Application notes

Application notes

How to select the right product

Most important decision criteria are the following:

- Transmission frequency range
- DC on the line (or DC injection), e.g. for powering of remote/outdoor equipment
- Protection requirements (surge current handling capability, residual pulse)
- RF requirements (RL, IL, PIM)
- Environmental requirements (outdoor operation)
- Dimensions
- Interfaces
- Mounting/grounding requirements
- Selection of the gas discharge tube for GDT lightning EMP protectors

These criteria have to be considered within the provided selection flow chart on the inner back cover.
(For special applications contact HUBER+SUHNER AG via your local representative,
Internet www.hubersuhner.com or the headquarter Switzerland.)

Selection according to surge-current-handling capability

The following table shows the surge-current-handling capability of HUBER+SUHNER lightning EMP protection device on the basis of the standardized test pulses:

Principle	Series	Connector interface	Surge current handling capability with test pulse 10/350 μs	Surge current handling capability with test pulse 8/20 μs
Gas discharge tube	3401, 3402, 3403, 3408, 3409, 3410	N and DIN 7/16	8 kA	30 kA
Gas discharge tube	3406	all interfaces	2.5 kA	10 kA
Quarter-wave stub	3400, 3407	DIN 7/16	50 kA	100 kA
Quarter-wave stub	3400, 3407	N	25 kA	50 kA

Selection of the surge protection gas discharge tube

RF power

A total of eight GDT with different static spark-over voltages are available. To select the correct GDT, the following criteria must be known:

- Max. RF transmission power P (CW or PEP)
- Supply voltage U_{DCsup} if used for remote powering
- System impedance Z
- Max. allowable VSWR (system adjustment)

The required static spark-over voltage (refer to tables on pages 131 and 132, consider the lowest possible voltage from the tolerance range!) is 1.5 times of the total peak voltage on the transmission line. The following formula is applicable for the peak voltage, if VSWR=1.

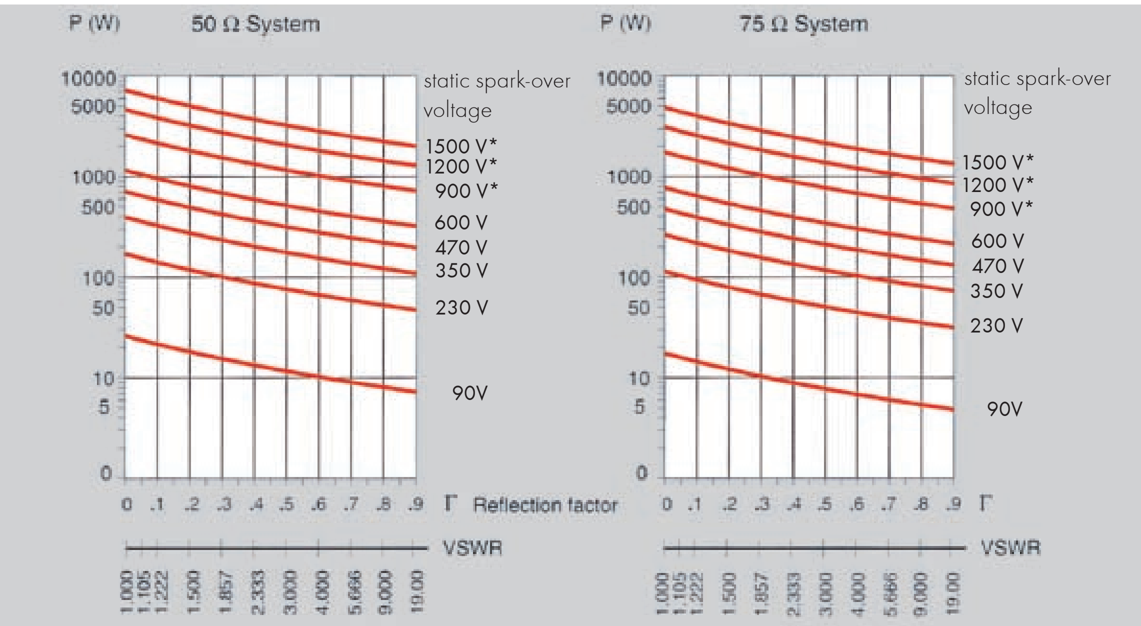
$$U_{zstat} \geq 1.5\ \hat{U}_{max.} \qquad \hat{U}_{max.} = \sqrt{2\ PZ}\ (1 + \Gamma) + U_{DCsup}$$

For multicarrier systems, the (inphase) peak voltage must be calculated as the total of all single peak voltages:

$$\hat{U}_{max.} = (\hat{U}_1 + \hat{U}_2 + \ldots \hat{U}_n)(1 + \Gamma) + U_{DCsup} = \left(\sqrt{2\ P_1 Z} + \sqrt{2\ P_2 Z} + \ldots + \sqrt{2\ P_n Z}\right)(1 + \Gamma) + U_{DCsup}$$

This consideration does not involve effects of the modulation. They have to be added according to the selected modulation principle.

The admissible RF power transmission (CW or PEP) versus the VSWR is shown in the following diagram for HUBER+SUHNER gas discharge tube.



Diagrams of permissible RF power (CW or PEP) for 50 Ω and 75 Ω systems
* non standard values

Application notes

Basic installation and grounding rules

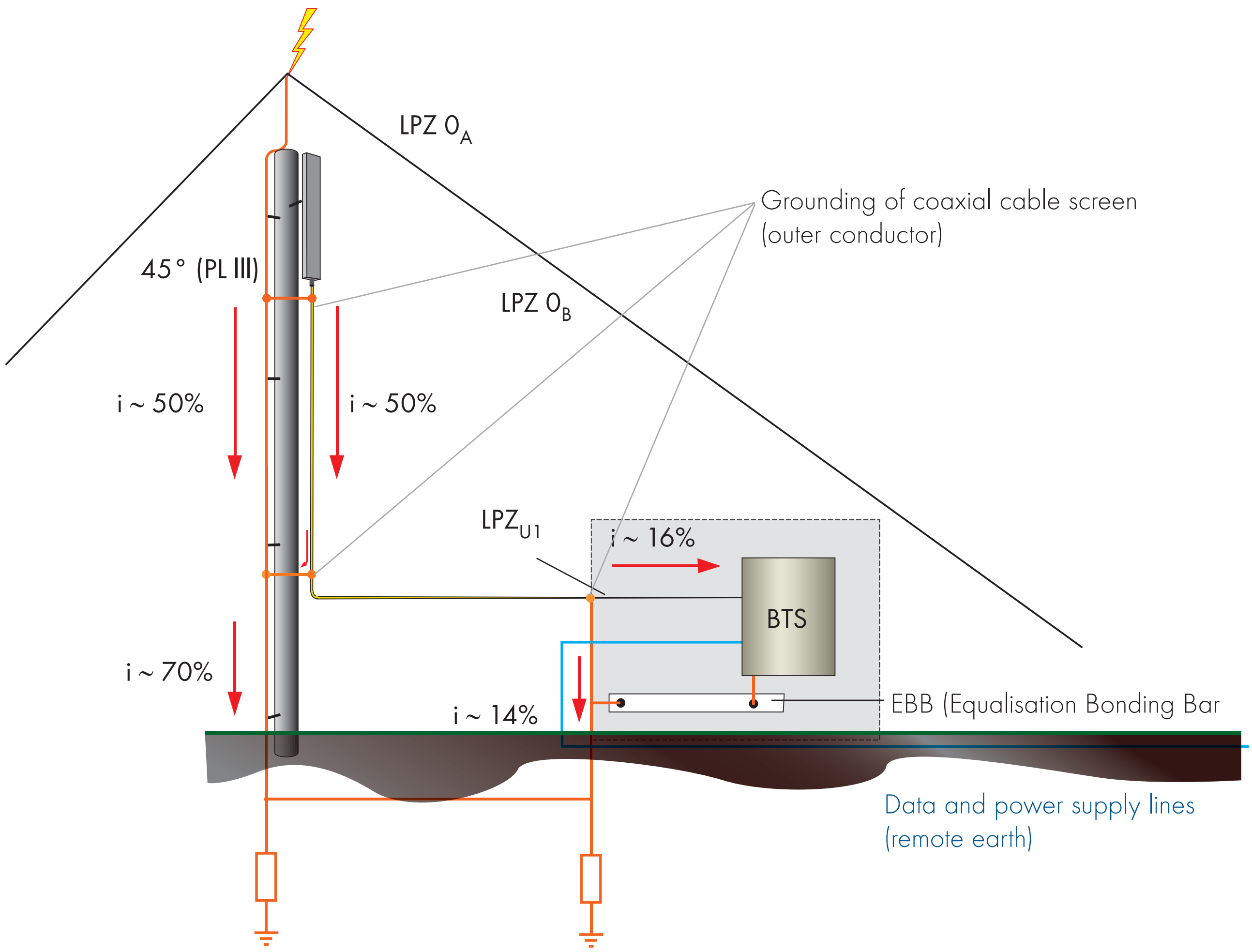
General protection recommendations

Model base station antenna system

Direct and indirect lightning strokes are mainly accompanied by resistive and magnetic coupling processes of their electrical energy. Capacitve coupling effects of surge energy by the high and fast-changing electrical field just before the lightning stroke occurs are negligible, if the system is well bonded to earth (electrical charge equalization).

