The impact of lightning and its effects

The effects of lightning can be exercised in three ways:

- The first effect is a direct coupling, such as lightning strikes on a pylon. A portion of the discharge current will be driven by the cable. The amplitude of the perturbation depends on the cable length and type.
- The second effect may be due to ground currents. When lightning occurs on a stormy day, a current up to 200kA may flow through the soil. Depending on soil composition and climate, the disturbance could be significant up to 2km.
- The latter effect is the inductive coupling. A cable that carries the current can induce a current in any cable that is parallel.

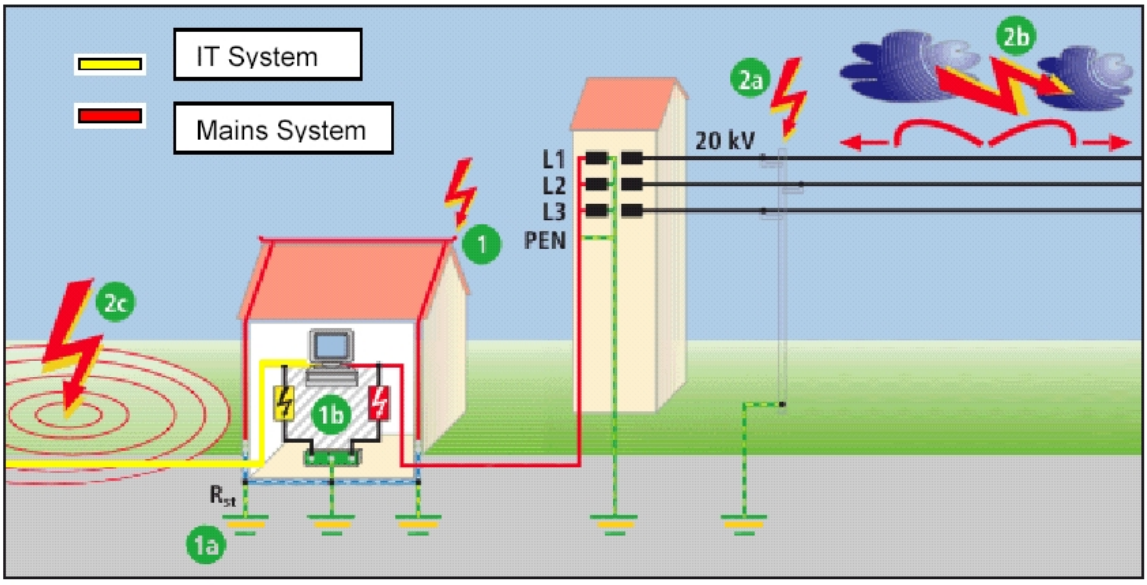


Fig. 3: Causes of surges at lightning discharges

1. Direct close lightening strike
   (a) voltage drop at the impulse earthing resistance R_{st}
   (b) inducted voltage in loops
2. Distant lightning strike
   (a) strike in medium voltage overhead lines
   (b) surge waves travelling on overhead lines due to cloud to cloud lightning
   (c) fields of the lightning channel.

Amplitude and frequency

The discharge currents can reach 200kA with an average of 28kA. Such currents destroy any equipment in case of direct impact. So, protection systems against lightning concern mainly indirect effects of lightning.

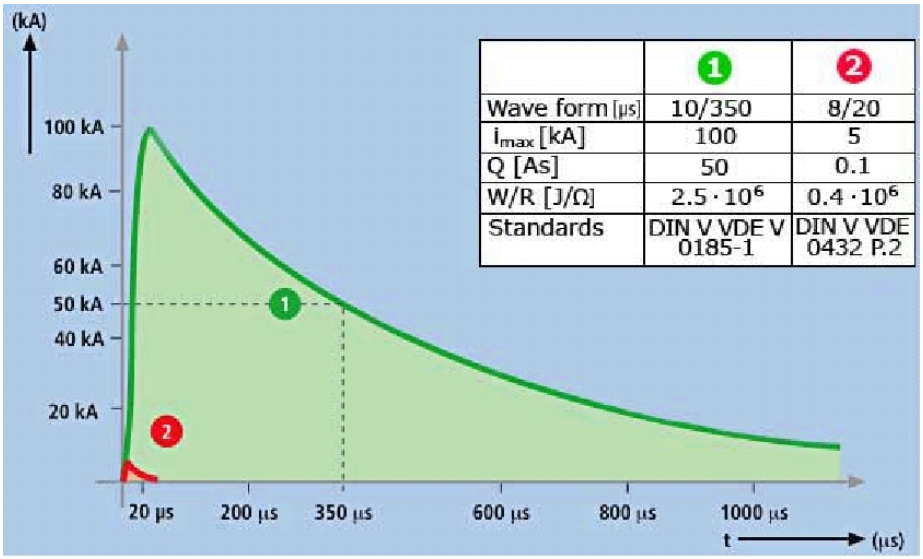
- Table showing the amplitude and frequency of impacts.

