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SERIES K: PROTECTION AGAINST INTERFERENCE

Lightning protection and earthing of a miniature base station

Recommendation ITU-T K.120

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Summary

Recommendation ITU-T K.120 provides guidelines for lightning protection and earthing of miniature base stations. A miniature base station is a new type of radio base station, which is different from a distribution base station (DBS) in many respects. The change of installation environment is the critical factor to affect the lightning protection of miniature base stations.

Miniature base stations have low radio frequency (RF) power and a small volume in size, which makes them suitable for the coverage of hotspots and/or blind areas for improving communication quality. Miniature base stations are ordinarily installed in residential or densely populated urban areas (unconventional telecommunication site), for example, ceiling (indoor), external wall, advertising board, rooftop, street light, low-voltage power pole, and so on, where the installation, wiring and earthing is difficult.

In comparison, distribution base stations, within the domain of macro-base stations, have high RF power and a large volume in size, which is suitable for wide area coverage. Usually a DBS is installed in a conventional telecommunication environment, where the installation, wiring and earthing is easier. Though some installation scenarios are covered by Recommendation ITU-T K.97, lightning protection of miniature base stations are not fully specified in the ITU-T K series of Recommendations.

The purpose of this Recommendation is to give guidance on the protection of miniature base stations against lightning surge, especially for those which are in unexposed environments (to lightning) and unconventional telecommunication sites.

Protection of miniature base stations is achieved by either surge protective devices and/or components or isolation of interfaces. For those where earthing is not available or it is difficult, the base station can be unearthed (floating), as long as the safety measures against electric shock are considered adequately. Bonding configurations of the protection module and of the optical fibre cable are also illustrated.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K.120	2016-12-14	5	11.1002/1000/13136

Keywords

Lightning, miniature base station, surge, unconventional telecommunication site, unexposed environment (to lightning),

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Lightning protection and earthing of a miniature base station

1 Scope

This Recommendation addresses the lightning protection, earthing, bonding and safety considerations for miniature base stations.

The purpose of this Recommendation is to give guidance on the protection of miniature base stations against lightning surge, especially those which are in unexposed environments (to lightning) and unconventional telecommunication sites.

For miniature wireless stations installed in conventional telecommunication sites or highly exposed environments (to lightning), [ITU-T K.97] is applicable.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T K.21] Recommendation ITU-T K.21 (2016), *Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents*.

[ITU-T K.27] Recommendation ITU-T K.27 (2015), *Bonding configurations and earthing inside a telecommunication building*.

[ITU-T K.45] Recommendation ITU-T K.45 (2016), *Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents.*

[ITU-T K.56] Recommendation ITU-T K.56 (2010), *Protection of radio base stations against lightning discharges*.

[ITU-T K.71] Recommendation ITU-T K.71 (2007), *Protection of customer antenna installations.*

[ITU-T K.97] Recommendation ITU-T K.97 (2014), *Lightning protection of distributed base stations*.

[ITU-T K.109] Recommendation ITU-T K.109 (2015), *Installation of telecommunication equipment on utility poles*.

[ITU-T K.112] Recommendation ITU-T K.112 (2015), *Lightning protection, earthing and bonding: Practical procedures for radio base stations*.

[IEC 61643-11] IEC 61643-11 (2011), *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*.

[IEC 62305-1] IEC 62305-1 (2010), *Protection against lightning – Part 1: General principles*.

[IEC 62305-2] IEC 62305-2 (2010), *Protection against lightning – Part 2: Risk management*.

[IEC 62305-3] IEC 62305-3 (2010), *Protection against lightning – Part 3: Physical damage to structures and life hazard.*

[IEC 62305-4] IEC 62305-4 (2010), *Protection against lightning – Part 4: Electric and electronic systems within structures.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

In this Recommendation, definitions already introduced by [ITU-T K.56], [ITU-T K.97] and [ITU-T K.112] are used to maintain conformity. Definitions in [ITU-T K.27], related to bonding configurations and earthing, also apply.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 miniature base station: A type of radio base station (RBS) whose size and RF power are much smaller or lower than typical macro-base stations or DBS base stations.

3.2.2 conventional telecommunication site: A typical telecommunication site (including remote electronic sites), where the lightning protection, earthing and bonding configurations are compliant with the requirements of the relevant ITU-T K series of Recommendations, e.g., [ITU-T K.27] and [ITU-T K.35].

