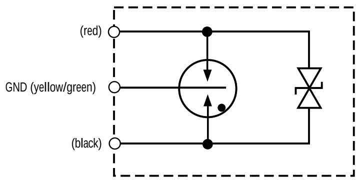
Field device (> 500 V isolated to earth)	SPB for field device protection	Signal
(SMART) transmitters (SMART) I/P converters, (SMART) positioners	F*-LB-*	Analogue input Analogue output

Approvals/certificates: EEx ia IIC T4; Class I, Division 1, Groups A-D (Intrinsic safety)
EEx d IIC T4; Class I,II,III, $^{1}/_{2}$" NPT Group A-G (Explosion Proof)

Mechanical dimensions:



Circuit diagram:



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9.3 Snap-on type, P-LB-*.*

Type code

Because of the different terminal connections of the devices to be protected, a suitable SPB is to be selected according to the following tables.

Snap-on for TIB application

Snap-on	TIB types from Pepperl+Fuchs (further models upon request)	TIB function
P-LB-1.A	KF□□-SR2-/-ST2-Ex1* KFD2-CR-Ex1. □0200, KFD2-ST□1-/-ST □3-Ex1* KF□□-UFC-/-DWB-/-DU-/-PWC-(Ex)1*, KF□□-UFT-Ex2	Sensor input 2-wire current input Universal signal conditioners
P-LB-2.A	KF□□-SR2-/-ST2-Ex2* KFD2-ST □4-Ex2*	Sensor input 2-wire current/voltage input
P-LB-1.B	KFD □-SD-/-SL-/-SCD-/-CD-/-CC-/-CS-(Ex)1	Solenoid driver, Voltage/ Current repeater
P-LB-2.B	KFD□-SL2-/-CS-(Ex)2	Solenoid driver, Voltage/ Current repeater
P-LB-1.C	KF□□-FSU-/-IT-/-DW-Ex1* KFD2-CR-Ex1. □03□□, KF□□-CV-/-CRG-/-ST□4-(Ex)1* KFD0-T□ -(Ex)1	Universal signal conditioners 3-wire current/voltage input Temperature converter
P-LB-1.D	KFD2-UT-Ex1*	Temperature converter

**: Types possibly with extensions*

Snap-on for RPI applications (Remote Process Interface)

Snap-on	Suitable for Pepperl+Fuchs RPI module	RPI function
P-LB-2.C	KSD2-BI-Ex2, KSD2-BO-Ex2*, KSD2-F1-(Ex)	Digital input, digital output, frequency converter
P-LB-1.E	KSD2-BO-Ex, KSD2-CO-(S)-(Ex)(H)	Digital output, current output
P-LB-1.C	KSD2-CI-S-(Ex)(H)	Current input
P-LB-2.D	KSD2-RO-(Ex)2, KSD2-C1-(Ex)2, KSD2-B1-(Ex)4*	Relay output, current input, digital input
P-LB-1.F	KSD2-TI-(Ex)	Temperature input
P-LB-1.B	KSD2-VI	Voltage input

**: Types possibly with extensions*

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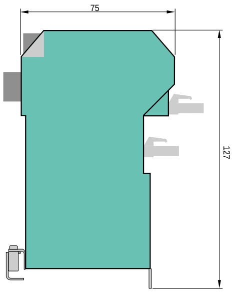
Mechanical characteristics

Mounting:	P-LB type SPBs are simply plugged into the module to be protected. Earth connection is established by a separate earthing rail in parallel to the existing DIN rail. The SPB is screwed to the earthing rail.
Housing material:	Macrolon
Flammability class UL:	94 V-0
Connection:	Removable connector with integrated self opening device terminals for leads of up to a max. of 1 x 2.5mm^2.

Important: *The breakdown voltage of P-LB type SPBs is 500V, i.e. P-LB is always an "isolated" type SPB.*

Mechanical dimensions, circuit diagram:



The circuit diagram correlates to the "isolated" type of K-LB-*.* but the terminal assignment fits to the used module, according to the above tables.

The plugs provided at the SPB fit into the used TIBs/ RPI modules. There are types with plug A or B only or A and B.

Terminal connection

The following table shows the terminals protected and used for the SPB.

