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Lightning protection and earthing of video surveillance systems

Recommendation ITU-T K.142

ITU-T

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Lightning protection and earthing of video surveillance systems

Summary

Recommendation ITU-T K.142 provides a set of practical procedures related to lightning protection, earthing and bonding of a video surveillance system (VSS).

The main objective of Recommendation ITU-T K.142 is to reduce the risk of damage to VSSs due to lightning strikes, which will improve the safety and reliability of the VSS itself and its related equipment. Recommendation ITU-T K.142 also provides the configuration and rating of protection modules required to protect VSSs against lightning surges.

Usually VSSs can be used to remotely capture multimedia, e.g., audio, video, image and alarm signals and present them to the end user in a user-friendly manner, based on a managed broadband network with ensured quality, security and reliability.

According to the type of signal transmitted, VSSs can be divided into three kinds: analogue; hybrid digital-analogue; and full digital (also called Internet Protocol (IP) based). Because IP-based VSSs are more complicated for lightning protection, they lie outside the scope of Recommendation ITU-T K.142, see Recommendation ITU-T K.45.

Annex A presents a VSS classification, while Appendix I presents an overview of practical procedures of earthing for VSS front-end equipment.

Related technical requirements have been adopted in many surveillance products, effectively improved the lightning protection ability and usage of related products, ensuring that networks operate normally.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K.142	2019-11-13	5	11.1002/1000/14073

Keywords

Lightning protection and earthing, video surveillance system.

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Recommendation ITU-T K.142

Lightning protection and earthing of video surveillance systems

1 Scope

This Recommendation deals with lightning protection and earthing of video surveillance system (VSS) access to the telecommunications network. It contains procedures for earthing and bonding, and direct lightning protection of the VSS, including protection methods for the associated power lines, requirements for surge protective devices (SPDs), and protection procedures for ancillary facilities.

Internet protocol (IP) camera systems are not included in this Recommendation, for such systems, see [ITU-T K.45]. The power over Ethernet (POE) port resistibility should comply with [ITU-T K.45].

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.20] Recommendation ITU-T K.20 (2019), *Resistibility of telecommunication equipment installed in a telecommunication centre to overvoltages and overcurrents*.

[ITU-T K.21] Recommendation ITU-T K.21 (2019), *Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents*.

[ITU-T K.44] Recommendation ITU-T K.44 (2019), *Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation.*

[ITU-T K.45] Recommendation ITU-T K.45 (2019), *Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents*.

[ITU-T K.85] Recommendation ITU-T K.85 (2011), *Requirements for the mitigation of lightning effects on home networks installed in customer premises*.

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

[ITU-T K.112] Recommendation ITU-T K.112 (2019), *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 61643-12] IEC 61643-12:2008, *Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles*.

[IEC 61643-21] IEC 61643-21:2000+AMD1:2008+AMD2:2012, *Low voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signalling networks; Performance requirements and testing methods.*

[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.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 video surveillance system [b-ITU-T H.626]: A telecommunication service focusing on video (including audio and image) application technology, which is used to remotely capture multimedia (such as audio, video, image, alarm signal, etc.) and present them to the end user in a user-friendly manner, based on a managed broadband network with ensured quality, security and reliability.

3.1.2 maximum continuous operating voltage (U_C) [IEC 61643-11]: Maximum r.m.s. voltage, which may be continuously applied to the SPD's mode of protection.

3.1.3 multiservice surge protective device (MSPD) [ITU-T K.85]: A surge protective device (SPD) containing both telecommunications and mains protection. It may also include port protection for video or Ethernet.

3.1.4 nominal discharge current for class II test (I_N) [IEC 61643-11]: Crest value of the current through the SPD having a current wave shape of 8/20 μs.

3.1.5 one-port SPD [IEC 61643-11]: SPD having no intended series impedance.

NOTE – A one port SPD may have separate input and output connections.

3.1.6 rated load current (I_L) [IEC 61643-11]: Maximum continuous rated r.m.s. current that can be supplied to a resistive load connected to the protected output of an SPD.

3.1.7 residual voltage (U_{res}) [IEC 61643-11]: Crest value of voltage that appears between the terminals of an SPD due to the passage of discharge current.

3.1.8 surge protective device (SPD) [IEC 61643-11]: Device that contains at least one nonlinear component that is intended to limit surge voltages and divert surge currents.

NOTE – An SPD is a complete assembly, having appropriate connecting means.

3.1.9 two-port SPD [IEC 61643-11]: SPD having a specific series impedance connected between separate input and output connections.

3.1.10 voltage protection level (U_p) [IEC 61643-11]: Maximum voltage to be expected at the SPD terminals due to an impulse stress with defined voltage steepness and an impulse stress with a discharge current with given amplitude and wave shape.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

NOTE – Some term definitions, specifically defined for non-linear voltage limiters, are inappropriate for the wide range of mitigation functions covered in this Recommendation. The definitions for these terms have been redefined to make them generic.

3.2.1 front-end equipment: Outdoor camera and associated ancillary equipment.

3.2.2 surveillance centre: A series of devices and subsystems located at the centre of a visual surveillance system. A surveillance centre is used to integrate all capabilities and provide visual surveillance services to customers. The main functions include: service-control function, media switching, distribution, storage, and control and management functions.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC	Alternating Current
AV	Audio-Video
CCU	Camera Control Unit
DC	Direct Current
DVR	Digital Video Recorder
IP	Internet Protocol
LPL	Lightning Protection Level
LPS	Lightning Protection System
LPZ	Lightning Protection Zone
MSPD	Multiservice Surge Protective Device
POE	Power Over Ethernet
PTD	Pan-Tilt Device
PVC	Polyvinyl Chloride
r.m.s.	root mean square
SPD	Surge Protective Device
VSS	Video Surveillance System

5 Video surveillance systems

5.1 Reference configurations

Generally, VSSs consist of front-end equipment, transmission equipment and a surveillance centre whose function is control and display.