3.2.3 unconventional telecommunication site: Using the simple facilities, such as street lighting poles, urban and rural transportation poles, advertising boards, etc., for the installation of telecommunication equipment, where lightning protection, earthing and bonding configurations are not compliant with the requirements of the relevant ITU-T K series of Recommendations, e.g., [ITU-T K.27] and [ITU-T K.35].

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BBU Base Band Unit

CBN Common Bonding Network

DBS Distribution Base Station

EUT Equipment Under Test

GPS Global Positioning System

ICT Information Communication Technology

LPZ Lightning Protection Zone

MBS Miniature Base Station

PE Protective Earthing conductor

PoE Power over Ethernet

PSE Power Sourcing Equipment

RBS Radio Base Station

RCD Residual Current Operated Device

RF Radio Frequency

RRU Remote Radio Unit

SPD Surge Protective Device

5 Conventions

None.

6 Reference configuration

6.1 Typical configuration of miniature base systems

A miniature base system typically consists of a miniature base station, antenna, power supply unit and transmission equipment. In some cases, the antenna and/or transmission unit is/are integrated into the base station. A typical configuration of a miniature wireless base system is as follows.

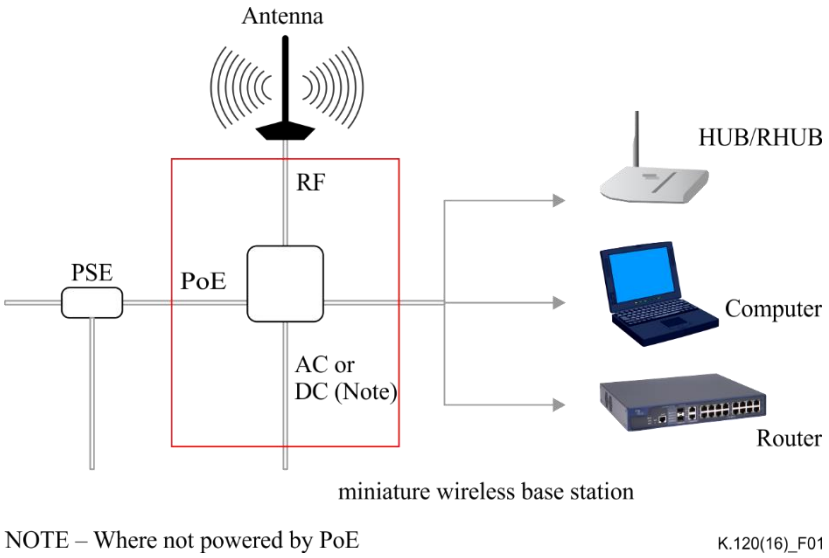


Figure 1 – Typical configuration of miniature wireless base system

A miniature base station has low RF power and a small volume in size, which makes it suitable for the coverage of hotspot areas and blind areas for improving communication quality. A miniature base station is ordinarily installed in residential or densely populated urban areas (unconventional telecommunication site), for example, ceiling (indoor), external wall, advertising board, rooftop, street lamp, power utility pole, and so on, where the installation, wiring and earthing is difficult.

In comparison, a distribution base station, within the domain of macro-base stations, has high RF power and a large volume in size, which is suitable for wide area coverage. Usually a DBS is installed in a conventional telecommunication environment, where the installation, wiring and earthing is relatively easy.

Besides, some miniature base stations take advantage of existing RBS sites, including DBS sites, which are considered as conventional telecommunication environments. In these cases, the requirements of [ITU-T K.56], [ITU-T K.97] and [ITU-T K.112] apply.

6.2 The ports susceptible to lightning surges

There are four types of ports that are susceptible to lightning surges; these are shown in Figure 2.

– Power port: Either alternate current (AC) or direct current (DC). In some cases, the station is powered by PoE, which is classified as a signal port.

– Signal or control port: e.g. transmission port (including PoE), monitoring port and control port.
– RF port: all kinds of RF ports, such as antenna, GPS, etc.
– Earthing port: the earthing port of equipment.