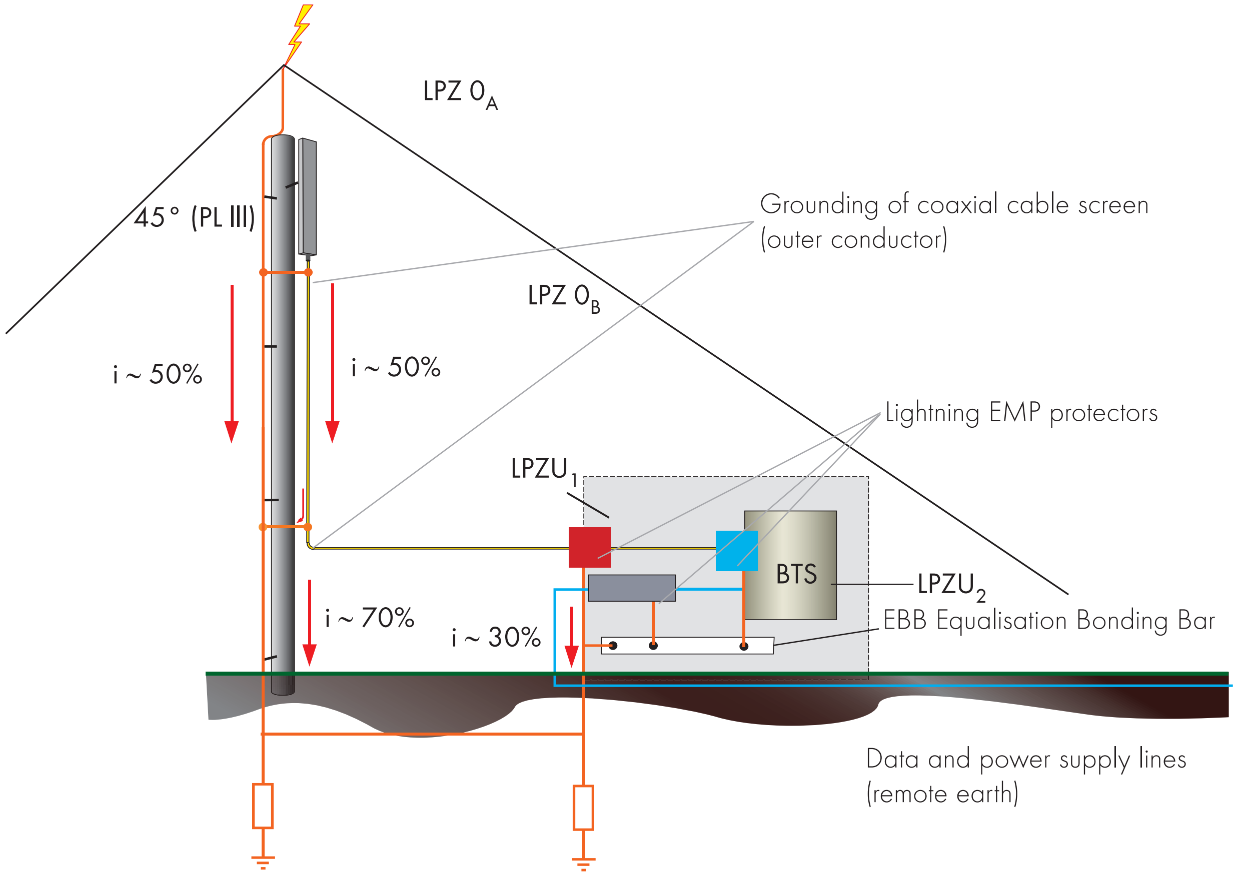
The following figure shows the lightning current distribution after a stroke into the antenna mast, respectively into the lightning protection system, caused by resistive coupling (equal current distribution as proven assumption according to IEC 62305, protection against lightning:

Current distribution without application of lightning EMP protection device



LPZ: Lightning protection zone
PL: Protection level (according to IEC 62305)

The following illustrates the resistive current distribution with lightning EMP protection device (e.g. quarter-wave shorting stub protectors) in detail:



Recommendations

Antennas or radio equipment should be located within the protection zone of the external lightning protection system (LPS)(according to IEC 62305, protection against lightning: air-terminations, down-conductors and earth-termination) – LPZ 0_B. It is established as a 45° area downwards, related to the highest point of the air-termination as shown (assumption for a mast height up to
20 m and the protection level PL III according to IEC 62305).
LPZ 0_B can principally be evaluated by the application of the sphere model according to IEC 62305, which allows to determine LPZ 0_B for even more complicated structures.

Thus, the antenna or radio equipment is protected against direct lightning strokes with a probability of 90% (PL III according to IEC 62305). But the electromagnetic field still acts unattenuated!

By the bonding of the antenna earth, radio equipment or upper-cable end screen to the down-conductor of the mast or the building surge voltages caused by magnetic coupling of direct and near lightning strokes into loops through earth can be avoided. If not done, the cables would have to be protected magnetically by iron tubes (which would also protect the inner conductor of coaxial cables).

Low-frequency short-circuit connection of antennas against down-conductor (e.g. shunt-fed antennas or application of quarter-wave protectors). This helps avoiding a high surge voltage and therefore a possible undefined breakdown in the cable due to magnetic coupling of direct and near lightning strokes into loops across earth or remote earth). Direct-stroke-initiated partial lightning currents over the coaxial cable screen would otherwise cause together with the measure of the previous section undefined cable breakdown by the voltage drop against earth (as the inner conductor can have zero potential).

Bonding of the cable screen to the down-conductor where it leaves the mast and with higher masts every 20 m. Thus, a potential equalization is achieved and the current over the cable screen to earth is reduced, as the down conductor has a lower impedance.

Application of coaxial cables with low DC resistance over inner and outer conductor (e.g. corrugated copper tube cables of as large size as possible – larger size means also higher dielectric withstanding voltage).

Application of reliable lightning EMP protection devices at the entry of LPZ 1. Thus, high partial lightning and induced currents (test pulse 10/350 µs according to IEC 62305) can be led to earth and overvoltages are reduced to a low level (potential equalization). HUBER+SUHNER ran several tests to evidence the necessity of this measure. The cables RG 213, LMR 400, LDF 4-50A (1/2") and LDF 5-50A (7/8") were measured in the case of a resistive/inductive equipment input:

Measurement of the longitudinal voltage over the inner conductor

- Here a test surge current of pulse shape 8/20 µs and 10/350 µs was sent into a 1 m piece of cable, inner and outer conductor connected at the input, output screen connected to earth and inner conductor to the oscilloscope input.
- Most important result: applying the 8/20 µs test pulse with 25 kA amplitude (half of the assumed load of the model antenna system, as 100 kA is the total lightning current according to PL III) leads to a calculated (if a cable lengths of 10 m is assumed, for example) longitudinal voltage of:
  RG 213: 867 V
  LMR 400: 1438 V
  LDF 4-50A: 356 V
  LDF 5-50A: 133 V

The longitudinal voltage is proportional to cable length and partial lightning current amplitude!

Measurements with lightning currents of pulse shape 10/350 µs resulted as expected in longitudinal voltages of smaller amplitude (due to the lower rise time) but much higher pulse energy.

In case of DC selection over the coaxial cable to supply power for remote active electronic circuits in the antenna system, only gas discharge tube lightning EMP protectors can be employed. The residual pulse voltage behind the protector reaches up to several hundred volts over some nanoseconds, dependent on the selected gas discharge tube.

This requires additional protective devices for sensitive input circuits of electronic equipment. They can be located directly behind the gas discharge tube lightning EMP protector (or be a combined arrangement), if the equipment to be protected is nearby. Normally they should be placed at the entry of next protection zone, if a consequent zone concept is being followed (e.g. LPZ 2 – according to IEC 62305 every zone transition requires a separate lightning/surge protection device). The additional protector – here called surge suppressor due to its function – reduces the surge pulse voltage to a well-tolerated extent of only a few volts (e.g. HUBER+SUHNER fine protectors).

Coaxial cable

Such a surge suppressor is not only required due to the leftover residual pulse of the gas discharge tube lightning EMP protector, but also due to magnetic coupling into the possible loop which the antenna cable length between the lightning EMP protector and the equipment is part of (within zone LPZ 1). This is illustrated by the following:

Thirty meters of coaxial cable can form together with other signal, energy or bonding connections large induction circuits, which produce induced voltages of several hundred kV. Already the coaxial cable alone can act as an induction circuit for the strong magnetic fields of near lightning strokes, if not specially screened.

The induced voltage can be calculated with the following formula:

$U = - M_2 ^* \, di/dt$ (M_2 – mutual inductance of the loop, i – lightning current).