The links between front-end equipment, transmission equipment and surveillance centre can be coaxial cable, optical fibre or other means.

Figure 1 is a schematic diagram of a typical VSS.

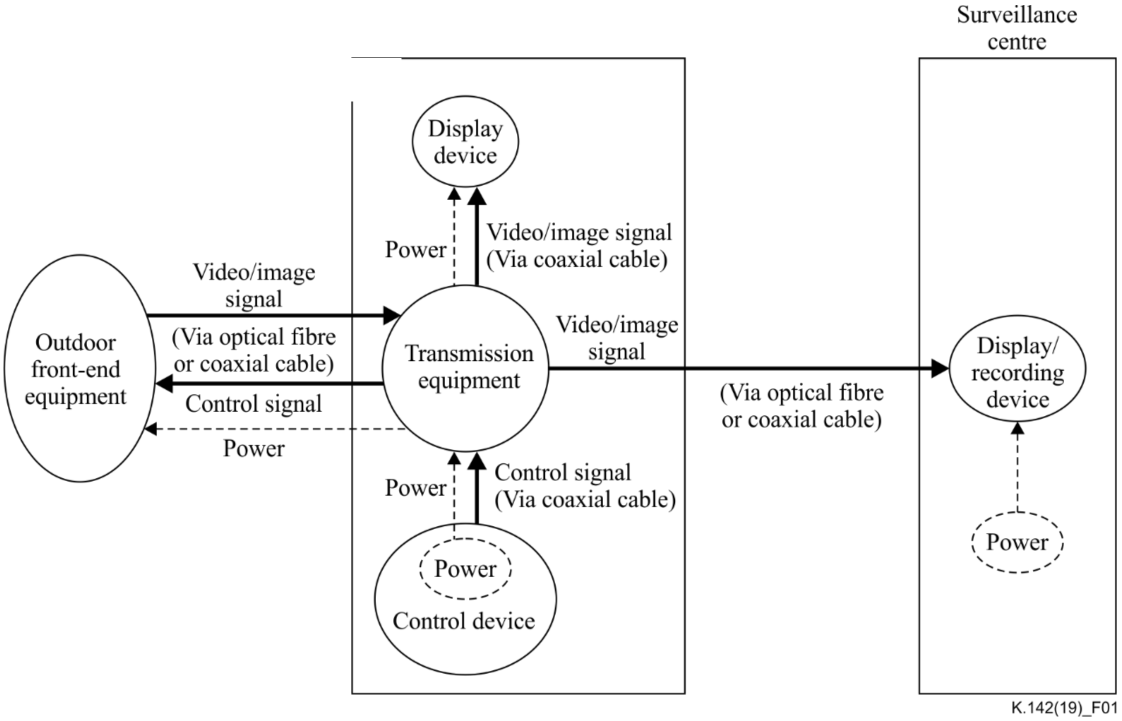


Figure 1 – System schematic of a video surveillance system

(IP POE camera systems are not included**)**

5.2 Need for protection

A VSS has front-end equipment (such as an outdoor camera), transmission equipment, control equipment, display/storage equipment etc. The following technical aspects should be taken into account.

A Outdoor cameras are vulnerable to direct lightning strike, as any vertical supporting pole in an urban environment may not be properly earthed; consequently, a lightning protection box (within the power and signal SPD) is needed.

B Transmission cable may be laid overhead into a room, increasing the risk of inducing lightning.

C Surveillance system centre monitoring or control equipment is designed with lower resistance, and can be easily damaged.

The main sources of lightning damage to video surveillance outdoor systems include direct lightning and induction lightning. See Figure 2.

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

– the geographical environment where a VSS is installed, e.g., urban environment, suburban environment or rural environment, as specified 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 lightning strikes. Subsequently, VSS installation scenarios can be classified as follows.
  - Unexposed environment: an environment is unexposed if a VSS 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 or SPDs upstream. The lightning electromagnetic field may be attenuated too.

- Low-exposed environment: an environment is subject to low exposure if a VSS is installed on the upper building external wall, street lamp, advertising hoarding, 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: an environment is subject to medium exposure if a VSS is installed on the rooftop of a high-rise building in an urban area, rooftop in the suburbs or countryside and 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: an environment is subject to high exposure if a VSS 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 (LPS) may not be necessary. For medium and high-exposed environments, risk assessment against lightning shall be performed according to [IEC 62305-2] or practically to [ITU-T K.97] in order to determine whether an external LPS is needed. In any case, except for the unexposed environment, SPDs for the AC power port of a VSS may be needed if an overhead power line is used.