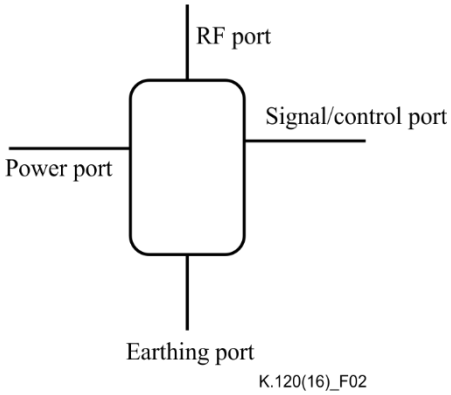


Figure 2 – The ports susceptible to lightning surge

7 Need for protection

The main key factors to be considered when determining the need for protection, and any necessary protective measures to be taken, are as follows:

– the geographical environment where a miniature base station is installed, e.g., urban environment, suburban environment or rural environment, as defined in [IEC 62305-2];
– the lightning ground flash density, or roughly the keraunic level;
– the lightning protection zone (LPZ);
– the type of power supply, the length of power cable and its exposure to lightning strikes.
– the type of signal transmission, the length of signal cable and its exposure to the lightning strikes.

Subsequently, the installation scenarios of miniature base stations can be classified as follows:

– Unexposed environment: It can be considered as an unexposed environment if a miniature base station is installed indoors or on the lower building external wall, and powered through an indoor distribution box or panel. In this environment, the surge current is limited by current sharing and by isolating interfaces and/or SPDs upstream. The lightning electromagnetic field may be attenuated too.
– Low-exposed environment: It can be considered as a low-exposed environment if a miniature base station is installed on the upper building external wall, street lamp, advertising board, power utility pole, urban ordinary building rooftop, and in regions of low lightning activity. In this environment, direct lightning current is not likely to be injected into the system, but inductive lightning current can be produced to some extent.
– Medium-exposed environment: It can be considered as a medium-exposed environment if a miniature base station is installed on the rooftop of a high-rise building in an urban area, rooftop in the suburbs or countryside, utility or lighting poles alongside railways or highways. In this environment small partial direct lightning current may be injected into the system, but inductive lightning current is dominant.
– High-exposed environment: It can be considered as a high-exposed environment if a miniature base station is installed at a tower site or countryside rooftop site. In this environment a substantial part of the lightning current may be injected into the system.

Generally, for unexposed and low-exposed environments, an external lightning protection system may not be a necessity. For medium and high-exposed environments, the risk assessment against lightning shall be performed according to [IEC 62305-2] or practically to [ITU-T K.97] in order to determine whether the external lightning protection system is needed or not. In any case, except for the unexposed environment, surge protective devices for the AC power port of a miniature base station may be needed if an overhead power line is used.

8 Lightning protection

8.1 Air-termination system and down conductor

All parts or components in a miniature base station, including base station equipment, antenna, power supply unit, transmission equipment, and the cables, shall not be exposed to lightning strikes directly. To this aim, the miniature base station shall be within the protective range of either another structure, building or an air-termination system.

For miniature base stations installed in an unexposed area, low-exposed area and parts of a medium-exposed area, where supplementary protective measures are not necessary according to the risk assessment, the air-termination system may not be installed. For the installation scenarios where supplementary protective measures are necessary according to the risk assessment, the air-termination system shall be installed.

Unless otherwise specified, the related specifications of [ITU-T K.112] on air-termination system and down conductors are applied.

The metallic poles or masts can act as natural air-termination system and down conductor when its minimum cross-sectional area meets the requirement of [ITU-T K.112] and the electrical continuity is made durable. In this case, the upper side of all parts or components of a miniature base station shall be at least 30 cm lower than the top of the pole or mast, as shown in Figure 3a.

It is recommended that the minimum length of the lightning rod is 30cm, when it is installed on the pole, as shown in Figure 3b.