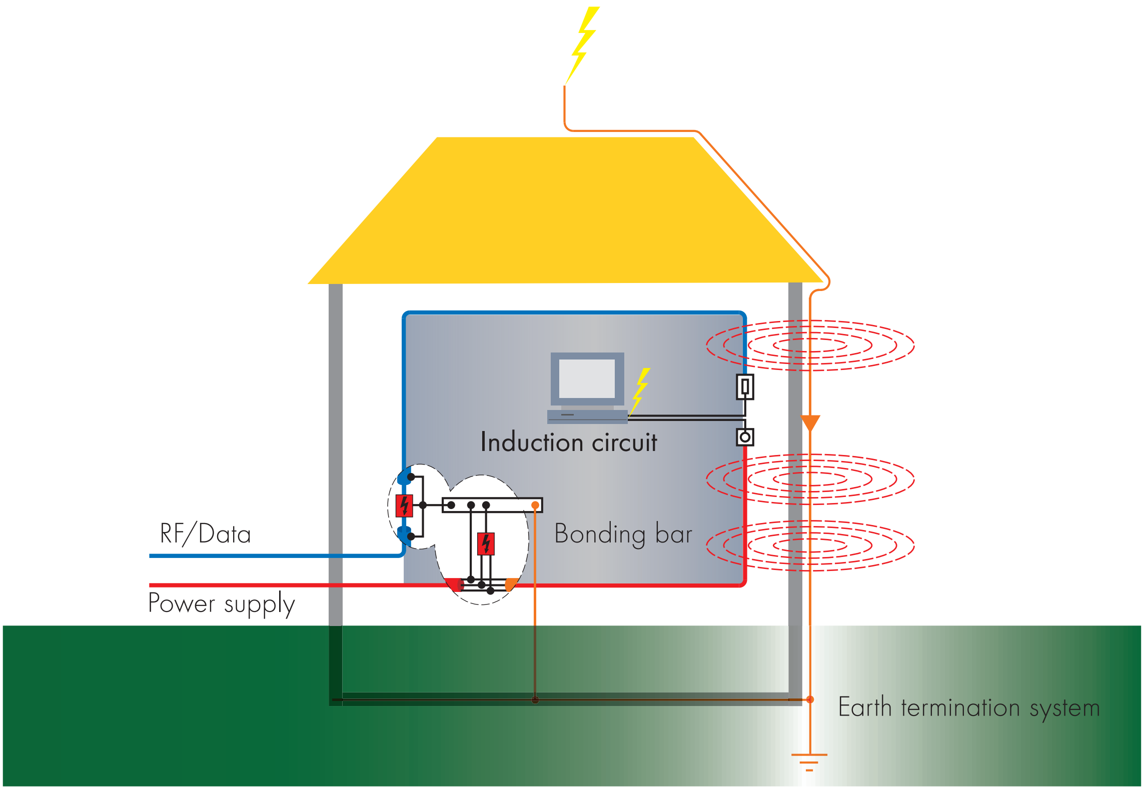
First partial lightning strokes show a current rate of change of up to 20 kA/µs, subsequent lightning strokes even of up to 200 kA/µs. The loop inductivity depends on the loop circumference and on the distance to the lightning stroke channel. Larger loops – e.g. 40 m – possess a M_2 of about 1.5 mH at a distance of 10 m; with a distance of 1 m it increases to about 5 mH. Therefore, induced voltages ranging from 24 to 1000 kV can be produced.

Measures to minimize or compensate in-house lightning induction effects:

- Application of surge protectors and suppressors
- Short cable lengths
- Magnetic screening of cables (steel tubes/cable tunnels)
- Magnetic screening of the complete structure (Faraday shield)
- Distance to the possible lightning current channel as large as possible
- Hybrid earth-grounding system – single-point grounding, suitable line routing

Active electronic circuits in the antenna and additional line amplifiers have to be protected against surge pulses supplied from the connected coaxial cables (application of lightning EMP protectors and surge suppressors, high-pass not allowed with DC injection) and if possible also against magnetic coupling. Concerning the otherwise occurring surge load refer to section application of reliable lightning EMP protection devices.

For a complete lightning/surge protection of a base station, you must consider all further connected signal and power supply lines. They have to be protected under similar considerations. HUBER+SUHNER can recommend certain reliable lightning protection solutions for these purposes.



Application notes

Mounting and grounding recommendations

The HUBER+SUHNER lightning EMP protector product range offers a high flexibility to meet mounting and grounding requirements in the field. Basically all mounting options are simultaneously suitable for grounding purposes.

HUBER+SUHNER offers:

Bulkhead mounting

Preferred mounting/grounding!

- Protection zone principle
- Lowest contact resistance
- Corrosion-resistant contact zone
- Waterproof wall sealing
- RF leak-proofness
- Vibration resistance

- Screw mounting and
- Bracket mounting

For best protection according to IEC 62305 when establishing protection zones consequently, it is recommended to deploy bulkhead mounting facilities. Thus the protectors can be installed as wall feed-through directly in the wall of the protected room. Doing so, the protectors should be installed consequently with the surge down conducting part – quarter-wave stub or gas discharge tube – outside of the protected area not to cause any unnecessary interferences when dissipating surges. (This is reflected by the recommendations and definitions for «unprotected and protected side» of the device tables. Bulkhead mounting types and all high-pass filter types are marked accordingly.)

The special HUBER+SUHNER bulkhead fixation design automatically enables a good long-term performance concerning a waterproof bulkhead transition, a corrosion-resistant (gas-tight) contact area resulting in a stable contact to the bulkhead ground-plane, a low transition resistance and a vibration-resistant mounting of the protector (assuming the right sufficient torque forces are applied as shown in the supplied assembly instructions).

This is true for standard sheet metal bulkheads such as stainless steel, copper or passivated aluminium with standard surface roughness and mounting holes according to the related HUBER + SUHNER product mounting hole specification.

For other mounting solutions care has to be taken for minimum interference. But generally all mounting options can carry the specified surge current when properly installed.

Grounding/bonding rules!

For a good grounding respectively bonding the following has to be considered:

- During installation, the lightning EMP protection device must be connected with the central grounding point of the equipment (EBB Equalisation Bonding Bar) in a low-resistance and low-inductance way. Inadequate grounding concepts with ground loops, insufficiently sized grounding cables (smaller than 16 mm^2/AWG 6), poor connections, etc., will increase the residual energy behind the lightning EMP protector as a result of high impedance (ohmic resistance by length and size and in addition inductance by length).

- The contact points of the ground connection must offer good electrical conductivity (contact points must be bare and free from dirt, dust and moisture).

- When threaded contacts are tightened (bulkhead grounding, GDT capsule holder), the minimum torque specified by the manufacturer must be observed in order to minimize the contact resistance and to establish the effects mentioned above.

- The lightning EMP protection devices should wherever possible be located in the unprotected zone in order to rule out inductive interference.

- HUBER+SUHNER lightning EMP protection devices are characterized by their quick, easy, and at the same time reliable installation methods. The preferred variant is single-hole mounting as wall feed-through. They can be applied with round or with D- or H-shaped also called double-D-shaped mounting holes to prevent rotation. The mounting hole size is matched to the connector size and thereby to the forces acting on the device.

All this is crucial for achieving the lowest possible residual surge pulse (voltage and energy) on the protected side and with it keeping the interference load for the equipment as low as possible.

All HUBER+SUHNER lightning EMP protection devices are supplied along with an installation instruction describing the proper installation procedure.

For more detailed information on mounting and grounding please see page 166.

Maintenance requirements

Quarter-wave lightning EMP protectors

Quarter-wave lightning EMP protectors are basically maintenance-free. However, we recommend customers to check the condition of the grounding/bonding system connections and of the connector interfaces in the context of routine system maintenance. But connector interfaces which are heavily damaged by lightning current overload (in excess of specification) will lead to increased reflections and will be detected by the return loss tracing circuit of the transmitter anyway. Field experience shows that lightning EMP protectors are not the only devices which can be affected in such cases of direct hits.

Gas discharge tube lightning EMP protectors

Gas discharge tube protectors use different technology, but are still very reliable products. The MTBF value determined by the carefully selected HUBER+SUHNER gas discharge tube is about 10 FIT (FIT: Failure in Time, 1 FIT is defined as 10^{-9} h^{-1}) – one failure within 10^8 hours. This is true, as long as no events of critical surge current load occur.

A degradation of the gas discharge tube is possible due to surge current overload and multiple loads at the specification limit. But a lot of tests previously conducted reveal that there is a large safety margin built in to HUBER+SUHNER gas discharge tubes. Even with excessive overload the GDT maintain at least their dynamic switching performance (dynamic spark-over voltage specification) which determines the residual pulse amplitude left by transient surges of lightning events.

Any destruction of the GDT due to a heavy overload would lead to a short, due to its unique and special design, and therefore shutdown the transmitter. This will be recognised immediately. But this is most probably not the only system damage in such cases and a service will be necessary anyway. HUBER+SUHNER protectors feature an easy access to the GDT and the exchange is quickly made.