Snap-on	Channel 1	Channel 2
P-LB-1.A	1, 3	
P-LB-1.B	1, 2	
P-LB-1.C	1, 2, 3	
P-LB-1.D	1, 2, 3, 4	
P-LB-1.E	2, 3	
P-LB-1.F	1, 2, 3, 6	
P-LB-2.A	1, 3	4, 6
P-LB-2.B	1, 2	4, 5
P-LB-2.C	2, 3	5, 6
P-LB-2.D	1, 2, 3	4, 5, 6

9.4 Technical Data

1 channel (2 wires) standard type:	K-LB-1.30(6)(G)	terminals	1, 2; 7, 8
2 channels (4 wires) standard type:	K-LB-2.30(6)(G)	terminals	1, 2; 7, 8/3, 4; 5, 6
Screw-in type:	F*-LB-*	leads	+, -, GND

	Standard type		**Screw-in type**	**Snap-on type**
	K-LB-*.30(6)G	K-LB-*.30(6)	F*-LB-*	P-LB-*.*
Operating valves Operating voltage Operating current Leakage current	≤ 30 V (6 V) ≤ 250 mA ≤ 5 µA (≤ 10 µA)		≤ 48 V not applicable ≤ 5 µA	≤ 30 V ≤ 250mA ≤ 5µA
Let-through voltage Differential mode	≤ 45 V (≤ 12 V)		≤ 85 V	≤ 45V
Earth isolation	not applicable	≥500 V	≥500 V	≥500 V
Maximum values in accordance to conformity requirements Voltage Current Power Internal capacitance Internal inductance	≤ 30 V ≤ 250 mA ≤ 1.3 W ≤ 1.5 nF (≤ 7 nF) ≤ 200 µH		≤ 50 V – – ≤ 1 nF negligible	≤ 30V ≤ 250 mA ≤ 1.3 W ≤ 1.5 nF ≤ 200 µH
Nominal discharge *current according to IEC 60060-1*	10 kA (8/20 µs) per lead			
Nominal response time Symmetric Asymmetric	1 ns 100 ns			
End to end resistance	≤ 0.5 Ohm per conductor		-	≤0.5 Ohm per conductor
Band width	≥ 40 kHz		not applicable	≥40 kHz
Ambient temperature Application in safe area in hazardous area, T6	– 30 °C... + 80 °C – 30 °C... + 50 °C		– 30 °C... + 90 °C – 30 °C... + 70 °C	– 20 °C... + 60 °C

9.5 Installation guide

9.5.1 Standard housing type, K-LB-*.**

The following steps should be used as a guideline for the proper installation of the standard housing SPB *(see Figure 36: Installation of the standard housing SPB).*

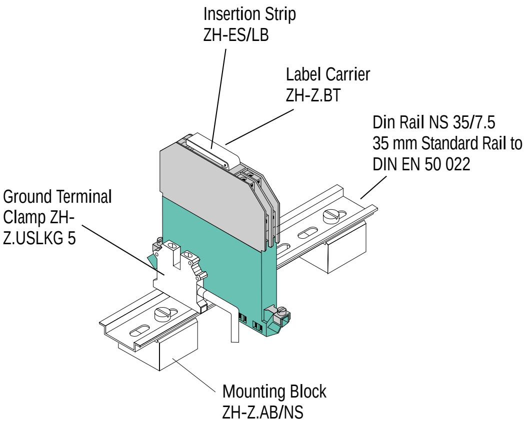


Figure 36: *Installation of the standard housing SPB*

1. The earthing clamp on the bottom of the SPB is hooked at the field side of the base over one flange of the DIN-rail.
2. The protected side is pressed down firmly until it clicks into position.
3. Check that the SPB is securely clamped on the mounting rail.
4. For removal, use a screw driver as indicated on the SPB, press the blade of the screw driver down the protected side next to the copper clamp and rotate the handle gently towards the SPB. Pull upwards to disengage the spring.