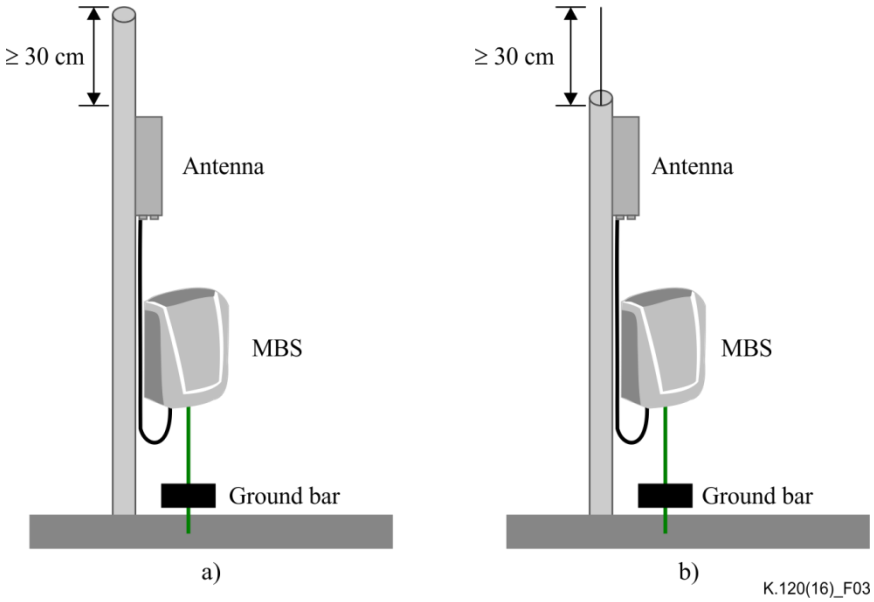


Figure 3 – The ports susceptible to lightning surge

8.2 Earth electrode

The earth electrode of a miniature base station shall be designed according to factors such as the form of the base station structures, geographic position, neighbouring environment, geology and climate conditions, soil constitution and soil resistivity, and so on.

For a telecommunication tower site or rooftop site, [ITU-T K.112] is applied. For a pole or mast site along a railway line or highway, [ITU-T K.112] for telecommunication tower sites is referred to.

For other sites, such as street lights, advertising boards and the like, whenever feasible, low earthing resistance with a ring loop earth electrode is preferred. Otherwise, the Type A arrangement specified in [IEC 62305-3] is generally needed as a minimum requirement.

– This type of arrangement comprises horizontal or vertical earth electrodes installed outside the structure to be protected, connected to each down-conductor or foundation earth electrodes not forming a closed loop.
– In Type A arrangements, the total number of earth electrodes shall be not less than two.
– The minimum length of each earth electrode at the base of each down-conductor is:
  • 5 m for horizontal electrodes, or
  • 2.5 m for vertical (or inclined) electrodes.
– For combined (vertical or horizontal) electrodes, the total length shall be considered.
– The minimum length stated above may be disregarded, provided that an earthing resistance of the earth-termination system less than 10 Ω (measured at a frequency different from the power frequency and its harmonics, in order to avoid interference) is achieved.

Where a conventional earth electrode cannot be implemented for any reason, for an unexposed area or low-exposed area, the underground part of a metallic pole or steel-reinforced concrete can be used as natural earth electrodes. Meanwhile, additional protection measures should be considered to ensure personal safety.

Where no condition for an earth electrode is provided, for an unexposed area or low-exposed area, the miniature base station shall be installed as specified in clause 9, and additional protection measures should be considered to ensure personal safety.

8.3 Protection of power port

Miniature base stations installed in an existing RBS or DBS site are usually powered by a DC power supply. The lightning surge protection of its DC power port is described in [ITU-T K.97].

For miniature base stations installed in an unconventional telecommunication site, it is usually powered by a single-phase AC power supply due to its low RF power. The AC SPD or protection module (either being a protection module inside a miniature base station or being an SPD box outside, as shown in Figures 4a and 4b) is recommended according to the installation scenarios and shall comply with [IEC 61643-11]. The minimum nominal discharge current I_n or impulse current I_{imp} is recommended as shown in Table 1. The protection level should be selected in order to achieve an effective protection level lower than the resistibility of the miniature base station.

In some countries, an isolation transformer or other protective measures are used. If the isolation voltage of the isolation transformer is not less than 10kV, the SPD or protection module may not be necessary.