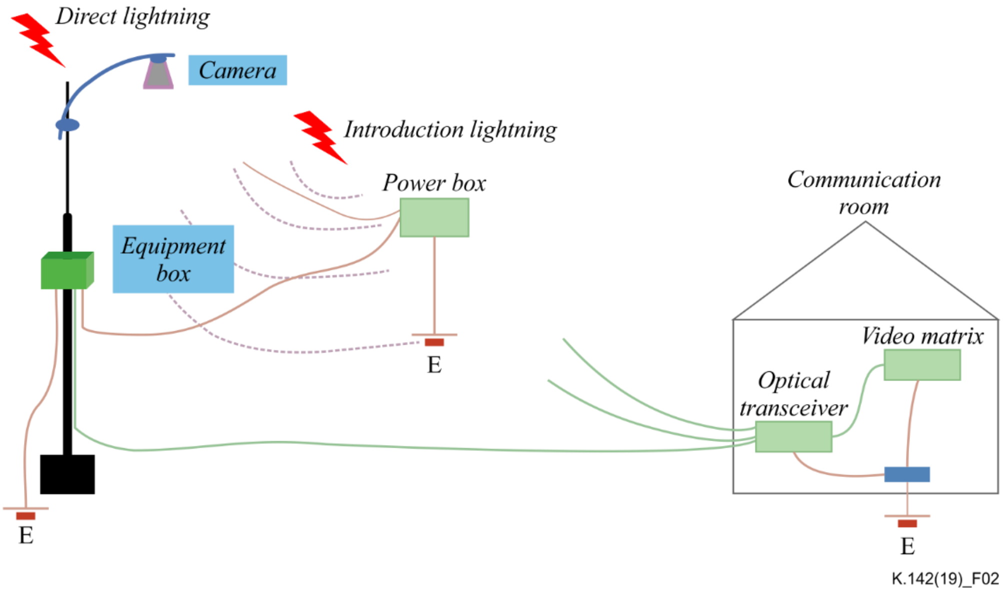


Figure 2 – Sources of lightning damage to a video surveillance outdoor system

6 Direct strike protection

6.1 Lightning protection system

In order to protect front-end equipment, e.g., outdoor cameras, and auxiliary equipment from a direct strike, it may be necessary to install an LPS. If the nearby shelter or buildings do not protect front-end equipment, it may also be necessary to install an LPS in the shelter. The assessment of the need for an LPS and the determination of its positioning are preferably performed with the protective angle method described in [IEC 62305-3] and [ITU-T K.112].

6.1.1 Protection zone of air-termination system

The protective angle shall be determined based on the lightning protection level (LPL) and the height of the air-termination system. Figure 3, which is adapted from [IEC 62305-3], shows the relationship between and the protective angle and the height of the air-termination system, for different values of the LPL.

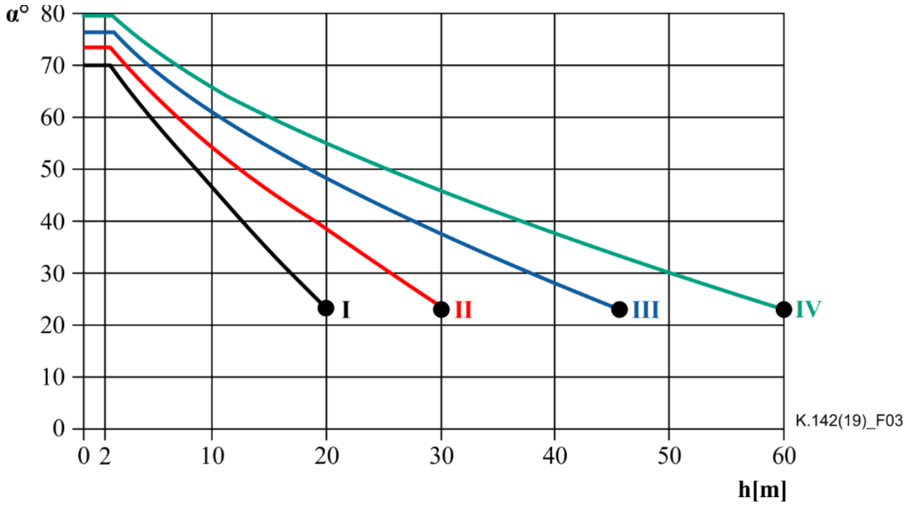


Figure 3 – Relationship between protective angle, *a*, and height of the air-termination system, *h*, in a lightning protection system

6.2 Protection procedures for the installation of the LPS

6.2.1 Metallic pole

The LPS rod(s) shall be connected directly to the metallic pole and shall be shorter than 5 m.

Therefore, the metallic pole will conduct the stroke current to the ground and there is no need to install lightning down conductors.

6.2.2 Non-metallic pole

If the structure that supports outdoor camera is not metallic (e.g., a wooden pole), it is necessary to install two down-conductors to earth the LPS rod(s). The down conductors shall have a minimum cross-section of 50 mm^2 each. The down conductors shall be installed on opposite sides of the pole.

6.2.3 Shelter or buildings

In the majority of the cases, the nearby shelter or buildings will protect the front-end device against direct strikes. However, the need for an LPS in the shelter or buildings shall be investigated with the rolling sphere method described in [IEC 62305-3]. If the shelter or buildings require an LPS, it shall be earthed in the earthing system for a VSS.

6.2.4 Transmission cables

In order to avoid direct lightning strikes to transmission cables, lay them underground encased in metal pipe (with both ends earthed) in preference to laying them overhead.

7 Earthing and bonding

Because outdoor surveillance points often situated below the height of the surrounding buildings and street lamps, the probability of suffering a direct strike is not high, the function of the earth system is mainly to provide a safe path for the lightning current to earth and to reduce the potential gradient at the earth surface around the VSS. The earth resistance (or impedance) of the earthing system is not of prime importance for the protection of the VSS.

Experience has shown that a resistance of 10 Ω is sufficient to meet the basic requirement to reduce construction investment. For practical procedures of earthing for VSS's front-end equipment, see Appendix I.

However, earth resistance has an important influence on the surges transferred from the VSS to its neighbourhood through the metallic services connected to it (e.g., power lines). In order to reduce these surges, earth resistance is suggested to be as low as possible.

8 Equipment protection

8.1 The front-end equipment resistibility

When the front-end equipment is located in a low-exposed area, the lightning risk is low; the basic test level should be adopted. When the front-end equipment is located in a medium or high-exposed area, the lightning risk is high; the enhanced test level should be adopted. The recommended resistibility of the front-end equipment should comply with [ITU-T K.21].