- Accessories

Mounting Rail: DIN Rail NS 35/7.5	Mounting Block:	ZH-Z.AB/NS
Ground Terminal Clamp: ZH-Z.USLKG 5	Label Carrier:	ZH-Z.BT
	Insertion Strip:	ZH-ES/LB

Important: *Suitable earth connections are essential for the proper operation of the SPB.*

Issue date 11.2001

Subject to reasonable modifications due to technical advances

The earth connection between the SPBs and the mounting rail is done by properly snapping the device onto the rail. The group earthing of the SPBs (e.g. in lots of 8/16) can be arranged by installing the ground terminal clamp ZH-Z.USLUG 5 next to the SPBs. A suitable earth cable should be used to establish the connection between the ground terminal clamp and the equipotential bonding system *(see Figure 37: Group earthing).*

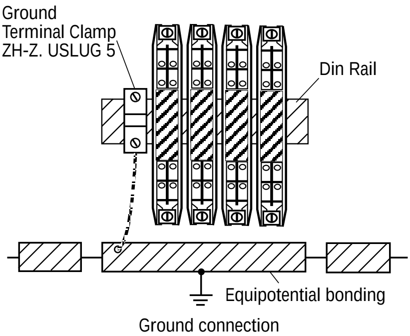


Figure 37: Group earthing

9.5.2 Screw-in type, F*-LB-*

The following steps should be used as a guideline for the proper installation of the screw-in SPB *(see Figure 38: Installation of the screw-in SPB).*

1. The leads of the screw-in SPB should be cut to the appropriate connection length.
2. The F*-LB-* is screwed directly to the spare cable entry of the transmitter or the terminal junction box.
3. The three leads are connected to the field device or junction box terminal connections + (red), - (black), GND (yellow/green).
4. The field device or terminal box must be bonded appropriately to ensure a sufficient earth connection to ground.

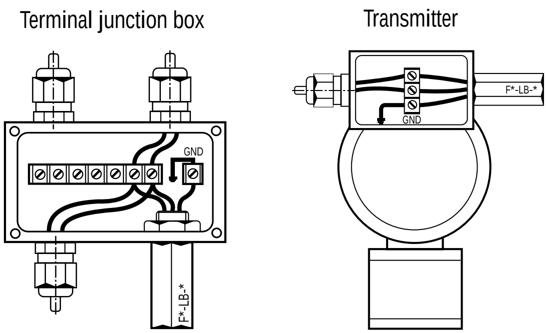


Figure 38: Installation of the screw-in SPB

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9.5.3 Snap-on type, P-LB-*.*

The following steps should be used as a guideline for the proper installation of the snap-in SPB (see Figure 39: Installation of the snap-on SPB).

1. Plug the SPB into the TIB or the RPI module.
2. Screw the SPB earth connection clamp on to an earth rail.
3. Ensure a good connection to earth.

