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Electromagnetic compatibility requirements for information perception equipment

Recommendation ITU-T K.141

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Electromagnetic compatibility requirements for information perception equipment

Summary

Recommendation ITU-T K.141 gives the general electromagnetic compatibility (EMC) requirements for information perception equipment (IPE) used in the perception layer on the basis of Internet of things (IoT), combined with wireless and wired access, broadband and narrowband applications, as well as various intelligent applications.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K.141	2019-07-14	5	11.1002/1000/13960

Keywords

Electromagnetic compatibility, EMC, information perception equipment, IPE, Internet of things, IoT.

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Electromagnetic compatibility requirements for information perception equipment

1 Scope

This Recommendation specifies the general requirements for electromagnetic compatibility (EMC) for information perception equipment (IPE) used in the perception layer of Internet of things (IoT) network, taking into account combinations of devices to form schemes of an information perception system including control, monitoring, communication and process interface equipment.

In most cases, a typical IPE includes different parts such as sensor and communication parts, and it has the mandatory capabilities of communication and optional capabilities of sensing, actuation, data capture, data storage and data processing. The EMC measurement methods and performance criteria should consider the specific of these various devices, e.g., sensor part or telecommunication part, respectively.

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.

[IEC CISPR 11] IEC CISPR 11:2015+AMD1:2016+AMD2:2019, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*.

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[IEC CISPR 32] CISPR 32:2015+COR1:2016, *Electromagnetic compatibility of multimedia equipment – Emission requirements*.

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[IEC 61000-2-5] IEC TR 61000-2-5:2017, *Electromagnetic compatibility (EMC) – Part 2-5: Environment – Description and classification of electromagnetic environments*.
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[IEC 61000-6-2] IEC 61000-6-2:2016, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards—Immunity standard for industrial environments*.

[IEC 61000-6-3] IEC 61000-6-3:2006+AMD1:2010: *Amendment 1 – Electromagnetic compatibility (EMC) – Part 6-3: Generic standards -Emission standard for residential, commercial and light-industrial environments*.

[IEC 61000-6-4] IEC 61000-6-4:2018, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*.

[IEC 61000-6-5] IEC 61000-6-5:2015, *Electromagnetic compatibility (EMC) – Part 6-5: Generic standards – Immunity for equipment used in power station and substation environment*.

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[IEC 62236-1] IEC 62236-1:2018, *Railway applications – Electromagnetic compatibility ǂ Part 1: General*.

[IEC 62236-4] IEC 62236-4:2018, *Railway applications – Electromagnetic compatibility – Part 4: Emission and immunity of the signalling and telecommunications apparatus*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 device [b-ITU-T Y.2060]: With regard to the Internet of things, this is a piece of equipment with the mandatory capabilities of communication and the optional capabilities of sensing, actuation, data capture, data storage and data processing.

3.1.2 Internet of things (IoT) [b-ITU-T Y.2060]: A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

NOTE 1 – Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled.

NOTE 2 – From a broader perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.3 thing [b-ITU-T Y.2060]: With regard to the Internet of things, this is an object of the physical world (physical things) or the information world (virtual things), which is capable of being identified and integrated into communication networks.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 information perception equipment (IPE): A collective name, covering a series of individual devices used in the IoT perception layer.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

2G Second Generation

3G Third Generation

AC Alternating Current

AV Audio-Visual

CAN Controller Area Network

DC	Direct Current
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EUT	Equipment Under Test
ICT	Information and Communication Technology
IoT	Internet of Things
IPE	Information Perception Equipment
LTE	Long Term Evolution
NGN	Next Generation Network
PSTN	Public Switched Telephone Network
RF	Radio Frequency
RFID	Radio Frequency Identification
TCP/IP	Transmission Control Protocol/Internet Protocol

5 Conventions

None.

6 Equipment and EMC problems in IoT

6.1 Equipment in the scope of this Recommendation

The term information perception equipment (IPE) is defined in clause 3.2.1. IPE devices collect various kinds of information and provide it to the information and communication networks for further processing. Some devices also execute operations based on information received from the information and communication networks. Figure 1 shows the different types of devices and the relationship between devices and physical things.