8.2 Surveillance centre resistibility

The surveillance centre and telecommunication centre equipment are in the same position, so their resistance requirements should comply with [ITU-T K.20].

9 SPD requirements

9.1 AC SPD used for front-end equipment

Outdoor front-end equipment is usually powered by a single-phase alternating current (AC) power supply, the AC SPD or protection module (either being a protection module inside front-end equipment or being an SPD box outside, as shown in Figure 4) is recommended according to the installation scenarios and shall comply with [IEC 61643-11].

The minimum nominal discharge current (I_N) is not less 10 kA. The protection level of the AC SPD should be lower than the resistibility of the AC power ports of the front-end equipment.

9.2 Signal SPD

The protection level of the signal SPD should be lower than the resistibility of the signal ports. The signal SPD should comply with [IEC 61643-21]. The typical specification of a signal SPD is shown in Table 1.

Table 1 – Signal SPD specification example

Port	Specification	Wave shape	Connection
Audio-video (AV) signal port	3 kA, line to shield	8/20 µs	Coaxial
	5 kA, shield to earth		
Controller signal port	3 kA, line to line	8/20 µs	Symmetry line
	5 kA, lines to earth		

9.3 MSPD used for surveillance centre

A MSPD contains both telecommunications and mains protection. It may also include port protection for video or Ethernet. MSPDs with a mains connection should comply with [ITU-T K.85].

10 Protection scheme

Figure 4 shows the main protection scheme applied to the VSS. These procedures, as well as others not shown in the Figure 4, are described in clauses 10.1 to 10.4.

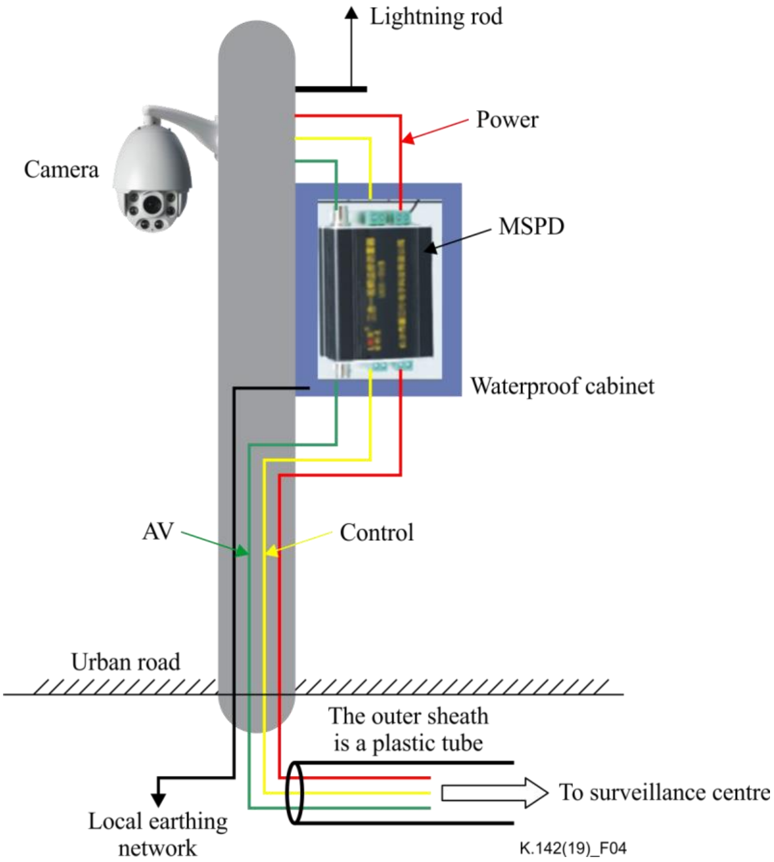


Figure 4 – Main protection scheme

The outer sheath is plastic, preferably laid underground, running through polyvinyl chloride (PVC) pipe, to the surveillance centre.

10.1 Front-end equipment protection

Front-end equipment on the outdoor pole needs protection from direct strikes. According to the specific power supply (AC or direct current (DC)), different SPDs are taken for an outdoor camera's power protection. A camera with a holder should have an MSPD to protect the power line, control signal and AV signal; a camera without a holder should have an MSPD to protect the power line and AV signal.

Front-end equipment usually presents high common-mode impedance at its input port. Coordination between the secondary SPD and any primary SPD installed upstream needs to be achieved. [ITU-T K.44] and [IEC 61643-22] give procedures to coordinate primary and secondary SPDs in signal lines and [IEC 61643-12] gives procedures for power lines.

10.2 Transmission line protection

For video or control signals transmitted through optical fibre or cable to the surveillance centre, statistical data show that more than 80% of lightning damage is caused by overvoltage from long-line lightning induction.

It is recommended that wiring should be led through metal pipe laid underground, while ensuring that the metal tube ends are effectively earthed. When its entire length cannot be laid underground, the cable should be buried until it reaches the front of the device or centre, the buried length being not less than 15 m. If possible, all transmission line ends should install the corresponding signal SPDs.

10.3 Optical fibre protection

Optical fibre is often considered to be an insulator and therefore power fault and lightning events are not considered a threat. However, fibre optic cable often has additional external sheath layers, such as metal braid, to provide reinforcement to the fibre optic cable. The sheath layer can contain a strip of wire, often called the locate wire, to allow the fibre cable to be detected when laid underground. Since this is metal and behaves like a cable shield, correct termination is required or this can impair field reliability. The metal of the fibre cable should ideally be terminated by connecting it to an earth rod, but if this is not possible, it should be cut away from the fibre cable at ground level to provide enough clearance or isolation between it and the optical network terminator. This will help mitigate field problems caused by the sheath or locate wire arcing to Earth. Under no circumstances should the metal sheath or locate wire be terminated right at or in the equipment.