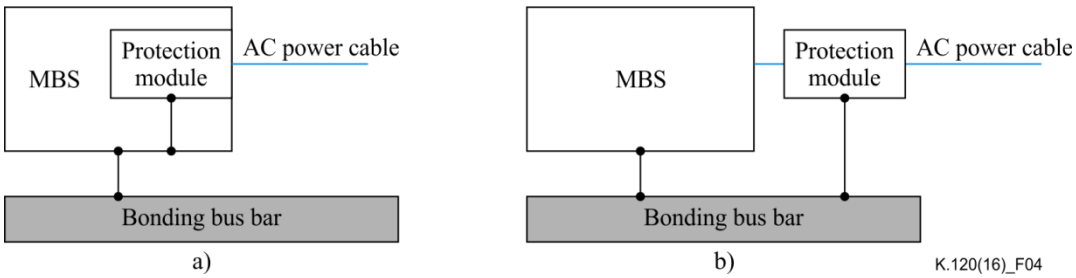


Figure 4 – Protection module on AC power cable

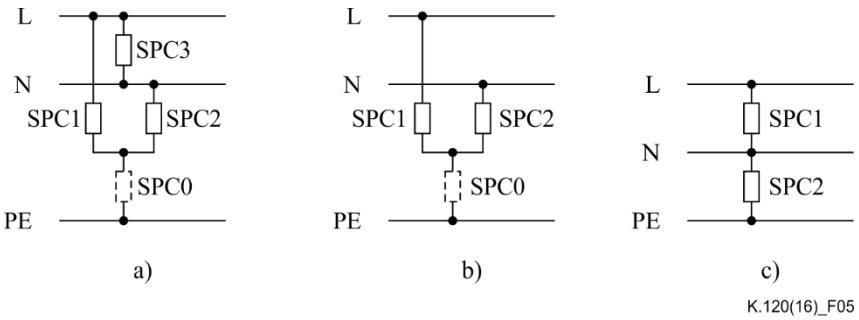
Table 1 – Minimum nominal discharge current I_n or impulse current I_{imp} of SPD

Installation scenarios	I_n (8/20 us)	I_{imp} (10/350 us)
Unexposed area	–	–
Low-exposed area	5 kA	–
Medium-exposed area	10 kA	–
High-exposed area	10 kA	To be determined
NOTE: a) All values refer to each line conductor. b) All values refer to unshielded lines. For shielded lines, the values can be reduced by a factor of 0.5.		

The recommended surge protection diagrams for a single-phase power supply system are shown in Figures 5a, 5b and 5c. The protection diagram in Figure 5a is a symmetric circuit, which is suitable in the case when there is the risk of reverse connection between the live conductor and neutral conductor, and the resistibility of down-stream circuit is relatively low.

The protection diagram in Figure 5b is a symmetric circuit as well, which is suitable in the case when there is the risk of reverse connection between the live conductor and neutral conductor, and the resistibility of down-stream circuit is relatively high.

The protection diagram in Figure 5c is an asymmetric circuit, which is suitable in the case when there is no risk of reverse connection between the live conductor and neutral conductor. In this case, the nominal discharge current of SPC or SPD between N and PE shall be twice the value specified in Table 1.



NOTE – Where SPC0 exists in Figures 5a and 5b, its nominal discharge current shall be twice the value specified in Table 1.

Figure 5 – Possible protection schemes of AC power port

8.4 Protection of signal port

For the signal port, including PoE port of MBS, the requirements of [ITU-T K.21] and [ITU-T K.45] shall be met.

9 Bonding configuration

9.1 The power distribution

There are at least three possible types of power supplies to power the miniature base station equipment:

– AC power: Typically, the miniature base station equipment is powered by AC from the power utility. A single-phase AC power supply is usually used due to its low RF power.

– DC power: For a miniature base station installed in an existing RBS or DBS site, it is usually powered by -48V DC power supply, since it is readily available.

– Power over Ethernet (PoE). For those base stations with very low RF power, PoE is an easy and convenient way to power the equipment.

9.1.1 AC power distribution

It is recommended that type TN-S, as specified by the [IEC 60364-1], be used in order to improve the safety both for equipment and personnel. This requires that there shall be a PE conductor in the power cable for miniature base stations. Consequently, a single phase power cable is, physically, a three-wire cable (L, N, PE).

Measures shall be taken to assure the electrical continuity of the PE conductor from its origin side up to the base station equipment.

9.1.2 DC power distribution

In existing radio base stations, including distribution base stations, DC power is generally distributed from a DC power cabinet, with the positive terminal connected to the common bonding network of the site.

The return conductor of the DC distribution system may be connected to the common bonding network (CBN) in either of two manners. It may be connected at only one location, as an isolated DC return system (dc-I). Or the DC return may connect to the CBN at several locations (in which case some DC current is conducted by the CBN), as a DC return common to a CBN (dc C-CBN). Because of the small size of an RBS site, the common-mode voltages (and the conversion to transverse mode voltage) supported by either of these two distribution systems should be comparable.