Table 1. Lightning Parameters

Percent of strokes	90%	50%	10%
Crest current i	2-8kA	10-25kA	40-300kA
Rate of current rise di/dt	2kA/µs	8kA/µs	20-300kA/µs
Duration of single pulse	100-600µs	0.5-3ms	20-400ms
Total stroke duration	10-100ms	100-300ms	0.5-1.5s
Number of pulses per stroke	1-2	2-4	5-34

Reference: Ezell, T.F., survey of lightning characteristics SC-TM-67-630 (August 1976).

- View of a shock wave from a direct effect 10/350µs in comparison with an indirect effect of lightning 8/20µs



	1	2
Wave form [µs]	10/350	8/20
i_{max} [kA]	100	5
Q [As]	50	0.1
W/R [J/Ω]	$2.5 \cdot 10^6$	$0.4 \cdot 10^6$
Standards	DIN V VDE V 0185-1	DIN V VDE 0432 P.2

Fig 4: **1 = Test impulse current for lightning current arresters**
2 = Test impulse current for surge arresters

Insurance and standards

Insurance companies have become increasingly concerned by repairing and replacing costs of equipment damaged by lightning.

Generally, companies recognize and can impose the protections described in the following documents:

- The Lloyd's of London and an association of insurers refer to the document BS6651: 1999 Appendix C. This document details the various aspects of protection against lighning.
- the U.S. standard IEEE C62.41: 1991
- The international standard IEC 61000-4-5 about electromagnetic compatibility
- The new international standard IEC 62305-4, 2006 regarding protection against lightning. The philosophy of this standard is to define a risk assessment based on zones (Lightning Protection Zones) even in the presence of direct effects of lightning. For each zone, adapted protection devices must be used.

According to IEC 62305-4, the definition of outdoors zones (Lightning Protection Zones) is as follows:

- **LPZ 0_A:** an area subject to the risk of a direct effect of the lightning current pulse
- **LPZ 0_B:** protected area against the direct effect of lightning, subject to the risk of indirect current pulses.

Weighbridge or outside system protection

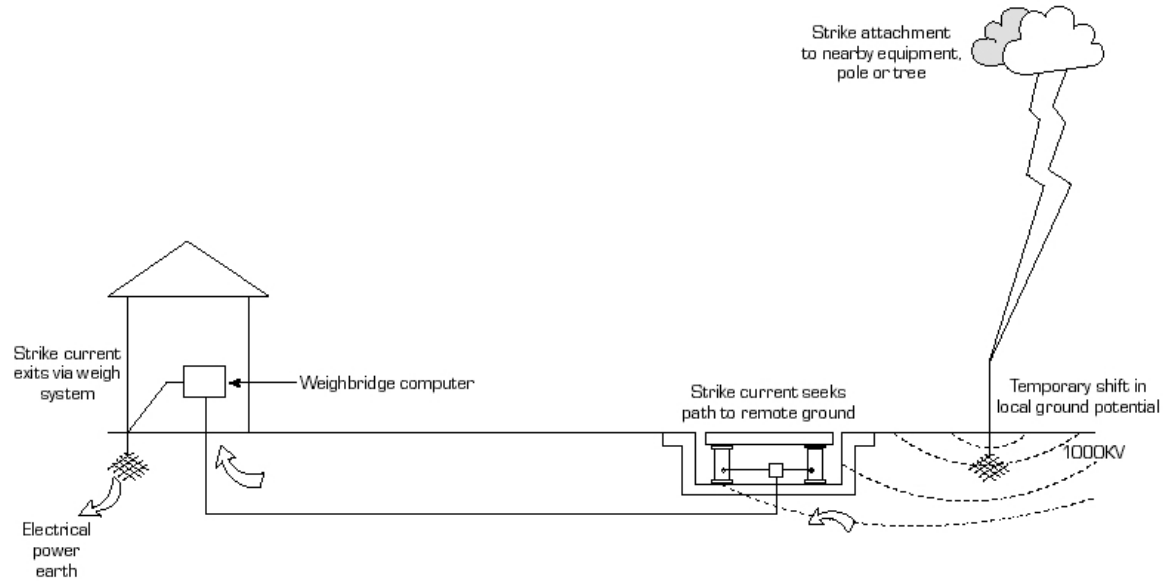
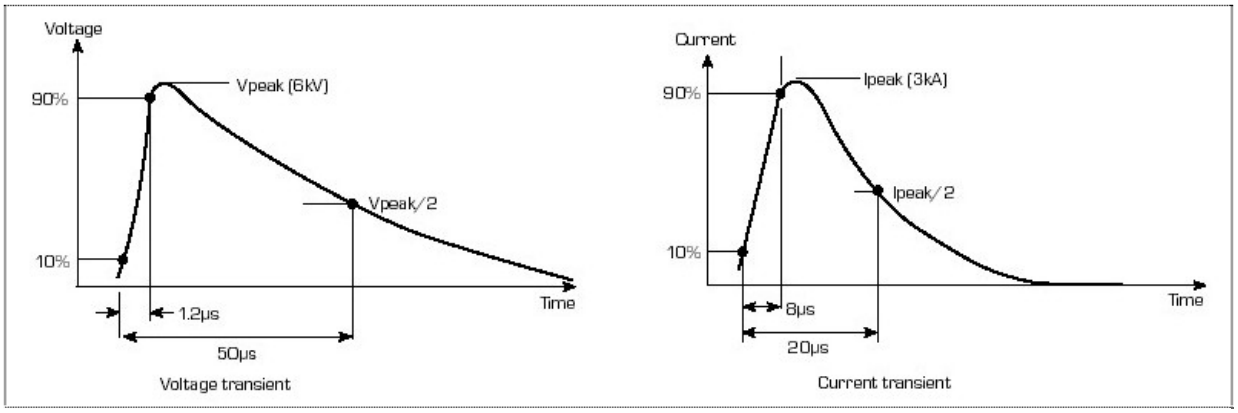