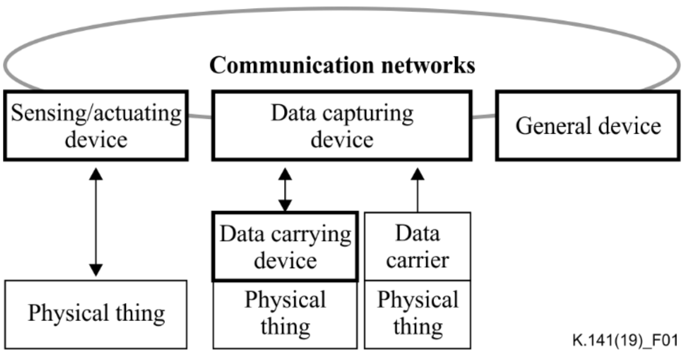

Figure 1 – Types of devices and their relationship with physical things

NOTE – A "general device" is also a (set of) physical thing(s). A physical thing can have a bi-directional or uni-directional communication/interaction.

Generally, an IPE includes a sensor part and/or communication part, which have the mandatory capabilities of communication and optional capabilities of sensing, actuation, data capture, data storage and data processing. For IoT architecture and capabilities, refer to Appendix I.

IPEs can be categorized into data-carrying devices, data-capturing devices, sensing and actuating devices and general devices. To distinguish these devices, their support of communication capabilities in the IoT is considered. They are described as follows:

– data-carrying device: A data-carrying device is attached to a physical thing to indirectly connect the physical thing with the communication networks;

– data-capturing device: A data-capturing device refers to a reader/writer device with the capability to interact with physical things. The interaction can happen indirectly via data−carrying devices, or directly via data carriers attached to the physical things. In the first case, the data-capturing device reads information on a data-carrying device and can optionally also write information given by the communication networks on the data−carrying device;

NOTE – Technologies used for interaction between data-capturing devices and data-carrying devices or data carriers include radio frequency, infrared, optical and galvanic driving.

– sensing and actuating device: A sensing and actuating device may detect or measure information related to the surrounding environment and convert it into digital electronic signals. It may also convert digital electronic signals from the information networks into operations. Generally, sensing and actuating devices form local networks communicate with each other using wired or wireless communication technologies and use gateways to connect to the communication networks;

– general device: A general device has embedded processing and communication capabilities and may communicate with the communication networks via wired or wireless technologies. General devices include equipment and appliances for different IoT application domains, such as industrial machines, home electrical appliances and smart phones.

Device capabilities can be logically categorized into two types of capabilities:

1) **device capabilities**:

The device capabilities include but are not limited to:

- direct interaction with the communication network: Devices are able to gather and upload information directly (i.e., without using gateway capabilities) to the communication network and can directly receive information (e.g., commands) from the communication network;
- indirect interaction with the communication network: Devices are able to gather and upload information to the communication network indirectly, i.e., through gateway capabilities. On the other side, devices can indirectly receive information (e.g., commands) from the communication network;
- ad-hoc networking: Devices may be able to construct networks in an ad-hoc manner in some scenarios which need increased scalability and quick deployment.

NOTE – The support in a single device of both capabilities of direct interaction with the communication network and indirect interaction with the communication network is not mandatory.

2) **gateway capabilities**:

The gateway capabilities include but are not limited to:

- multiple interfaces support: At the device layer, the gateway capabilities support devices connected through different kinds of wired or wireless technologies, such as a controller area network (CAN) bus, ZigBee, Bluetooth or Wi-Fi. At the network layer, the gateway capabilities may communicate through various technologies, such as the public switched telephone network (PSTN), second generation or third generation (2G or 3G) networks, long-term evolution networks (LTE), Ethernet or digital subscriber lines (DSL);
- protocol conversion: There are two situations where gateway capabilities are needed. One situation is when communications at the device layer use different device layer protocols, e.g., ZigBee technology protocols and Bluetooth technology protocols, the other one is when communications involving both the device layer and network layer use different protocols e.g., a ZigBee technology protocol at the device layer and a 3G technology protocol at the network layer.