The bonding conductor that connects the return side of the DC power source to the bonding-bus bar shall be capable of conducting the maximum fault current of the power system.

9.2 Bonding of equipment

For miniature base stations installed in an existing RBS or DBS site, either a tower site or rooftop site, the bonding of the equipment is similar to the bonding of the RRUs in [ITU-T K.97] and [ITU-T K.112].

For miniature base stations installed in an unconventional telecommunication site, it shall be directly bonded to the bonding bus-bar or other equivalent means, which is connected to the local earth electrodes.

For an unexposed environment and low-exposed environment, where miniature base station equipment is powered with PE conductor whose electrical continuity is confirmed, the additional bonding conductor can be omitted. In this case, supplementary measures, such as isolation and using non-metallic enclosure, should be used to assure personal safety.

9.3 Bonding of shielded cable

The shield or metallic sheath of the cable shall be electrically continuous for its entire length and shall be bonded to the earthing network at its two ends. The bonding connection could be implemented to the equipment metallic shell or bus-bar inside or near the equipment.

9.4 Bonding of optical fibre cable

A metal-free optical fibre cable is recommended if possible.

If an optical fibre cable with metallic component or metallic sheath is used, the metallic component or sheath should be bonded to the bonding bus-bar or the equivalent means.

9.5 Other metallic parts

All frames, racks and metallic enclosures should be bonded to the bonding bus-bar or the equivalent means. Metallic hardware, such as framing channels, air ducts and permanently installed access ladders, should also be bonded together, as well as to the bonding bus-bar.

10 Miscellaneous

When miniature base stations are installed on utility poles, the guidelines of [ITU-T K.109] shall be observed.

Appendix I

Examples of earthing means for an MBS installed in two typical scenarios

(This appendix does not form an integral part of this Recommendation.)

NOTE – This appendix presents two hypothetical scenarios of the application of a miniature base station. This appendix is intended to provide information about the consideration of earthing solutions in limited situations to illustrate the application principles contained in this Recommendation. It is not intended to address the specific aspects of the conditions that exist in all facilities or systems.

I.1 Scenario I: MBS installed on external wall

One typical installation scenario of a miniature base station is on the external wall of an existing building. In most cases, there are earth electrodes beneath the building already, which can serve as earth electrodes for the MBS, if the building owner agrees. However, sometimes no existing earth electrode is available. In this case, earthing measures should be provided for the sake of both personal safety and surge protection of the MBS.

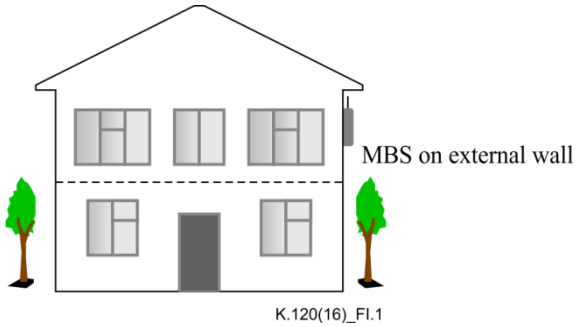


Figure I.1 – MBS installed on the external wall of an existing building

Generally a copper conductor, either solid or stranded, is used for the earthing conductor of the MBS. In some countries, other materials such as aluminium, copper-coated steel, etc., can also be used. For a copper earthing conductor used separately in an outdoor environment, the cross-sectional area should be not less than 6mm^2.

As a general specification, the length of the earthing conductor should not be longer than 30m. Where the length of earthing conductor exceeds 30 m, measures should be taken as follows:

1) rearranging the earthing bus-bar to shorten the earthing conductor; or
2) adding an additional bus-bar, and observing that the cross-sectional area of earthing conductor between the additional bus-bar to the existing bus-bar is not less than 16mm^2; or
3) using an earthing conductor not less than 16 mm^2.

Case 1: MBS earthed through an earthing bus-bar

Where an earthing bus-bar, which is well connected to earth electrodes already, is available in situ, it is recommended that the earthing terminal of an MBS be connected to the earthing bus-bar directly.

Case 2: MBS earthed through earthed metallic parts

The earthing terminal of an MBS can be connected to the metallic frameworks, brackets and the like on the wall only if these metallic parts are confirmed to be earthed reliably already. It is noted that water pipes and gas pipes shall not be used for earthing means in many countries.