Generally, inspection and maintenance schedules depend on the grade and frequency of surge loads. This is determined by the isokeraunic level (number of thunderstorm days, which decreases with latitude) of the operation area and several factors which determine the exposure of the equipment (e.g. altitude, country profile, nearby structures, water, etc., and even the existence of a lightning protection system). This is the reason that only the operator or his local consultant can judge the inspection requirements of their equipment (e.g. BTS), according to the actual exposure.

Recommendation!

We recommend as a general rule to test the static spark-over voltage of the gas discharge tube in the course of a routine inspection every 5 years and to exchange the failing parts. A suitable test unit can be supplied by HUBER+SUHNER (type 9075.99.0053).

As an alternative, a general overall replacement without testing might be more cost-effective in certain situations.

After a direct hit which caused damages in the antenna system, the GDT of the gas discharge tube protectors involved should be exchanged during the service in any case.

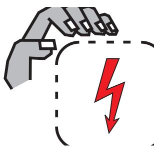
IP Dust and water protection rating

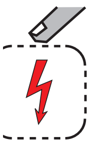
This section is intended to provide a short overview and essentials of the classification only. For more details refer to the latest original publication IEC 60529 (direct ordering or list of local sources via Internet www.iec.ch).

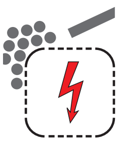
IP rating (IP XY)

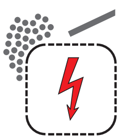
First number X
Protection against ingress of solid objects

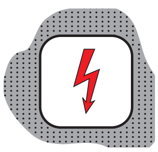
0  No protection

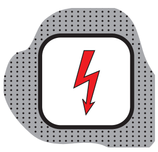
1  Protection against objects larger than 50 mm diameter

2  Protection against objects larger than 12.5 mm diameter

3  Protection against objects larger than 2.5 mm diameter

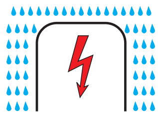
4  Protection against objects larger than 1.0 mm diameter

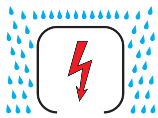
5  Protection against dust (limited ingress, not harmful)

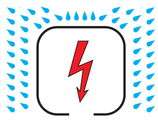
6  Protection against dust (dust-tight, no ingress)

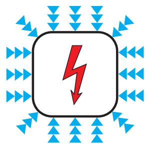
Second number Y
Protection against ingress of water

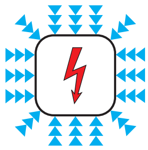
0  No protection

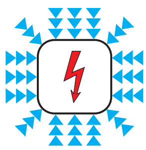
1  Vertically dripping water

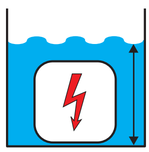
2  Dripping water, 15° tilted

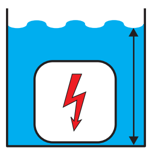
3  Spraying water

4  Splash water

5  Water jets

6  Powerful water jets

7  Temporary immersion (test 1 m, 30 min.)

8  Continuous immersion (test to be agreed, but exceeding no. 7)

Passive intermodulation issues

All PIM-specified HUBER+SUHNER lightning EMP protectors and their piece parts are designed according to the latest knowledge of PIM theory and practice. This is a continuous, progressive process.

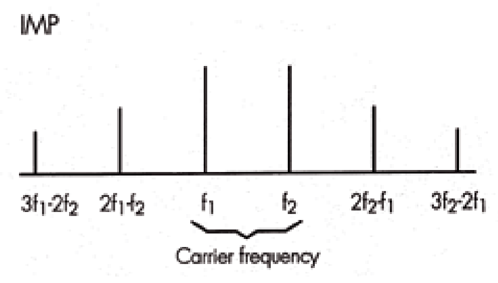
Generation of Passive Intermodulation Products (PIM)

- Non-linear behaviour of elements in signal path used with more than one carrier generates IM.
- The occurring spectral lines of the IMP can be described as:

$f_{IM}x = mf_1 + mf_2 + \ldots + y\, f_m$

where $f \ldots f_m$ are the used carrier frequencies
m…y are pos. or neg. integers
f_{IMx} =frequency of one generated IMP

IM spectrum by use of two carrier frequencies

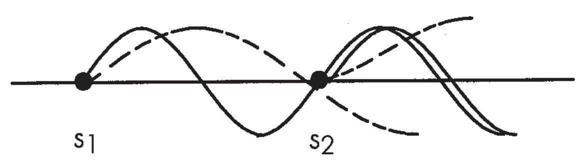


- Absolute linearity exists only as a mathematical idealization – passive elements are all weakly non-linear.
- Problem with PIM only occurs by:
  - High transmit levels
  - High receiver sensitivity
  - Several transmit channels and
  - Where only one antenna for transmission and receive path is used.
- Once in receive band, PIM cannot be reduced by filtering.
- In passive elements there are some dominant contributors of non-linearity:
  - Similar or dissimilar metal-to-metal joints
  - Plasma effects (local high fields causing
  - Corona)
  - Magnetic non-linear effects
  - High-current density
- For cable and connectors the metal-to-metal joints are the most significant PIM contributors.
- Gold, silver, copper, brass and copper-beryllium joints generate low PIM; steel, aluminium, stainless-steel-joints generate higher PIM.

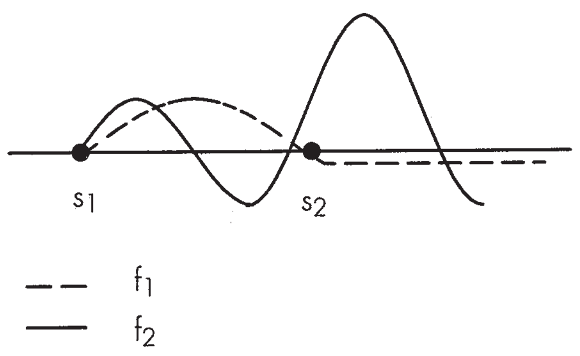
In practice:

- The IM level generated over the whole signal path is a result of many IM sources. The value of the resulting IM level depends on the phase relation of all these sources (constructive or destructive interference). This phase relation varies with frequency.

IMP of two sources



Resulting product



Relation between frequency and IM level

- IMP's of different order have different frequencies, and hence the resulting product does not have a constant amplitude.

- PIM's of different measurement setups are not exactly comparable (because of the different phase relations).

- The 3rd order IMP's have the higher value and normally are used to describe the IM behaviour of the device under test (DUT).

- In theory the IM level increases 3 dB per 1 dB power increase of the carriers. So, it is important when comparing different measured IM levels to consider the input power level. A standard value for input power is 2 x 20 W or 2 x 43 dBm.

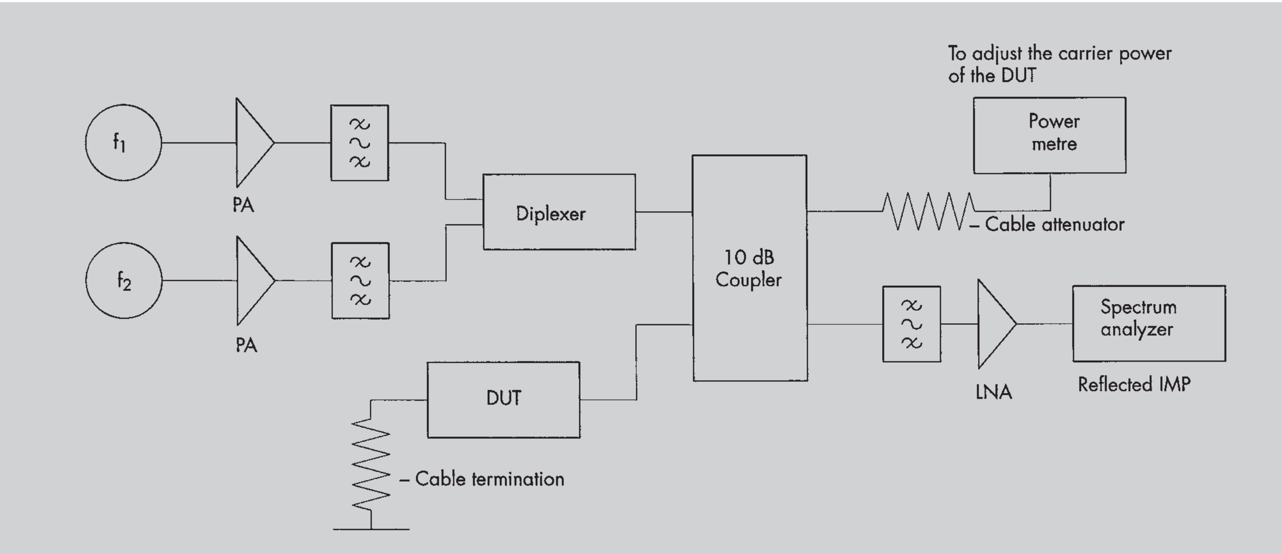
- All elements in the measurement setup generate IM. This ground level limits the measurement range (– 120 dBm ⇔ – 120 dBm – 43 dBm = – 163 dBc).

- It is not possible to measure a single connector. Only assemblies can be measured.

- The measured level can vary up to 40 dB by vibration or bending of the cable. So we have to know if the application of the assembly is mechanically static or dynamic.