Examples of equipment/devices under consideration in this Recommendation are as follows:

1) sensing and actuating device: Various sensors, intelligent sensors, antennas, radio frequency identification (RFID) tags etc. Generally, sensing and actuating devices form local networks communicate with each other using wired or wireless communication technologies and use gateways to connect to the communication networks;
2) data-capturing device: A data-capturing device refers to a reader/writer device with the capability to interact with physical things, such as RFID readers, image capture devices (such as video camera), and a variety of data acquisition (such as laser scanner), etc.;

   NOTE – Technologies used for interaction between data-capturing devices and data-carrying devices or data carriers include radio frequency, infrared, optical and galvanic driving.
3) data-carrying device: A data-carrying device is attached to a physical thing to indirectly connect the physical thing with the communication networks. The interaction can happen indirectly via data-carrying devices, or directly via data carriers attached to the physical things. In the first case, the data-capturing device reads information on a data-carrying device and can optionally also write information given by the communication networks on the data-carrying device;
4) controlling devices with telecommunication ports, such as micro-electromechanical system (MEMS) devices, wireless sensor network (WSN) equipment, etc.;
5) general device: A general device has embedded processing and communication capabilities and may communicate with the communication networks via wired or wireless technologies. General devices include equipment and appliances for different IoT application domains, such as industrial machines, home electrical appliances and smart phones.

6.2 EMC problems in IoT

Several types of perception devices that are connected via wired and wireless networks co-exist in an area where distances between devices may be very short compared to conventional distances. As a result, the influences caused by electromagnetic (EM) disturbance on sensitive equipment have become stronger than that in the past, and the probability of creating interference has increased.

Electronic equipment that did not have a network connection in the past has gained the capability of network connection now. Therefore, network configurations tend to be more and more complicated, and the issues related to EMC have to be taken into account.

Unlike the telecommunications centre, the IoT network and its EM environment cannot be controlled by network operators, and that may cause unstable EMC conditions.

Consequently, EMC problems due to a congested electronic equipment arrangement should be taken into account in addition to conventional problems.

7 Electromagnetic environments in IoT

7.1 Classification of application environment

According to the application of the perception layer equipment, the environment levels shall be selected in accordance with the most realistic installation and environment conditions in which the equipment under test (EUT) is expected to operate. Based on common installation practices, the recommended classification of the electromagnetic environment can be divided into three categories: E1, E2 and E3. Each category has its specific EMC immunity test levels and emission test limits. The object of these three location classes is to define the EMC test requirements for IPEs and these requirements are specified within this Recommendation in relation to continuous and transient, conducted and radiated disturbances including electrostatic discharges. The EUT shall comply with one or more of the class requirements. It is the responsibility of the manufacturers or operators to select the appropriate grade for its product.

7.2 Description of E1, E2 and E3 location classes

E1 – Residential, commercial and light-industrial environments location class

The environments encompassed by this class are residential, commercial and light-industrial locations, both indoor and outdoor (reference is [IEC 61000-6-1]). The following list, although not comprehensive, gives an indication of locations which are included:

– residential properties, for example houses, apartments;

– retail outlets, for example shops, supermarkets;

– business premises, for example offices, banks;

– areas of public entertainment, for example cinemas, public bars, dance halls;

– outdoor locations, for example petrol stations, car parks, amusement and sports centres;

– light-industrial locations, for example workshops, laboratories, service centres.

Locations which are characterized by being supplied directly at low voltage from the public mains network are considered to be residential, commercial or light-industrial.

E2 – Industrial location class

The environments encompassed by this class are industrial, both indoor and outdoor (reference is [IEC 61000-6-2]).

This class applies to IPEs intended to be connected to a power network supplied from a high or medium voltage transformer dedicated to the supply of an installation feeding manufacturing or similar plant, and intended to operate in or in proximity to industrial locations, as described below.

This class applies also to IPEs which are battery operated and intended to be used in industrial locations.

Industrial locations are in addition characterised by the existence of one or more of the following:

– a power network exists powered by a high- or medium-voltage transformer dedicated for the supply of an installation feeding manufacturing or similar plant;

– industrial, scientific and medical (ISM) equipment (as defined in [CISPR 11]);

– heavy inductive or capacitive loads are frequently switched;

– currents and associated magnetic fields are high.

E3 – Special location class such as railway, power station or substation environments

The environments encompassed by this class are special locations except E1 and E2. The typical representatives of such environments are railway, power station and/or substation environments, etc.