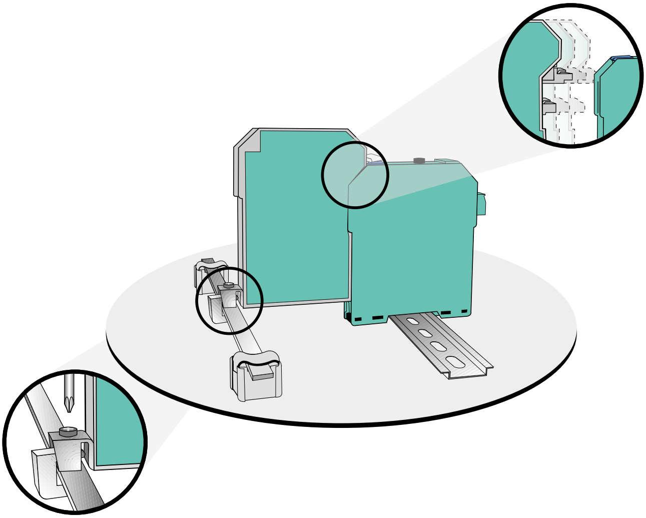

Figure 39: Installation of the snap-on SPB

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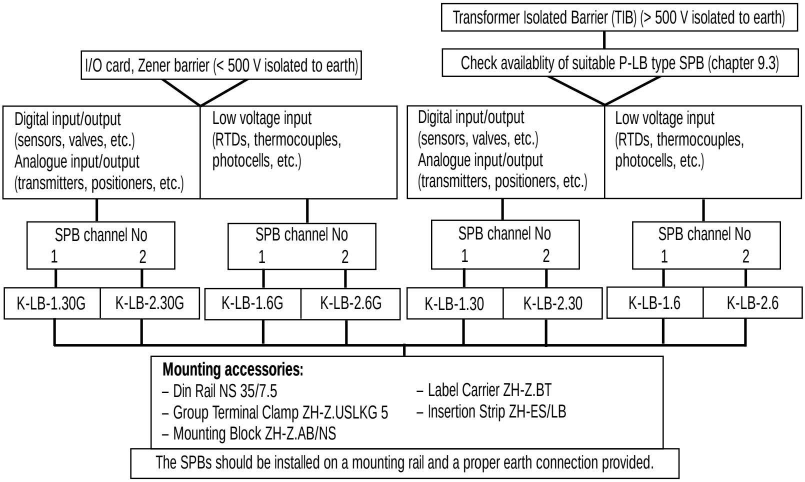
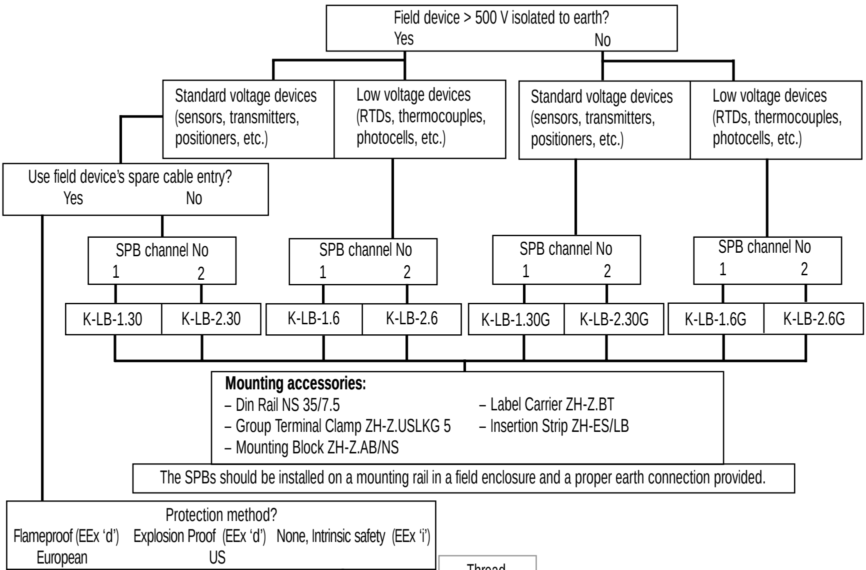
10 Ordering information

Protection of process control equipment



Protection of field device



Flameproof (EEx 'd') European	Explosion Proof (EEx 'd') US	None, Intrinsic safety (EEx 'i')	Thread
FS-LB-D	FS-LB-ND	FS-LB-I	M20 x 1.5
FP-LB-D	FP-LB-ND	FP-LB-I	Pg 13.5
FN-LB-D	FN-LB-ND	FN-LB-I	1/2" NPT

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11 Appendix

Standards:

- IEC 61024-1 1993-08	Protection of structures against lightning
- DINV / ENV 61024-1 1993	Protection of structures against lightning
- IEC 61312-1 1995-02	Protection against lightning electromagnetic impulse – Part 1: General principles
- IEC 60060-1 1989-11	High-voltage test techniques
- DIN VDE 0845	Requirements and tests of overvoltage protective installations
- EN 50020 1996	Electrical apparatus for potentially explosive atmospheres-Intrinsic safety 'i'
- IEC / EN 60079-14 1997	Electrical installations in hazardous areas (other than mines)
- IEC 60079-19 1996-12	Electrical installations in hazardous areas (other than mines)
- BS 6651 1992	Code of practice for protection of structures against lightning
- IEEE C62.41 1991	IEEE recommended practice on surge voltages in low-voltage AC power circuits
- CCITT	The protection of telecommunication lines and equipment against lightning discharges
- NZS/AS 1786-1991	Australian standard, New Zealand standard- Lightning protection

Notes

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Notes

Notes

One Company, Two Divisions.

Factory Automation Division

Product Range

- Binary and analogue sensors:
  - Inductive capacitive sensors
  - Magnetics sensors
  - Ultrasonic sensors
  - Photoelectric sensors
- Incremental and absolute rotary encoders
- Counters and control equipment
- ID systems
- AS-interface

Areas of Application

- Machine engineering
- Conveyor or transport
- Packaging and bottling
- Automation industry

Process Automation Division

Product Range

- Signal conditioners
- I.S. Barriers
- Remote Process Interfaces
- Intrinsically safe fieldbus solutions
- Level control sensors
- Surge protection barriers
- Process measuring and control system engineering at the interface level
- Intrinsic safety training

Areas of Application

- Chemical industry
- Industrial and community sewage
- Oil, gas and petrochemical industry
- PLC and process control system
- Engineering companies for process systems

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