10.4 AV signal line protection

Most signal lightning protection products on the market have two stage protection. The first stage is coarse protection, generally using GDTs as protective devices; the second stage is careful protection, commonly using TVSs as protective devices. As a result, signal SPDs inevitably have IN-OUT ports; installation errors should be avoided.

Annex A

Video surveillance system classification

(This annex forms an integral part of this Recommendation.)

A.1 Analogue video surveillance systems

Early VSSs rely on special equipment, e.g., cameras, cables, video recorders and monitors, to transmit and share analogue video, audio signals, and only support local monitoring. Later analogue VSSs can manage, move, share and remotely manage multiple video pictures through a multimedia video management system, but still do not support IP network access. Figure A.1 is a schematic diagram of a recent analogue VSS.

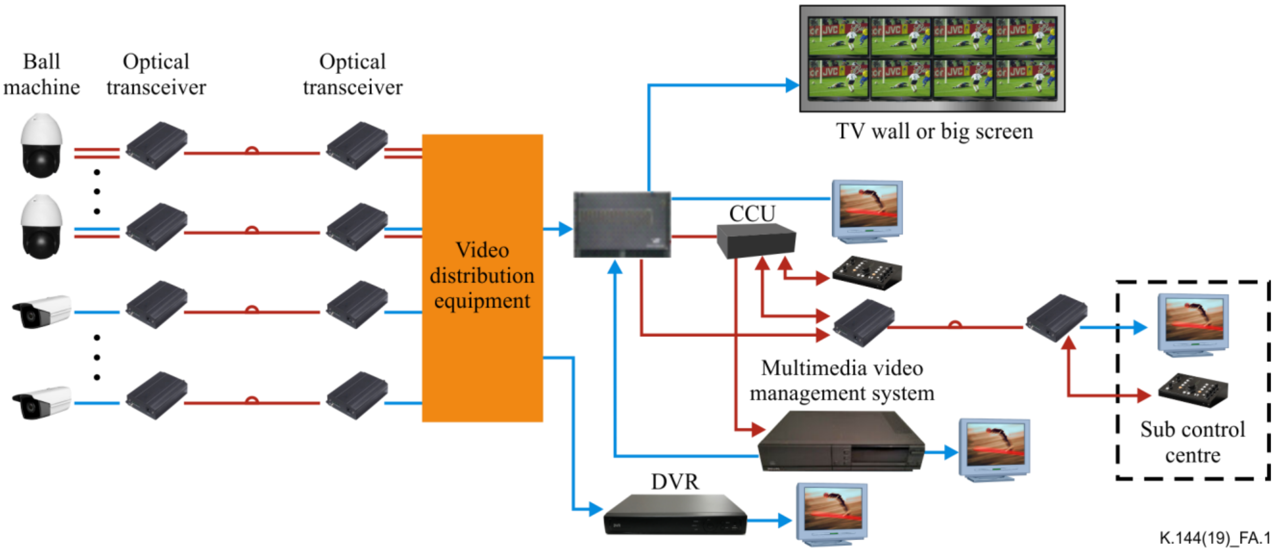


Figure A.1 – Schematic diagram of an analogue video surveillance system

CCU: camera control unit

An analogue video monitoring system for outdoor equipment covers: front-end equipment, analogue ball machine/camera (including a pan-tilt device (PTD)); and for transmission equipment: point-to-point optical transceiver or video amplification relay equipment.

A.2 Hybrid digital- analogue video surveillance system

Hybrid digital-analogue VSSs are still based on a hard disk digital video recorder (DVR) as the core of the solution; the transmitter from the camera to the DVR still uses a coaxial cable output video signal. Video recording and playback are supported simultaneously by the DVR. Hybrid digital-analogue VSSs support limited IP network access, users can make use of an external server and management software to control multiple DVR or to monitor points remotely; the management convenience of such systems greatly exceeds that of analogue VSSs. Figure A.2 is a schematic diagram of a hybrid digital-analogue VSS.

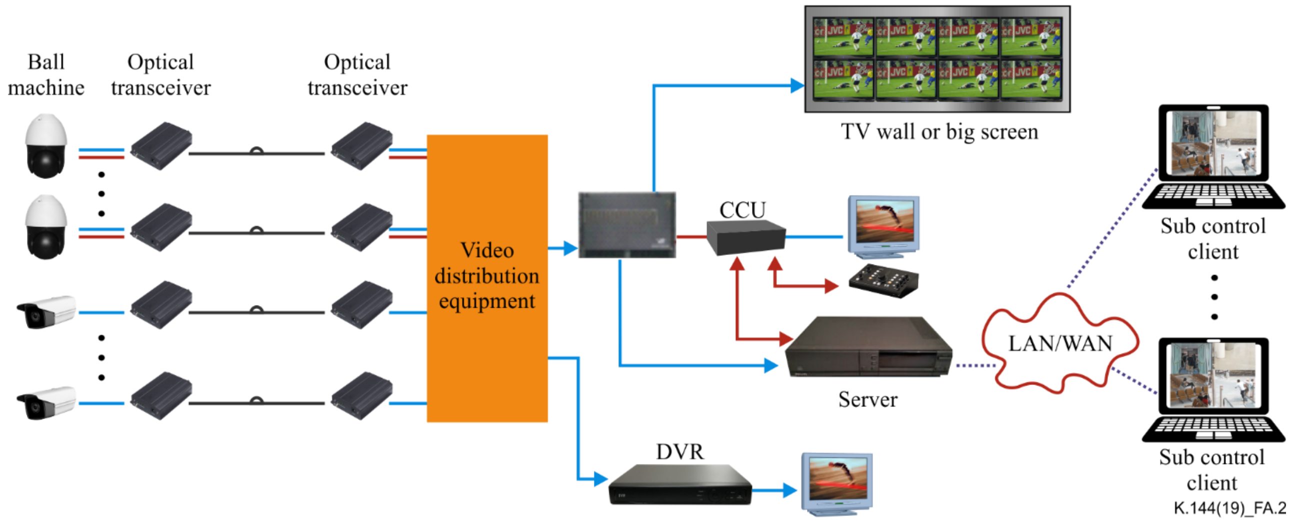


Figure A.2 – Schematic diagram of a hybrid digital-analogue video surveillance system

A hybrid digital-analogue VSS for outdoor equipment covers: front-end equipment, analogue ball machine, camera; and for transmission equipment: point-to-point optical transceiver or video amplification relay equipment.