The railway environment is characterized as described in [IEC 62236-1]. Special consideration should be given to IPEs intended to be installed within 3 m of the centreline of the nearest track and/or mounted in areas where a high risk of interference from moving EM sources (such as moving vehicles or mobile radio telephones) has been identified.

The power station and substation environment is characterized as described in [IEC 61000-6-5]. For IPEs intended to be mounted or operating in such circumstance, the electromagnetic phenomena outlined in Annex A of [IEC 61000-6-5] should be considered.

7.3 Consideration of location classes and the requirements of EMC basic standards

Currently, there are many standardized immunity tests available, such as those described in the IEC 61000-4 series. In many cases, advantage can be taken from these basic EMC standards when their immunity tests reflect the real electromagnetic environment at a location of interest to a certain extent. This means that such standardized tests can be used, either directly or partly modified, to conclude corresponding immunity requirements. Hence, in many cases an approach might be followed where stress due to an electromagnetic environment is reflected by the application of appropriate immunity standards.

As the various location classes are defined in clause 7.2, special attention should be paid when considering different EM disturbance degrees and immunity requirements according to these location classes when applying the EMC basic standards.

8 EMC requirements

8.1 General consideration of requirements

In general, equipment should comply with EMC requirements from the family of standards, such as IEC or CISPR publications.

If a relevant product family standard does not exist, a generic standard should be applied to the equipment.

The input/output ports for IPEs may include several types of ports such as alternating current/direct current (AC/DC) power ports, input/output ports for access networks, internal connection ports for IoT network connections, enclosure ports, protective earth (PE) ports, coaxial ports, etc.

The functionality of these ports should be assessed according to the relevant EMC requirements given in the product family standards.

If an IPE has a port that is not covered by existing product family standards, then requirements given in generic standards should be applied, if those standards have requirements for that port.

The following clause gives emission and immunity requirements for IPEs.

8.2 Emission requirements

8.2.1 Test requirements

IPEs shall be tested in the operating mode producing the largest emission in the frequency band being investigated, e.g., based on limited pre-tests and consistent with normal applications. The configuration of the test sample shall be varied to achieve maximum emission consistent with typical application and installation practices.

The configuration and mode of operation during measurements shall be precisely noted in the test report. If the IPE has a large number of similar ports or ports with many similar connections, a sufficient number shall be selected to simulate actual operating conditions and to ensure that all the different types of termination are covered.

8.2.2 Principles of the selection of emission measurements

The emission requirements have been selected so as to ensure that disturbances generated by equipment operating normally in E1, E2 and E3 locations do not exceed a level that could prevent other equipment from operating as intended.

The application of measurements for emission(s) depends on the particular IPE, its configuration, its ports, its technology and its operating conditions.

It may be determined from consideration of the electrical characteristics and usage of a particular IPE that some of the measurements are inappropriate and therefore unnecessary. In such cases, it is required that the decision and justification not to measure shall be recorded in the test report.

8.2.3 Emission requirements for E1, E2 and E3

IPEs, in accordance with the definition of this Recommendation, shall comply with the emissions requirements described in [IEC CISPR 32], [IEC 61000-6-3] and [IEC 61000-6-4].

The emission requirements for IPEs covered by this Recommendation are given on a port by port basis. For E1 location, measurements shall be applied to the relevant ports according to Tables 1 to 4 in [IEC 61000-6-3]; For E2 and E3 locations, measurements shall be applied to the relevant ports according to Tables 1 to 3 in [IEC 61000-6-4]. Measurements shall only be carried out where the relevant ports exist.

Measurements shall be conducted in a well-defined and reproducible manner.

8.3 Immunity requirements

8.3.1 Test requirements

The immunity requirements for IPEs covered by this Recommendation are given on a port by port basis.

Tests shall be conducted in a well-defined and reproducible manner. The tests shall be carried out as single tests in sequence. The sequence of testing is optional. The description of the test, the test generator, the test methods and the test setup are given in the basic standards. If the IPE has a large number of similar ports with many similar connections, then a sufficient number shall be selected to simulate actual operating conditions and to ensure that all the different types of termination are covered.