Figure 3 Weigh system damage caused by resistive coupling following a breakdown under local high voltage

Typically the sensors and indicator are classified into LPZ 0_A zone (area exposed to the risk of a direct effect of lightning). However, depending on distance and how the cables run between the indicator and bridge's infrastructure, protection requirements should be not be the same:

▶ Weighing indicator near the weighbridge

In this case, only the indicator is classified in zone **LPZ 0_A**. The main protection against the direct effects of lightning will cover only the indicator power supply. Protecting indirect effects of lightning will be recommended by a device (Surge Protection Device) built into each sensor or placed into the junction box (or both). This device provides a resistance to the waveforms of voltage 8/20µs 20kV and 10kA current (see below).



▶ Weighing indicator away from the weighbridge

In this case, the **LPZ 0_A** classification concerns the sensors and the indicator. Not only protection from the indirect effects is required (junction box and / or sensors), but following the path of the cable (buried or aerial, near other power cables in the same gallery…), a protection against the direct effects is required on both sides of the line.

On the sensors side, the high flow capacity protection 90kA, 150kA or 300kA (Lightning Current Arresters) cannot be integrated into the sensors or the junction box and must be placed upstream of it.

Means for strain gage load cells protection

Analog load cells

An analog load cell consists of four strain gauges connected in Wheatstone bridge and mounted on a test body.

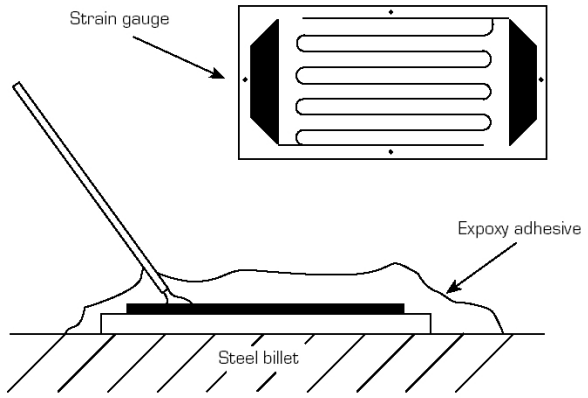


Figure 1 Strain-gauge element construction

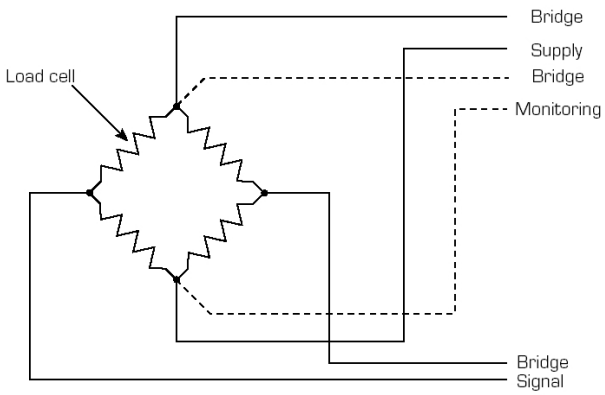


Figure 2 Load cell measurement circuit

The dielectric strength of the strain gauge to the test body is about 500V. Protection against lightning is usually provided by two bipolar gas discharge tubes resistant to waveforms of voltage 8/20µs 20kV and 10kA current.