- It is difficult to give a typical value for a connector. It depends on the method of mounting (remove cable isolation, crimping, clamping, soldering and contamination).

HUBER+SUHNER measurement setup



Application notes

Electrochemical potential differences – outdoor applications

General consideration

When installing and grounding lightning EMP protection device, consideration must be given to the electrochemical potential difference existing between the metallic housing parts of the device and the mounting walls or other fastening and contact elements.

According to MIL-F-14072, the magnitude of the potential difference should not exceed 250 mV in order to minimize possible electrochemical corrosion. The following table shows the associated potential differences of the most important metals and galvanically applied metal surfaces for the applications under consideration.

Magnitude of the electrochemical potential difference between different surface metals Values in V	Gold	Silver	Nickel	SUCOPLATE® and commercial alloys of copper	Stainless steel	Chromium	Tin	Aluminium
Gold	0.00	0.15	0.30	0.40	0.50	0.60	0.65	0.75
Silver	0.15	0.00	0.15	0.25	0.35	0.45	0.50	0.60
Nickel	0.30	0.15	0.00	0.10	0.20	0.30	0.35	0.45
SUCOPLATE® and commercial alloys of copper	0.40	0.25	0.10	0.00	0.10	0.20	0.25	0.35
Stainless steel	0.50	0.35	0.20	0.10	0.00	0.10	0.15	0.25
Chromium	0.60	0.45	0.30	0.20	0.10	0.00	0.05	0.15
Tin	0.65	0.50	0.35	0.25	0.15	0.05	0.00	0.10
Aluminium	0.75	0.60	0.45	0.35	0.25	0.15	0.10	0.00

Important

The classification according to ASTM D1141-90 conforms to MIL-F-14072 and has proved convenient for contacting metals in electronics. It must not be confused with the academic consideration of chemistry textbooks. The tables shown there refer to a gas reference electrode and a salt solution of the specimen metal between the electrodes.

Special case consideration – transition of lightning EMP protectors to bulkheads and panels made from steel or aluminium.

Concerning the electrical and mechanical performance of the flange mount version of HUBER+SUHNER lightning EMP protectors, the following two issues are of significance:

- Impedance of the link between lightning EMP protector and ground bar/entry plate.

The transfer resistance between lightning EMP protector and panel is not the only contributor to the total impedance of the connection to the ground bar. Much more important is the inductance formed by other parts of the link, as lightning strikes cause transient voltages and currents with rise times of only a few microseconds.

In general every contribution to the impedance should be as low as possible. This means that for the transition between lightning EMP protector and panel, one needs to use materials of very good conductivity and to be very careful when assembling (clean contact areas).

HUBER+SUHNER supplies with all its bulkhead versions a corrosion-protected soft-copper washer with the well-proven SUCOPLATE coating. This washer features a V profile, which is pressed into the mating material with a very high force when the fixation nut is tightened. Thus, several effects occur:

- The soft copper washer adjusts to the surface of the bulkhead material and levels any customary production surface roughness.
- Thin surface plating is broken, and a direct material contact between the copper of the washer and the base metal of the panel is created.
- Water-protected contact areas are established.
- The transition is made simultaneously RF-tight.

This yields the following for cold rolled steel, zinc- plated and chromated entry plates:

The brittle chromate layer is usually less than 0.1 mm thick (typically about 0.02 mm) and the zinc layer is only a few μm thick. Upon assembly, both layers are broken up, and a contact between copper and steel is formed.

Aluminium sheet metal with similar plating behaves equally, and contact between copper and aluminium is produced.

In tests it is shown that the contact resistance of such transitions is generally below 1 mΩ. The resistive contribution to the total impedance is negligible and does not affect the conduction of lightning currents to ground.

When conducting away lightning currents, assurance needs to be given that a good conductive path is created, even when a reduced number of active contact points at the transition are present. Due to the high currents caused by a lightning strike, conductive paths are created (melted open) in a sufficient way.

- Corrosion at the bulkhead transition

The corrosion performance under the influence of water is determined by the electrochemical potential difference between the metals being in contact (refer to the table shown in the previous section).

As a result of some studies it can be concluded, that thin metal layers of only a few μm do not change the potential differences of the contacting base materials significantly. Moreover, the influence of the plating is reduced by the effects described under section one.

Therefore, an effective potential difference of 0.10 V can be assumed at the transition to cold-rolled steel plates (between copper and stainless steel). Thus, the material combination is both from theoretical and practical aspects not susceptible to electrochemical corrosion under the influence of moisture. (For low-alloy steel, the potential difference increases slightly.)

At the transition to aluminium, the permitted range is exceeded based on a potential difference of 0.35 V. Testing performed by HUBER+SUHNER have shown, however, that the MIL standard allows for a very high safety margin. Transitions of copper alloy plated with SUCOPLATE to passivated aluminium were tested according to:

- MIL 202, Method 6, 10 days at high humidity and temperatures of 25 °C and 50 °C, followed by
- MIL 202, Method 100, Condition B, salt mist and afterwards followed again by
- MIL 202, Method 6, 10 days at high humidity and temperatures of 25 °C and 50 °C.

As a result, neither the contact resistance changed significantly nor essential effects of corrosion occurred. The chromate layer obviously fulfils its corrosion-inhib-iting function excellently.

In this context another fact is important for the maintenance of a low contact resistance. Through the soft-copper washer, which is provided by HUBER+SUHNER, a water-protected contact area is formed according to the effects mentioned in the previous section. Thus, electrochemical corrosion is prevented within the important contact zone. Therefore, a corrosion-inhibited degradation of the contact resistance at the bulkhead transition is not possible. This can be expected obviously only under the condition that the fixation nut is tightened applying the appropriate torque force.

Taking into account the theoretical aspects of electrochemical corrosion, we recommend steel panels over aluminium panels for long-term outdoor applications to achieve a safe and reliable long-term stability (mechanically and, ultimately, electrically). In addition, safety increases with wall thickness.

Material selection and design of HUBER+ SUHNER products take these effects into consideration and provide a long-term safety and reliability.

Lightning EMP protectors made of aluminium

The trend towards industrial solutions which are expected to ensure optimum performance while minimizing weight is increasing steadily. The scarcity of raw materials is becoming more acute as a result of the rapid development of global markets. Stringent environmental requirements ranging from production to disposal are bringing into question conventional products of plated brass. In view of these conditions, aluminium as an engineering material offers opportunities for developing ideal products. HUBER+SUHNER have identified their customers' needs and developed a new generation of lighting EMP protection systems. Further details are discussed in our White Paper Aluminium. This paper is available upon request (refer to DOC-0000324906).

Galvanic corrosion is the most frequent form of aluminium corrosion. A humid environment in combination with sea salt will further accelerate galvanic corrosion. Aluminium is a highly reactive metal in the electrochemical series. As a result of galvanic corrosion, aluminium will act as an anode and thus corrode when in contact with other, nobler metals.

For a sustainable use and prolonged life span some simple but effective measures can be applied.

In case of outdoor application conditions the following is recommended to avoid galvanic corrosion:

- Unprotected aluminium components may only be in direct contact with: other aluminium alloys, stainless steel, zinc or tin.
  Selected mounting material which prevents forbidden metal combinations is supplied by H+S together with the lightning EMP protector, see figure 1 (i.e. stainless steel washers, nuts and bolts).
- If it is not possible to comply with the above recommendation it is mandatory to protect the contact areas between forbidden metal combinations from moisture ingress. This can emerge when an aluminium EMP lightning protector is contacted to a connector interface made of other material. Narrow gaps and treads where humidity can penetrate must be protected by means of appropriate measures like taping, coating or sealing, see figure 2 (i.e. wrapping with self vulcanizing tape).

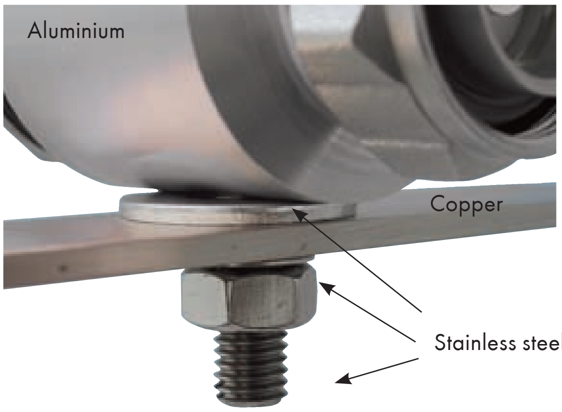


Fig. 1

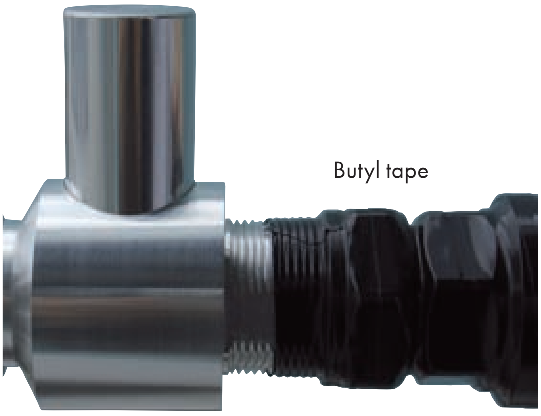


Fig. 2

In practice, the following material pairs have proven their worth.