Case 3: MBS earthed through an earthed power distribution box

Where a power distribution box with good earthing conditions is used, the earthing terminal of an MBS can be connected to the earthing of the box.

Case 4: MBS earthed through a PE conductor of the power cable

Where an MBS is powered with a PE conductor whose electrical continuity is confirmed, the additional bonding conductor can be omitted. In this case, supplementary measures, such as isolation, using non-metallic enclosure and installing an RCD should be used to assure personal safety.

Case 5: MBS earthed through newly-constructed earth electrodes

If none of above earthing means are available or guaranteed, new earth electrodes should be constructed.

As an example, two simplified earth electrodes which meet the minimum requirements of the Type A arrangement specified in [IEC 62305-3] are shown in Figure I.2.

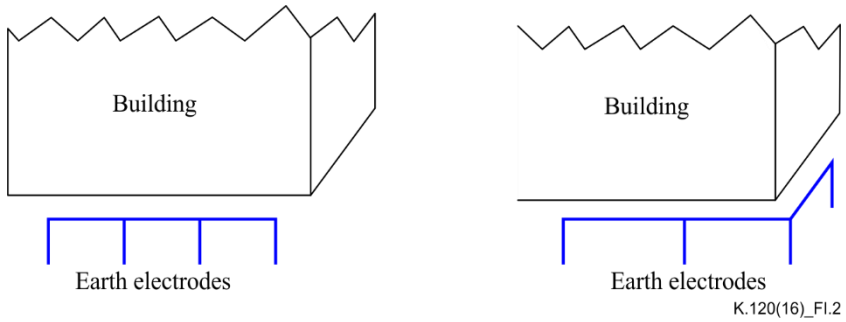


Figure I.2 – Earth electrodes for an MBS installed on the external wall of an existing building

The total length of horizontal earth electrodes is typically between 10 m and 20 m. It is recommended that vertical earth electrodes, typically 1.5 m ~ 2.5 m long, be added at every 5m interval. The earth electrodes could be made of copper, tin plated copper, copper coated steel, hot-dipped galvanized steel, or stainless steel. For the minimum dimensions of earth electrodes, refer to [ITU-T K.112].

I.2 Scenario 2: MBS installed on a street light

The other typical installation scenario of a miniature base station is on the poles of street lights, including metallic poles, concrete poles, wooden poles, etc. In most cases, there is earthing means for a lighting fixture already, which can be used for the earthing of the MBS. However, sometimes no existing earthing means are available. In this case, earthing measures should be provided for the sake of both personal safety and surge protection of the MBS.

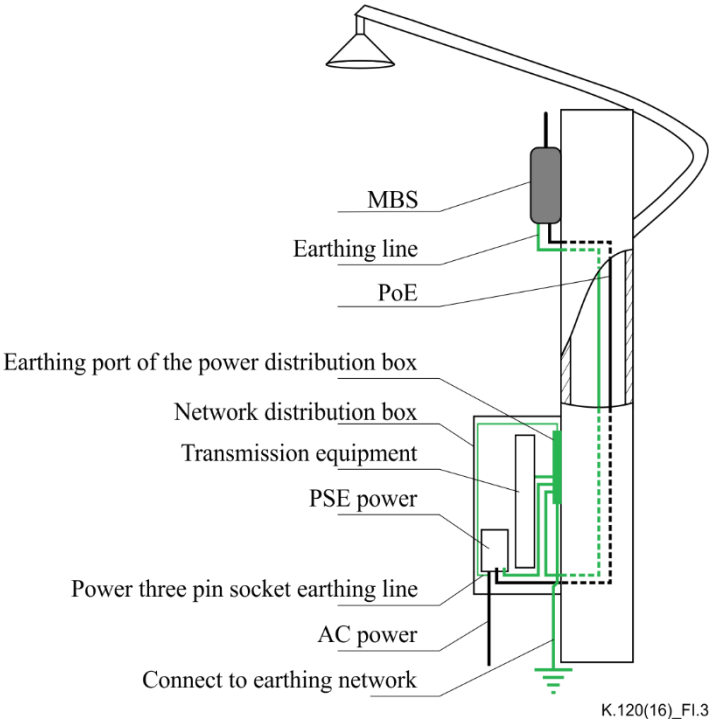


Figure I.3 – MBS installed on a street light

Case 1: MBS earthed through earthing bus-bar

Where earthing bus-bar, which is well connected to the earthing electrode already, is available in situ, it is recommended that the earthing terminal of an MBS be connected to the earthing bus-bar directly.