A.3 Digital video surveillance system (also called an IP-based system)

A digital VSS is basically an IP VSS. Digital VSS cameras include a built-in web server and an Ethernet port. Instead of generating continuous analogue video images, digital VSS cameras generate JPEG or MPEG4, ITU-T H.264 data files that can be monitored, recorded and printed by authorized users from anywhere in the network. Digital VSS systems can also be easily upgraded and expanded. Because of their many advantages, digital VSS systems are nowadays gaining in popularity. Figure A.3 is a schematic diagram of a digital VSS.

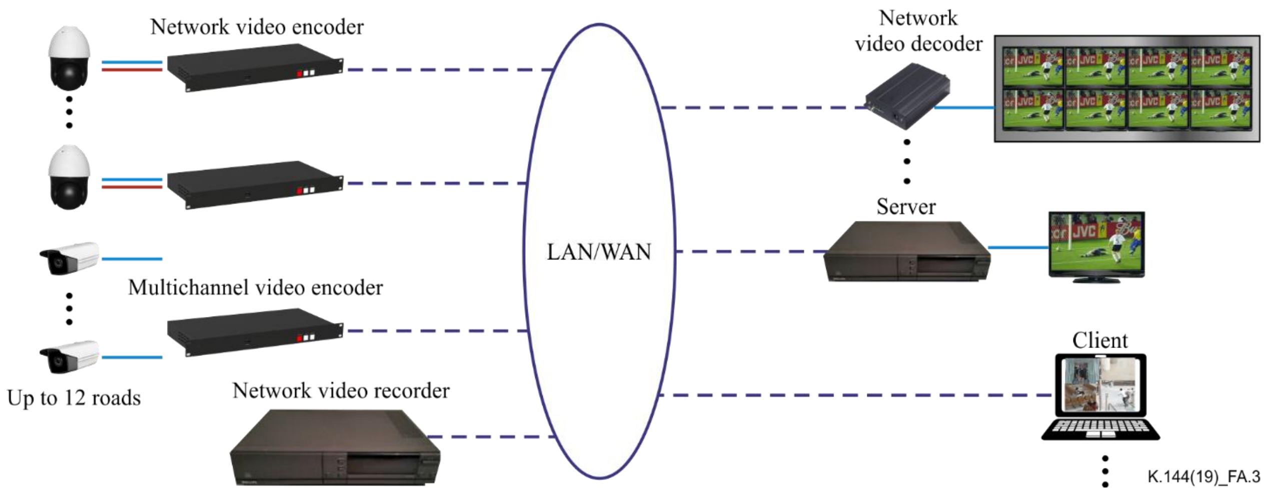
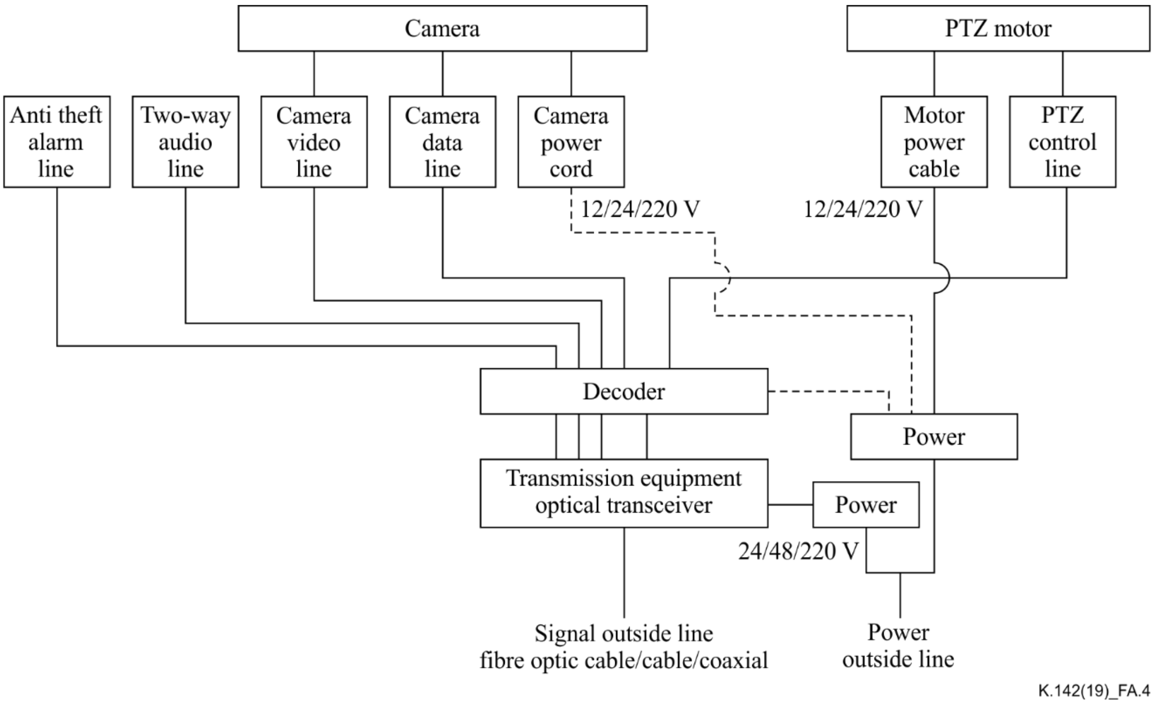


Figure A.3 – Schematic diagram of a digital video surveillance system

A digital video monitoring system for outdoor equipment covers: front-end equipment: digital ball machine, camera; and for transmission equipment: digital transmitter and video encoder.