8.3.2 Principles of the selection of immunity levels

According to [IEC 61000-2-5], the design, manufacturing, installation and maintenance of an item with a high degree of immunity can be a costly process if proper practices are not applied. For different environments, the immunity requirements should, therefore, be selected carefully. The proposed approach is that immunity should be selected according to:

– the electromagnetic environment in which the item will be used;

– the criticality of the different possible interferences.

Different immunity characteristics might be appropriate for different functions of a multi-function item. For instance, a safety-related function should have a higher immunity level than a convenience-related function. Therefore, a more rigorous approach should take into consideration the need for undisturbed operation of each function performed by an item.

However, it would not be realistic to require this selective specification of immunity as a general requirement, because available data are generally insufficient or imprecise.

The choice of different immunity characteristics for different functions of the same item is relevant because of the statistical nature of an electromagnetic environment, an aspect of EMC which has been recently emphasized. It should be stressed that the proposed approach is not only relevant for very complex systems having many different functions.

8.3.3 Immunity requirements for E1 and E2

The immunity requirements have been selected to ensure an adequate level of immunity for IPEs at E1 and E2 locations. The levels do not, however, cover extreme cases, which may occur at any location, but with an extremely low probability of occurrence. Not all disturbance phenomena have been included for testing purposes in this Recommendation but only those considered as relevant for the equipment covered by this Recommendation. These test requirements represent essential electromagnetic compatibility immunity requirements.

Test requirements are specified for each port considered. For E1 environment, IPEs shall comply with the immunity requirements described in [IEC CISPR 24], [IEC CISPR 35] and [IEC 61000-6-1]; For E2 environment, IPEs shall comply with the immunity requirements described in [IEC CISPR 24], [IEC CISPR 35] and [IEC 61000-6-2].

8.3.4 Specific immunity requirements for E3

For E3 location, the general immunity requirements for the industrial environment may be considered not sufficient. Therefore, IPE shall be designed and tested to withstand the various types of induced conducted and radiated electromagnetic disturbances that occur in such locations. The following gives two example locations which need severer immunity levels.

8.3.4.1 Immunity requirements in railway locations

The dedicated immunity requirements given in Table 1 to Table 5 of [IEC 62236-4] apply to IPEs which are located or mounted within a distance of 3 m of the centreline of the nearest track as defined in [IEC 62236-4].

For other IPEs within the railway environment but at distance further than 3m from the sources of high risk of interference, the generic standards, immunity for industrial environments of [IEC 61000-6-2] applies as defined in [IEC 62236-4].

8.3.4.2 Immunity requirements in power station and substation locations

In power station and substation environments, the dedicated requirements are defined in [IEC 61000-6-5], details of these requirements and testing procedures are given in parts of the IEC 61000-4 series. The most important cases and documents are referenced in clauses 5.7.1 to 5.7.3 in [IEC 61850-3].

8.4 EMC requirements for a special port

If the equipment has a port that is not covered by these standards, then the port should be tested by relevant standards that have requirements for that port. For example, when an IPE has an audio and visual port, then testing is recommended by the audio-visual (AV) port test described in [IEC CISPR 32] for emission, and [IEC CISPR 24] or [IEC CISPR 35] for immunity.

9 Management of EMC

The information perception system is a complex installation with various sources of electromagnetic energy and the application of the published EMC standards is not a guarantee of satisfactory performance. There may be cases where the IPE has to be positioned in restricted spaces or added to an existing assembly, with the possible creation of environments of unusual severity. All cases shall be considered with respect to a formal plan for the management of EMC. This plan should be established at the earliest stage of the project.

For any information perception equipment or systems introduced within the E1, E2 and/or E3 boundary, potential sources and victims as well the coupling mechanisms between these sources and victims shall be considered.

The EMC plan shall make reference to the basic EMC phenomena described in the IEC 61000-4 series as applicable.

10 Performance criteria

This clause is based on [IEC 61000-6-1] and [IEC 61000-6-2].

The variety and the diversity of the IPEs within the scope of this Recommendation makes it difficult to define precise criteria for the evaluation of the immunity test results.