	Aluminium alloys	Copper	Stainless steel	Galvanised steel	Tin
Aluminium alloys	OK	X	OK	OK	OK
Copper	X	OK	OK	X	OK
Stainless steel	OK	OK	OK	OK	OK
Galvanized steel	OK	X	OK	OK	OK
Tin	OK	OK	OK	OK	OK

In order to minimise contact corrosion of metal components in outdoor applications, the difference between the electrochemical potentials of unprotected connections must not be higher than 300 mV, and for well protected connections not more than 600 mV.

General information

General mounting and grounding instructions

(refer to DOC-0000176104)

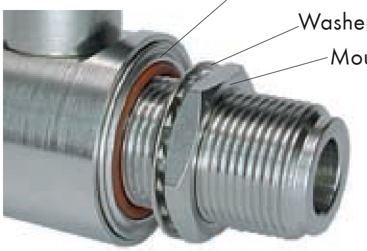
CE Series 3400, 3401*, 3402*, 3403, 3404, 3405, 3406, 3407, 3408*, 3409 and 3410 are compliant to the international standard IEC 61643-21.

*Products delivered ex works without inserted gas discharge tubes are not subject to EC directives and are therefore not marked.

HUBER+SUHNER EMP protectors provide reliable protection against dangerous surge signals on coaxial lines. This includes all kinds of interference e.g. resistive, magnetic field and electric field coupling caused by lightning strikes, switching and other natural or man made electrical effects.

Integration of protective devices

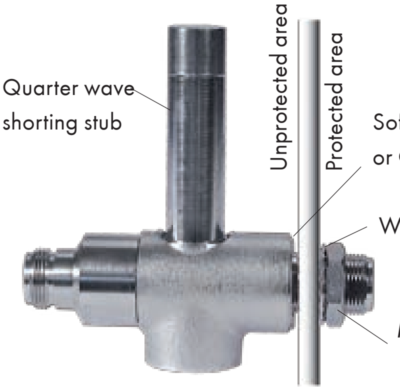
The international standard IEC 62305 describes protection against lightning. According IEC 62305 the protective device integration is based on the lightning protection zone (LPZ) concept with bonding and shielding.



1. Preferred installation

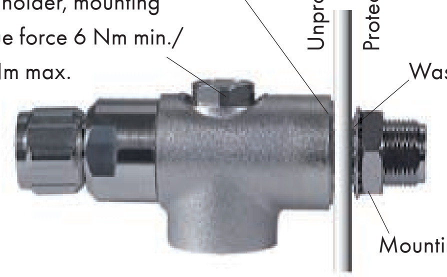
The protection zone principle favours the feed-through installation in a well conductive and grounded panel which is simultaneously the boundary to the higher protection zone containing the equipment to be protected. It is recommended to place quarter-wave (QW) or gas discharge tube (GDT) protective devices as follows: at the line entrance into the structure or alternatively close to the equipment to be protected.

Protectors without GDT
Series 3400, 3407



Well conducting and grounded bulkhead

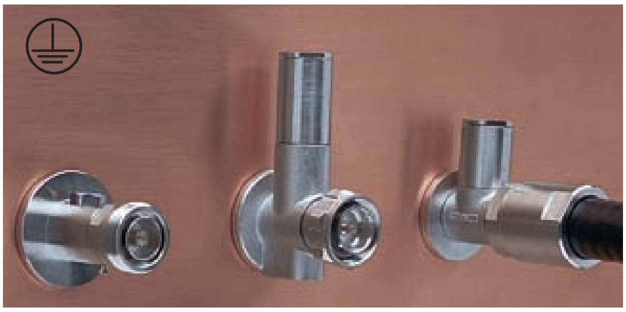
Protectors with GDT
Series 3401, 3402, 3403, 3404, 3405, 3406, 3408, 3409, 3410



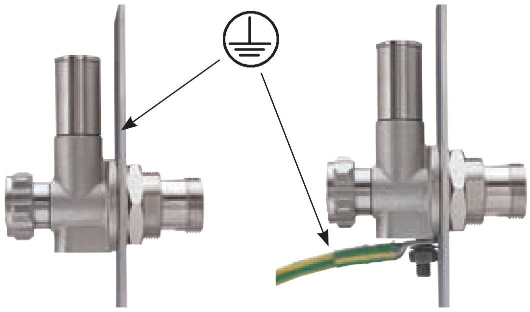
Well conducting and grounded bulkhead

Mounting torque:	AF 19 mm (3/4") max.:	20 Nm (14.7 ftlb) min./25 Nm (18.4 ftlb) max.
For mounting nut size:	AF larger 19 mm (3/4"):	35 Nm (25.8 ftlb) min./44 Nm (32.3 ftlb) max.

Recommendations for bulkhead mounting:



Preferred installation view to the unprotected side



Well grounded panel

Additional grounding measures are necessary if the panel is poorly grounded

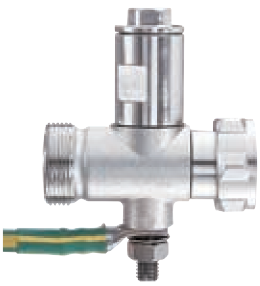
These variants avoid any surge currents which are down conducted by the protector to flow inside of the protected area where they could induce secondary surge signals.

2. Alternative installation possibilities

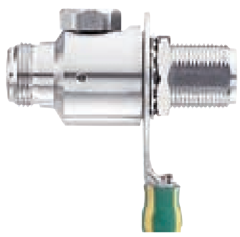
The protectors can alternatively be installed to the equi-potential bonding bar (EBB). The following shows the most common variants:

If this is not possible then the protectors should be connected to the bonding facility by a sufficiently sized grounding cable (AWG 6/16 mm2 min.) as short distant as possible (0.5 m max.)

Via screw to EBB



Via screw and grounding cable to EBB



Via grounding lug and cable to EBB

3. Further general recommendations and hints

- The protector should be grounded directly if any possible (not via the connected cable screen) to keep the ground connection as short as possible.
- Take care for clean and smooth contact transitions when installing. This is also important for waterproof bulkhead installations.
- Torque for bulkhead mounting/grounding for mounting nut size:
  - AF 19 mm (3/4”) max.:
    20 Nm (14.7 ftlb) min./25 Nm (18.4 ftlb) max.
  - AF larger 19 mm (3/4”) max.:
    35 Nm (25.8 ftlb) min./44 Nm (32.3 ftlb)
- Waterproof installations require suitable IEC/MIL conform counter connectors (male connectors include sealing ring) which must be properly tightened.
- With GDT protectors of series 3401, 3402, and 3408 (normally delivered without GDT) select and insert the suitable GDT according to RF power.

Coupling nut torque forces must not exceed IEC standard or manufacturer detail specifications (IEC: DIN 7/16 - 30 Nm (22.1 ftlb) max. and N - 1.13 Nm (0.8 ftlb) max.).

- Select the GDT with the lowest suitable static sparkover voltage to achieve best protection. Generally the minimum value of the static sparkover voltage must not be lower than 1.5 times the peak voltage $\hat{u} = \sqrt{2PZ} \cdot (1 + \Gamma) + U_{DC\_SUP}$ (RF and DC supply voltage) on the line.
- Recommended GDT holder torque force:
  6 Nm (4.4 ftlb)
- Series 3403, 3404, 3405, 3406, 3409 and 3410 products are shipped with GDT included.
- When connecting cables the protector has to be counter-held by a spanner across existing flats on the protector head:
- The bending moment created by connected cables must not exceed specified values (DIN 7/16 - 50 Nm (36.6 ftlb) max. and N - 1 Nm (0.7 ftlb) max.).
- If exposed to extreme environmental conditions, especially icy conditions or polluted atmosphere, the protector should be covered with a self-vulcanising tape or a cold shrink tube.
- Especially protectors made of aluminium mated with connectors made of copper-alloy base material and trimetal or nickel plating must be taped to improve long-term durability.
- When installing and grounding EMP protection devices the electrochemical potential between different metallic contacts should not exceed 300 mV. If exceeding the contact area must be taped, coated or sealed in order to minimize electrochemical corrosion.
- Any liability or responsibility for the result of improper installation is disclaimed.

Warning

Disconnect or switch off in-line equipment when installing, checking, disconnecting and connecting EMP protectors. This includes also the exchange of gas discharge tubes. Keep back from such activities during thunderstorms.
Be aware that only a complete protection system according to IEC 62305 can protect your equipment and personnel against the impact of lightning.

This includes an external lightning protection system with air terminal, down conductor and grounding system and bonding of all incoming and outgoing lines (e.g. protectors for mains, data and telephone lines) - not RF lines only.
With gas discharge tube protectors take care that the GDT has been properly installed before putting the equipment into operation.