A.4 Cable wiring diagram of video surveillance outdoor equipment

Figure A.4 and Figure A.5 are cable wiring diagrams for video surveillance outdoor equipment.



FigureA.4 – Schematic diagram of a gun camera connection

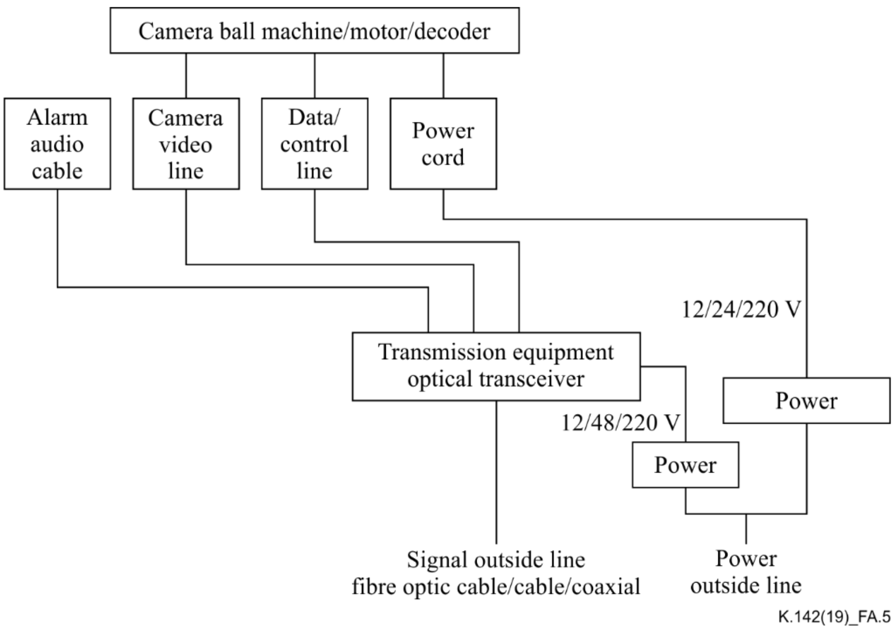


Figure A.5 – Schematic diagram of an integrated ball machine connection

Appendix I

Practical earthing procedures for a video surveillance system for front-end equipment

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

I.1 Introduction

The front-end equipment of a VSS can employ a cement foundation within which are embedded two hot dipped galvanized square rods as vertical earth electrodes, which are connected to the horizontal.

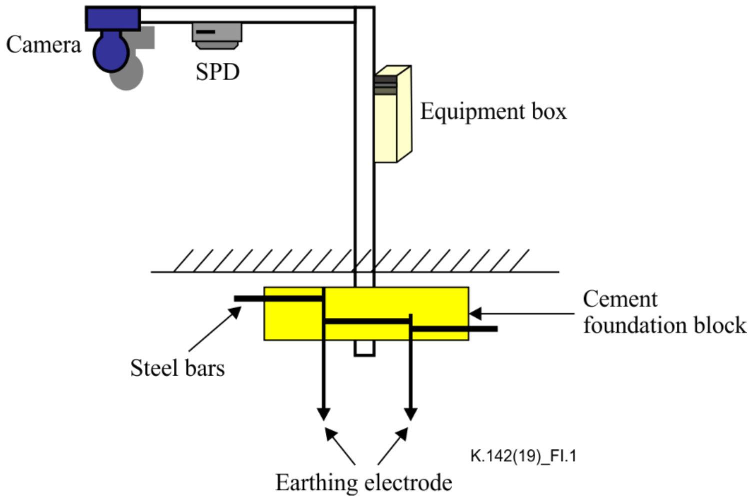


Figure I.1 – Basic earth network

This basic earth network increases investment only a little, and can be simply used in low soil resistance areas. However, in most cases, the earth resistance cannot satisfy requirements and the earth has an inadequate drainage area. Consequently, the four methods to construct earth networks described in clauses I.1 to I.4, are recommended.

I.2 Using neighbour structure earth network

When VSSs are close to public buildings, the earth network of the structure can be used as the earth network of the system.

1) The main earth line can be drawn forth from the test points of the building earth network.

2) If the building has no reserve test points, the main earth line can be led from the reinforced structure of the building.

3) The resistance of a building earth network should be less than 4 Ω, if it is more than 4 Ω or there is no main earth bar connected to a nearby building, a new earth network should be constructed with a reliable connection to a neighbouring structure earth network.

I.3 Ring earth grid

If excavation conditions permit, outdoor VSSs should include a new ring earth network, whose resistance should be less than 4 Ω. Wild or suburban earth resistance can be up to 10 Ω. When earth resistivity is greater than 2000 Ω•m, the earth resistance is not limited to 10 Ω, but the ring earth grid should be set up with a horizontal radiated earth electrode of length 10 m to 20 m. Figure I.2 is a schematic diagram of a ring earth grid. The ring earth grid should be connected reliably to a ring network of embedded parts of flat steel.