Case 2: MBS earthed through down conductor or earthed metallic pole itself

In most countries, down conductor is installed along the lighting pole for the earthing of PE conductor of overhead power lines and/or safety earthing for equipment such as lighting fixture. The earthing terminal of an MBS can be connected to the down conductor, if it is confirmed to be reliably earthed. Besides, the earthing terminal of an MBS can be connected to the metallic pole by appropriate means, if the metallic pole is reliably earthed.

Case 3: MBS earthed through earthed power distribution box

Where power distribution box with good earthing condition is used, the earthing terminal of an MBS can be connected to the earthing bar of the box.

Case 4: MBS earthed through PE conductor of power cable

Where MBS is powered with PE conductor whose electrical continuity is confirmed, the additional bonding conductor can be omitted. In this case, supplementary measures, such as isolation, using non-metallic enclosure, installing a RCD, should be used to assure personal safety.

Case 5: MBS earthed through newly constructed earth electrodes

If none of above earthing means are available or guaranteed, new earth electrodes should be constructed.

As an example, a simplified earth electrode that meets the minimum requirements of the Type A arrangement specified in [IEC 62305-3] is shown in Figure I.4.

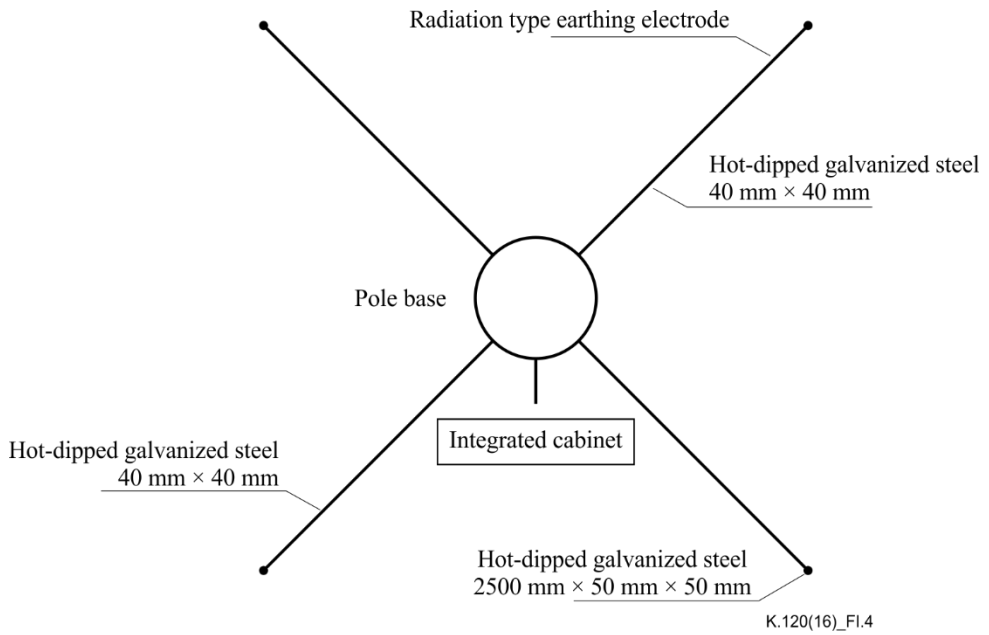


Figure I.4 – Earth electrodes for an MBS installed on a street light

A radial type earth electrode is recommended for the poles of street lights, if applicable. The total length of horizontal earth electrodes is typically between 10 m and 20 m. It is recommended that the vertical earth electrodes, typically 1.5 m ~ 2.5 m long, to be added at the far end of each radial horizontal earth electrode. The earth electrodes could be made up of copper, tin plated copper, copper-coated steel, hot-dipped galvanized steel or stainless steel. For the minimum dimensions of earth electrodes, refer to [ITU-T K.112].

Bibliography

[b-ITU-T K.46] Recommendation ITU-T K.46 (2012), *Protection of telecommunication lines using metallic symmetric conductors against lightning-induced surges*.

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