Radio frequency bands

Band	Nomenclature	Frequency
ELF	Extremely Low Frequency	3 - 30 Hz
SLF	Super Low Frequency	30 - 300 Hz
ULF	Ultra Low Frequency	300 - 3000 Hz
VLF	Very Low Frequency	3 - 30 kHz
LF	Low Frequency	30 - 300 kHz
MF	Medium Frequency	300 - 3000 kHz
HF	High Frequency	3 - 30 MHz
VHF	Very High Frequency	30 - 300 MHz
UHF	Ultra High Frequency	300 - 3000 MHz
SHF	Super High Frequency	3 - 30 GHz
EHF	Extremely High Frequency	30 - 300 GHz

Selected radio and microwave application

ILS, Back Course Marker	75 MHz
ILS, Runway Localizer	108 - 118 MHz
PMR, Paging	146 - 174 MHz
ILS, Glide Slope Transmitter	328 - 335 MHz
Tetra, Tetrapol	380 - 512 MHz
LTE, Long Term Evolution	700 MHz band USA
GSM 850	824 - 894 MHz
GSM 900	890 - 960 MHz P-GSM 880 - 960 MHz E-GSM 876 - 960 MHz R-GSM
TACS (N+E)	860 - 949 MHz
Tetra	870 - 925 MHz
DME	960 - 1215 MHz
ASR	1030 - 1090 MHz
IFF	1030 MHz
GNSS	1215 - 1240 MHz
GPS L2	1227.6 MHz
PDC	1429 - 1501 MHz
GNSS	1559 - 1610 MHz
GPS L1	1575.4 MHz
GSM 1800	1710 - 1880 MHz DCS 1800
GSM 1900	1850 - 1990 MHz DCS 1900
DECT	1880 - 1900 MHz
IMT-2000 / UMTS	1885 - 2200 MHz
WCDMA / TD-SCDMA	1850 - 2025 MHz
ISM	2400 - 2500 MHz
WLL (IEEE 802.11)	2400 - 5825 MHz
ASR	2700 - 2900 MHz
MLS	5030 5150 MHz
ISM	5725 - 5875 MHz

Glossary

Important terms and abbreviations of wireless communications and lightning protection.

A

Ampere
Unit of electrical current.

AC
Alternating Current – refers to power supply applications with frequencies of e.g. 50 or 60 Hz normally.

AMPS
Advanced Mobile Phone Service – US analog mobile phone standard.

ANSI
American National Standards Institute
Co-ordinator of US voluntary national standards and US representative within ISO and IEC.

Arc Voltage
Increasing current drives the gas discharge tube (GDT) into the arc state. The resulting voltage across the GDT is the arc voltage (UARC).

ASR
Airport Surveillance Radar.

Attenuation (α)
The decrease of a signal with the distance in the direction of propagation. Attenuation may be expressed as the scalar ratio of the input power to the output power, or as the ratio of the input signal voltage to the output signal voltage.

AWG
American Wire Gauge.
US standard for wire sizes.

B

Bandwidth
The range of frequencies for which performance falls within specified limits.

BLIDS
Lightning information service provided by Siemens.

BNC (Bayonet Navy Connector)
Coaxial connector interface definition, miniature size.

Body
Central part and housing of coaxial components or devices, as e.g. coaxial lightning protectors.

Bonding
All measures for a proper potential equalization.

Bonding Bar
Potential equalization facility – part of the LPS.

BS
British Standards Institute.

Bulkhead
A term used to define a mounting style of connectors. Bulkhead connectors are designed to be inserted into a panel cutout from the rear (device side) or front side of the panel.

BSC
Base Station Controller.

BTS
Base Transceiver Station – main part of cellular mobile communications networks, radio transceiver for communications with mobile phones.

BWA
Broadband Wireless Access

C

C – Coulomb
Unit of electrical charge (1 C = 1 As).

C (connector)
Coaxial connector interface definition, standard size.

Capacitance
The property of an electrical conductor (dielectric in a capacitor) that permits the storage of energy as a result of electrical displacement. The basic unit of capacitance is the Farad, however, measurement is more commonly in microfarads or picofarads.

CATV
Common Antenna Television – cable television.

CCIR
Comité Consultatif International des Radiocommunications.

CDMA
Code Division Multiple Access – spread spectrum technology for digital mobile communications.

Centre frequency
Mid-band frequency of a band-pass RF device, as e.g. quarter-wave protectors.

CEPT
European Conference of Postal and Telecommunications Administration.

Cloud-earth lightning
Lightning between cloud and earth (in the standard case from the negatively charged cloud to the positively charged earth).

CFR
Code of Federal Regulations (USA).

CIGRE
Conférence Internationale des Grands Réseaux Electriques à haute tension (International Conference on Large High Voltage).

Coaxial Cable (Line)
For transmission of RF/microwave signals in the TEM mode.

Combiner
RF circuit for the summation of several carriers within a defined frequency range.

Conductivity
A measure of the ability of a material to conduct electric current under a given electric field. Resistivity is the reciprocal of conductivity.

CT
Cordless Telephone.

Current-handling capability
Surge pulse current down-conducting capacity of a protector.

Cut-off Frequency
Upper frequency limit of a coaxial device.

CWG
Combination Wave Generator (surge pulse test generator 1.2/50; 8/20 μs according to IEC 61000-4-5).

CW
Continuous Wave.

CW power
Continuous RF power.

D

DAB
Digital Audio Broadcast.

DASR
Digital Airport Surveillance Radar.

dB – Decibel
Relative, dimensionless unit – 10 times the logarithm to the base ten of a power ratio or 20 times the logarithm to the base ten of a voltage ratio.

dBm
Absolute level of signal power with the reference 0 dBm being equal to 1 milliwatt.

dBc (Carrier)
Ratio of signal power to total carrier power.

DC
Direct current – a steady current in one direction.

DC Throughput
DC can be carried.

DC Injection
Component featuring an DC input/output.

DCS 1800
Digital Cellular System (1710 to 1880 MHz, GSM protocol).

DECT
Digital Enhanced Cordless Telecommunications (1880 to 1900 MHz, previously «Digital European Cordless Telephony»).Dielectric Withstanding Voltage
The maximum potential gradient that a dielectric material can withstand without failure.

DIN (Deutsche Industrienorm)
German Industry Standard.

DIN 1.6/5.6
Coaxial connector interface definition, standard size (outer diameter of inner conductor 1.6 mm, inner diameter of outer conductor 5.6 mm).

DIN 7/16
Coaxial connector interface definition, large size (outer diameter of inner conductor 7 mm, inner diameter of outer conductor 16 mm).

Diplexer
RF circuit for the combination of several carriers into one transmission line.

Direct Stroke
Direct lightning hit into a structure or equipment.

DLP
Data Line Protector.

DME
Distance Measuring System (DME, TACAN, SSR, MIDS, GNSS).

DQPSK
Differential Quadrature Phase Shift Keying.

Duplexer
RF circuit for simultaneous combination and splitting of several carriers for receive and transmit on one transmission line.

DUT
Device Under Test.

Dynamic Spark-over Voltage
Voltage which ignites the gas discharge tube in the case of a voltage rise of 2 kV/µs (U_{Zdyn}).

E

EAMPS
Extended Advanced Mobile Phone Service.

E-GSM
Enhanced Global System for Mobil Communications.

EMI – Electromagnetic Interference
Resistive, magnetic field and electric field cou pling effects caused by surge pulses in general.

EMC
Electromagnetic Compatibility.

EMP
Electromagnetic Pulse.

EM-Terrorism
Terrorism acted by EMI-producing devices.

EN
European Standard

ERC
European Radiocommunications Committee (of CEPT – European radio spectrum management).

ESD
Electrostatic Discharge.

ERMES
European Radio Messaging System.

ETACS
Extended Total Access Communications System.

ETSI
European Telecommunication Standards Institute.

Exo-NEMP
Exo-atmospheric Nuclear Electromagnetic Pulse.

Endo-NEMP
Endo-atmospheric Nuclear Electromagnetic Pulse.

F

F
Coaxial connector interface definition, miniature size.

Faraday Cage
Electric field screen for effective attenuation of electric and electromagnetic fields

FCC
Federal Communications Commission (USA).

FDD
Frequency Division Duplex.

FDMA
Frequency Division Multiple Access.

FDR
Frequency Domain Reflectometry.

Feed-through
Preferred HUBER+SUHNER® protector design enabling bulkhead installation and thus a consequent establishment of protection zones according to IEC 61312-1.

FPLMTS
Future Public Land Mobile Telecommunication System (1885–2025 MHz and 2110–2200 MHz, according to resolution 716 of WRC–95) removal term IMT-2000.

FSK
Frequency Shift Keying.
Basic digital signal modulation principle.

G

GDT
Gas Discharge Tube (gas capsule).

GFD Map
Ground Flash Density Map – showing no. of lightning hits per square mile or square km.

Gigahertz (GHz)
One billion cycles per second (10^9 cps).

GLC
Ground Loop Coupling.

Glonass
Global Orbiting Navigation Satellite System.
(Operator Russia – operation centre frequencies 1246 (1242–1252) MHz and 1602 (1598–1610) MHz).

Glow discharge voltage
Residual voltage across the gas discharge tube (GDT) when the discharge current operates the GDT in the glow state – typically at 10 mA (U_B).