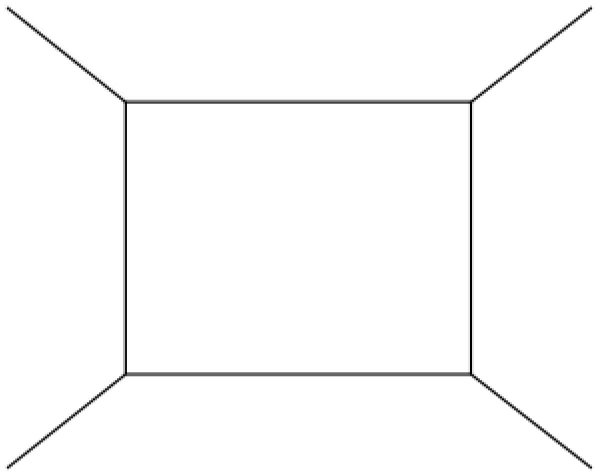


Figure I.2 – Ring earth grid

I.4 Earth network along an optical cable trench

If there is not enough space, construction of an earth network along an optical cable trench is a better choice.

It is recommended that during initial construction, a cable conduit is excavated along the channel in anticipation of an elongated earth network. Figure I.3 is a schematic diagram of a flat cement base connected to an outdoor system.

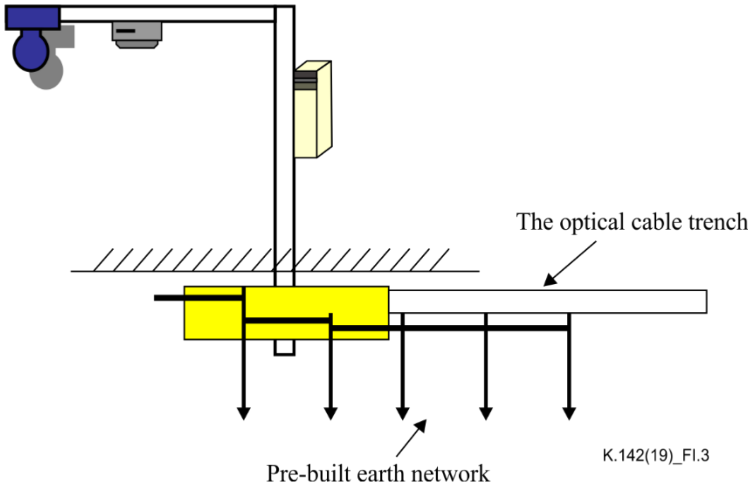


Figure I.3 – Pre-built earth network along an optical cable trench

I.5 Using copper coated steels or chemical electrodes in an earth network

Difficult points for building a ring earth network include the need to dig ground for putting in earth electrode rods. It is impossible to excavate a large area of pavement in a city due to the complicated process, great costs, etc. When only a small excavation for the construction of the earth network is required, the use of copper-coated steels or chemical electrodes is preferred.

I.5.1 If there is not enough space, copper-coated steels should be used (deep well method). See Figure I.4.

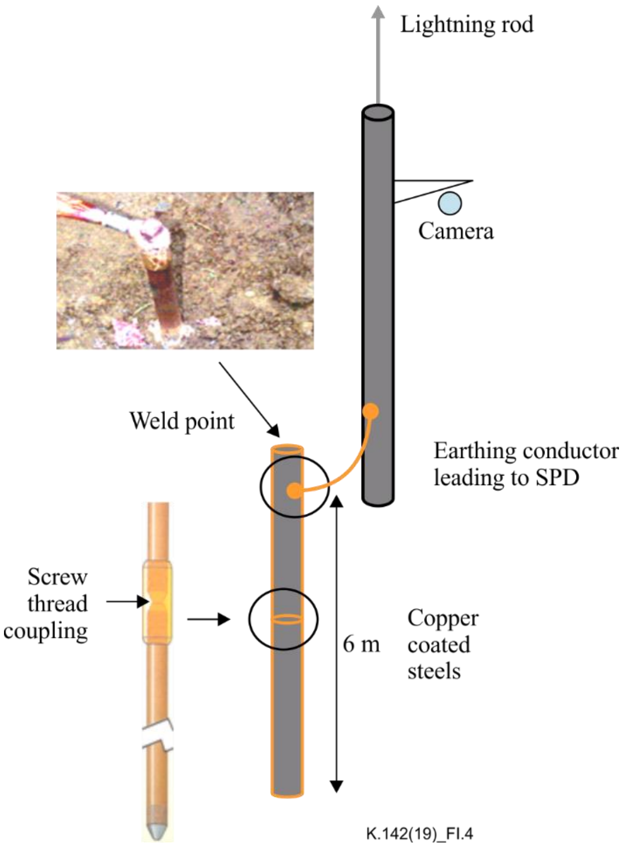


Figure I.4 – Using copper-coated steels

I.5.2 Another method employs chemical electrodes with a resistance-reducing agent and a conductive earthing electrode. See Figure I.5.

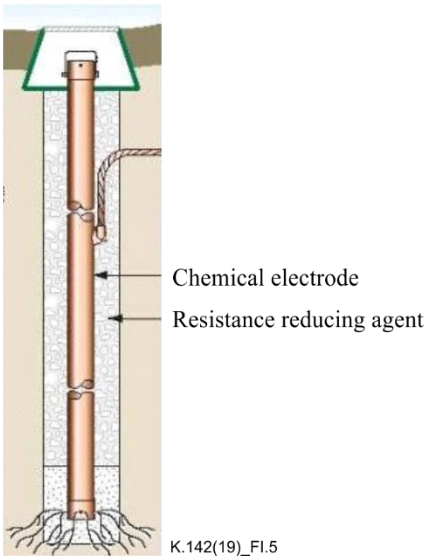


Figure I.5 – Using chemical electrodes with a resistance-reducing agent

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