Digital load cells

A digital load cell combines an analog sensor and electronics for processing and communication.

Protection against lightning is more restrictive than for an analog sensor because the electronic components will not accept over-voltage, even very short.

The waveform passing through a gas discharge tube must be capped at acceptable values with one or more additional stages of protective devices, generally power resistors and Tranzil diodes.

In the case of CB50X-DL digital load cell, the gas discharge tubes and additional protection stages are integrated into the DLCJB junction box.

Earthing and grounding

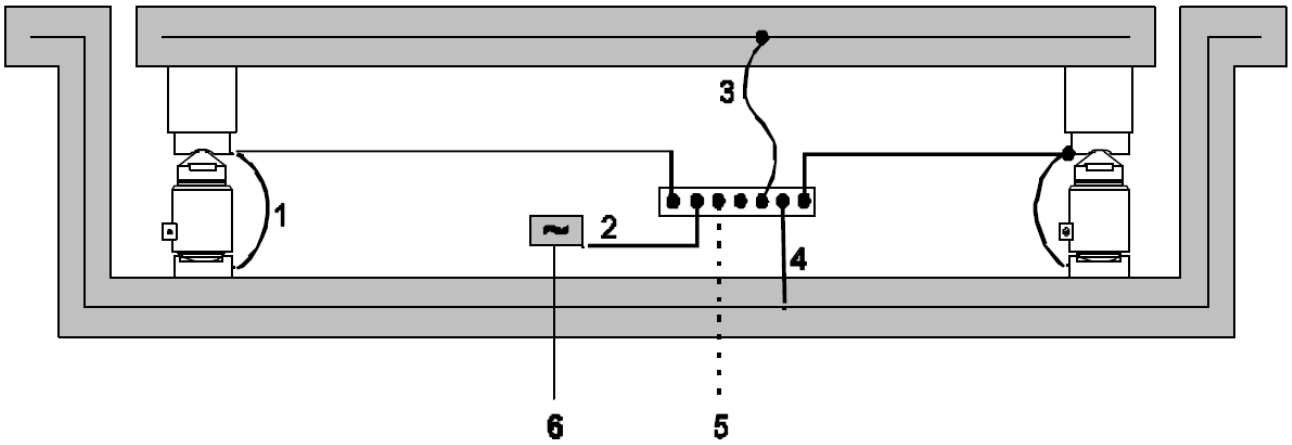
Correct earthing is essential for successful protection. The goal of any protection device for electronic equipment is to maintain a minimal potential difference between the circuit and the local earth/ground.

Surge protection devices are designed to control line-line and line earth voltages to levels acceptable to the equipment.

For that:

Bonding connection must be of low resistance (below 0,3Ω), short in length and as direct as possible without sharp bends.

The load cells and junction box bonding connections should have minimum cross section of 6mm^2 (preferably 16 mm^2).



1 - Bonding cable across load cell
2 - Bonding cable connected to SPD
3 - Bonding cable connected to concrete reinforcement of weighbridge deck
4 - Bonding cable connected to concrete reinforcement of weighbridge pit
5 - Bonding cable either to nearby earthing-bar in weigh cabin or to local earth
6 - Shielded signal/excitation cable to indicator

If the gas discharge tube protection is built into the load cell, the sensor housing must be grounded.

- **Insulation plates**

Some weighbridge manufacturers are using insulation plates between the load cell and the structure. Although some protection is established it should be realized that large lightning induced currents can still flow through the load cells circuit and damage it.

On the other hand, the insulation plates will only function if they are well protected against moisture; as soon as the plates are submerged the insulation resistance will drop dramatically.

So, insulation plates are not considered as a valuable long-term protection against lightning.

Conclusion

- Integrated into a sensor or a junction box, protection by gas discharge tube (GDT Option) covers only the indirect effects of a shock wave caused by lightning.
- In addition to the above protection, only an additional high energy protective device (Lightning Current Arresters) may protect against the direct effects of lightning.
- The effectiveness of the device directly depends on the equipotential grounding quality.

Limit of Warranty

- The GDT option proposed on CB50X load cells and AJCJB or DLCJB junction boxes consists of protective gas discharge tubes built into the products.
- This overcomes the protective effects of a minimum of 10 surges in the limit of 10kA/20kV (8/20 µs).
- It is consistent with the category C described by BS 6651:1999 standard Appendix C referenced by Lloyd's of London.

It can in no way be construed as a guarantee on the behavior of sensors to direct or indirect effects of lightning.