A functional description and a definition of performance criteria, during or as a consequence of the EMC testing, shall be provided by the manufacturer and noted in the test report, based on the following criteria:

– **performance criterion A**: The IPEs shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the IPEs is used as intended. The performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, either of these may be derived from the product description and documentation and what the user may reasonably expect from the IPEs if used as intended;

– **performance criterion B**: The IPEs shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the IPEs is used as intended. The performance level may be replaced by a permissible loss of performance. During the test, degradation of performance is however allowed. No change of actual operating state or stored data is allowed. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, either of these may be derived from the product description and documentation and what the user may reasonably expect from the IPEs if used as intended;

– **performance criterion C**: Temporary loss of function is allowed, provided the function is self-recoverable or can be restored by the operation of the controls.

Specific performance criteria can be found in EMC immunity product standards (e.g., [CISPR 35] for multimedia equipment).

Appendix I

Concept of the IoT and basic architecture of the IoT network

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

I.1 Concept of the IoT

The IoT can be perceived as a far-reaching vision with technological and societal implications.

From the perspective of technical standardization, IoT can be viewed as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies (ICT).

Through the exploitation of identification, data capture, processing and communication capabilities, IoT makes full use of "things" to offer services to all types of applications, whilst ensuring that security and privacy requirements are fulfilled.

NOTE – The IoT is expected to greatly integrate leading technologies, such as technologies related to advanced machine-to-machine communication, autonomic networking, data mining and decision-making, security and privacy protection and cloud computing, with technologies for advanced sensing and actuation.

IoT applications include various kinds of applications, e.g., "intelligent transportation systems", "smart grid", "e-health" or "smart home". These applications can be based on proprietary application platforms, but can also be built upon common service/application support platform(s) providing generic enabling capabilities, such as authentication, device management, charging and accounting.

Communication networks transfer data captured by devices to applications and other devices, as well as instructions from applications to devices. Communication networks provide capabilities for reliable and efficient data transfer. The IoT network infrastructure may be realized via existing networks, such as conventional transmission control protocol/Internet protocol (TCP/IP)-based networks, and/or evolving networks, such as next generation networks (NGN) [b-ITU-T Y.2001].

I.2 Basic architecture of the IoT network

The basic architecture of an IoT network is presented by the IoT reference model in [b-ITU-T Y.2060]. Figure I.1 shows the basic architecture/reference model of an IoT network in this Recommendation, which is a simplified architecture. In an IoT network, several kinds of equipment, such as information perception equipment, information processing systems and communication systems are connected via networks (wired and wireless) and communication system gateways.

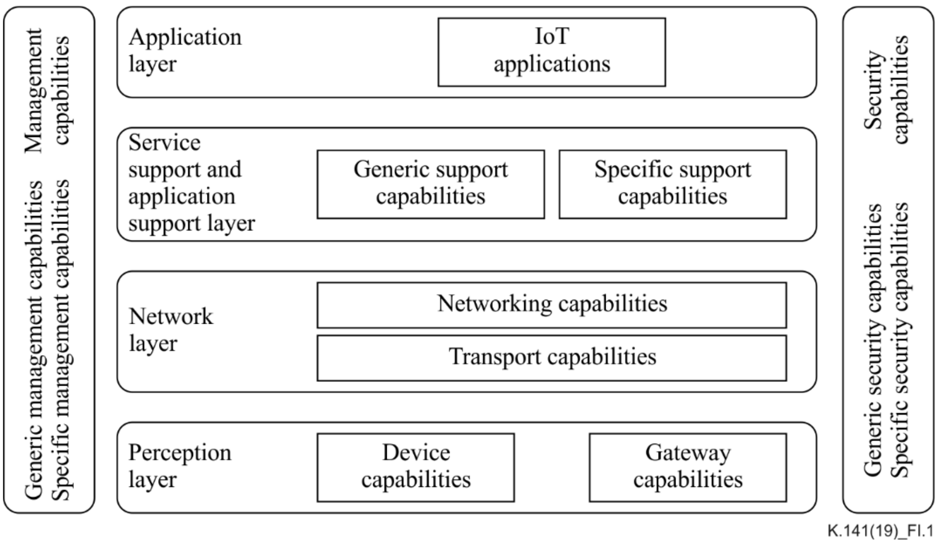

Figure I.1 – Basic architecture/reference model of IoT

Figure I.1 shows the IoT reference model. It is composed of four layers as well as management capabilities and security capabilities which are associated with the four layers. These four layers are as follows:

1) application layer;

2) service support and application support layer;

3) network layer;

4) perception layer/device layer.

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