GMSK
Gaussian Minimum Shift Keying.
Digital signal modulation principle.

GNSS
Global Navigation Satellite System (European system on scratch).

GPS
Global Positioning System (US military-operated positioning system – operation frequencies 1227.60 and 1575.42 MHz).

Grounding
All measures to lead a lightning current properly to earth (preferential system of earth termination for charge equalization).

GSM
Global System for Mobile Communications (previously «Groupe Spéciale Mobile»).

GSM-R
Global System for mobile communications for railway networks (GSM-F).

H

Hertz (Hz)
International standard unit for cycles per second.

HIPERLAN
Wireless LAN for mobile computing and multi-media applications.

I

IEC
International Electrotechnical Commission.

IEEE
Institute of Electrical and Electronics Engineers (USA).

IFF
Identify Friend or Foe.

IL Insertion Loss
The loss in load power due to the insertion of a device, connector or device at some point in a transmissions system. Generally expressed in decibels as the ratio of the power received at the load before insertion of the apparatus, to the power received at the load after insertion.

ILS
Instrument Landing System.

IM/PIM (Passive Intermodulation)
Nonlinear characteristics of RF devices cause undesirable signals by modulation effects in the case of several carriers being transmitted.

Impedance (characteristic, Z_0)
Nominal impedance of an RF device.

Impulse discharge current
Peak value of a defined current pulse which is allowed to be applied at least ten times at intervals of 30 seconds without causing any significant changes of the spark-over voltage specification. Values are given for a current pulse shape definition of 8/20 μs (rise time/half-value period) (I_S).

IMT-2000
International Mobile Telecommunication 2000 (1885–2025 MHz and 2110–2200 MHz according to resolution 716 of WRC-95) – also FPLMTS.

Inductance
The property of a circuit or circuit element that opposes a change in current flow, thus causing current changes to lag behind voltage changes. It is measured in Henrys.

Interface
The two surfaces on the contact side of both halves of a multiple-contact connector which face each other when the connector is assembled.

Intermodulation
Refer to IM/PIM.

ISM
Industrial, Scientific, Medical

ISO
International Standardisation Organisation.

Isokeraunic Level Map
Map showing lines of equal no. of thunderstorm days per year (isobronts), sometimes written «isoceraunic».

ITU
International Telecommunications Union (Headquarters Geneva/Switzerland).

J

JCT
Japanese Cordless Telephone.

Joule
Unit of energy (1 J = 1 Ws = 1 Nm)

JTACS
Japanese Total Access Communication System.

K

L

LAN
Local Area Network.

LEMP
Lightning Electromagnetic Pulse.

LPS
Lightning Protection System.

LPZ
Lightning Protection Zone.

LTE – Long Term Evolution
LTE is a set of enhancements to the Universal Mobile Telecommunications System (UMTS) which will be introduced in 3rd Generation Partnership Project (3GPP) Release 8. Much of 3GPP Release 8 will focus on adopting 4G mobile communications technology. Frequency band allocations are defined by 3GPP.

M

Maximum pulse current
Peak value of a defined single current pulse which can be conducted to ground without mechanical destruction or restriction of the protection function. For pulse shape refer to I_S (I_{SG}).

MCX (MICROAX)
Coaxial connector interface definition, subminiature size.

MIDS
Multi Functional Information Distribution System.

MIL-STD
Military standard (USA).

MLS
Microwave Landing System.

MSC
Mobile Switching Centre.

MSK
Minimum Shift Keying.
Basic digital signal modulation principle.

MSS
Mobile Satellite Service.

MTBF
Mean Time Between Failures.

N

N (Navy Connector)
Coaxial connector interface definition, standard size.

NEMP
Nuclear Electromagnetic Pulse (EMI caused by nuclear explosions).

NEMP Protectors
Protectors designed for the very fast NEMPs – a speciality of HUBER+SUHNER AG since 1975 – for coaxial and twin-axial transmission line applications.

NFPA
National Fire Protection Association.
(USA – general standards for lightning protection).

NMT
Nordic Mobile Phone (Europe).

NTIA
National Telecommunications and Information Administration (USA – radio spectrum management).

O

P

Passive Intermodulation
Refer to IM/PIM.

PCB
Printed Circuit Board.

PCN
Personal Communication Network (Europe).

PCS
Personal Communication Systems (North America).

PCS 1900
North American digital mobile communications standard.

PDC
Personal Digital Communications.

PEP
Peak Envelope RF Power

PHS
Personal Handyphone System (Japan).

Planar antenna
Special flat antenna design, suitable for wall integration, i.e. HUBER+SUHNER SPA series antennas.

Plating
Special metal surface layer of metal component parts, deposited galvanically or chemically – for improvement of electrical contact and environmental performance.

PMR
Professional/Private Mobile Radio.

POTS
Plain Old Telephone Service.

PSK
Phase Shift Keying.
Basic digital signal modulation principle.

PTFE (Polytetrafluorethylene)
High-grade isolation material of electronics, unaffected by sunlight, moisture (not wettable) and virtually all chemicals.

Q

QAM
Quadrature Amplitude Modulation.
Basic digital signal modulation principle.

QLA
Coaxial connector interface definition, subminiature size.

QPSK
Quadrature Phase Shift Keying.
Digital signal modulation principle.

R

Radio transceiver
Radio station for simultaneous transmit and receive operation, e.g. BTS

Reflection
See VSWR and RL – return loss.

Residual pulse (voltage and energy)
Output pulse of a protector in the case of any EMI, characterized by its voltage amplitude and energy.

RET
Remote Electrical Tilt unit (antenna drive unit).

RF
Radio Frequency.

RFI
Radio Frequency Interference.

R-GSM
Railway GSM.

Rise Time
Pulse front steepness specification, time period between 10% and 90% of amplitude.

RL – Return Loss
Part of signal which is lost due to reflection of power at a line discontinuity or mismatched RF device.

RLL
Radio in the Local Loop (also WLL).

rms (root mean square)
Characteristics of a sine-wave signal, effective value – important for power calculations.

Rx
Receive (path).

S

Screening Effectiveness
Ratio of the power fed into a coaxial cable to the power transmitted by the cable through the outer conductor.

SEMPER™
Self-extinguishing gas discharge tube protector

Shielding/Screening
Measures to reduce the effects of electromagnetic fields on electronic circuits (attenuation of the electric and magnetic field).

SMA (Subminiature A)
Coaxial connector interface definition, subminiature size.

SMS
Short Message Service.

SPD
Surge Protection Device.

Specific energy (action integral)
Characteristics of a surge current pulse, formula W/R = $\int i^2 L * dt$ (unit MJ/W or kA^2s).

SSR
Secondary Surveillance Radar.

Static spark-over voltage
Voltage which ignites the gas discharge tube in the case of a voltage rise of less than 100 V/ms (U_{Zstat}).

SUCOPLATE®
HUBER+SUHNER® proprietary plating for optimum electrical and environmental performance of RF components, nonmagnetic copper, tin, zinc alloy.

Surge
Overvoltage in general.

Surge Arrestor
Alternative name for surge protector (occasionally also for lightning protector).

Surge suppressor
Alternative name for surge protector (occasionally also for lightning protector).

T

TACS
Total Access Communication System.

TACAN
Tactical Air Naviation.

TDD
Time Division Duplex.

TDMA
Time Division Multiple Access
Digital wireless communications modulation principle where every user channel is formed by a fixed time slot.

TDR
Time Domain Reflectometry.

TETRA
Terrestrial Trunked Radio.

TNC (Threaded Navy Connector)
Coaxial connector interface definition, miniature size.

Total Charge
Characteristics of a surge current pulse,
formula $Q = \int iL * dt$ (unit As or C).

Tx
Transmit (path).

U

UHF (Ultra-High Frequency)
Coaxial connector interface definition, standard size.

UL
Underwriters Laboratory

UMTS
Universal Mobile Telecommunications System
Third generation mobile communication system being developed in Europe (European version of IMT-2000/ FPLMTS considered to be compatible)

V

Volt
Unit of electrical voltage.

VSWR
Voltage Standing Wave Ratio – ratio of U_{max} / U_{min} on an RF transmission line.

W

Wave Guide
Line for transmission of RF/microwave signals in the TM mode – hollow tube design.

W–CDMA
Wideband Code Division Multiple Access.

WiMAX
Worldwide interoperability for Microwave Access

WLAN
Wireless Local Area Network.

WLL
Wireless Local Loop (refer also to RLL).

WRC
World Radio Conference.

X

Y

Z

Special product enquiry form

In the case that you do not find a suitable lightning EMP protector within the presented product range you are invited to call our next available representative or to make use of our HUBER+SUHNER Internet home page www.hubersuhner.com for further information or contacts.
For the most effective discussion of your needs we would like you to fill in the following form. It can also be faxed to us. Once contacting us via Internet the home page will guide you in the products section to our "lightning EMP protector search page" for electronic processing and E-mailing as well.
Short term response guaranteed.

(NSI form – full page for direct copying, including customer's address data, technical specification needs and commercial aspects)