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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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VISIBLE LIGHT BEACON SYSTEM FOR MULTIMEDIA APPLICATIONS

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International Standard IEC XXX has been prepared by subcommittee XX: TITLE, of IEC technical committee XX:

The text of this standard is based on the following documents:

FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

71 The committee has decided that the contents of this publication will remain unchanged until
72 the maintenance result date[1)] indicated on the IEC web site under "http://webstore.iec.ch" in
73 the data related to the specific publication. At this date, the publication will be

74 • reconfirmed,
75 • withdrawn,
76 • replaced by a revised edition, or
77 • amended.

78

1) The National Committees are requested to note that for this publication the maintenance result date is ....

INTRODUCTION

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IE

1 Scope

This International Standard

- specifies a method of visible light communication

- specifies a system for sending data using lighting equipments

- gives guidelines for use cases for multimedia applications

The International Standard IEC XXX applies to Visible light beacon system for multimedia applications, which is a system for providing various applications such as data transmission through multimedia devices, identification of matters, providing positional information, and establishment of various guiding systems by radiation transmission of simple information or ID information unique to the visible light source from visible light sources ubiquitously surrounding us. This standard aims at establishment of a unified standard concerning lower communication layer common to these applications, and do not deal with upper communication layer which depends upon individual applications.

This standard prescribes the single directional communication system with visible light as the medium (hereinafter referred to as Visible light beacon system for multimedia applications). It especially prescribes the standard concerning IF-a (interface point a) part in the Visible light beacon system for multimedia applications in Fig. 1.

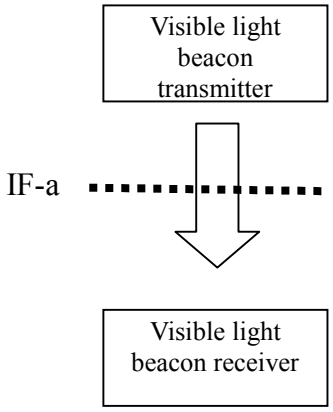

Fig. 1 Visible light beacon system for multimedia applications

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62471 : Photobiological safety of lamps and lamp systems

IEC TR 62471-2 : Photobiological safety of lamps and lamp systems Part2: Guidance on manufacturing requirements relating to non-laser optical radiation safety

3 Terms and definitions

For the purpose of this International Standard, the following terms and definitions apply.

3.1
visible light
light of waves visible to human eyes used for transmission of communication information

3.2
visible light beacon transmitter
a transmitter utilizing visible light beacon of visible light transmission standard

3.3
visible light beacon receiver
a receiver utilizing visible light beacon of visible light transmission standard

3.4
visible light beacon system
single directional beacon system utilizing visible light as its carrier

3.5
ID resolution
out of ID to draw location of information related to the ID

3.6
ID resolution server
a server capable of ID resolution from inquired ID

3.7
carrier
signal (light in the case of visible light communication) for transmission of information through (wired or wireless) communication media

3.8
modulation
to process and transform carrier and sub-carrier according to information in order to enable the information to be transmitted efficiently and correctly through communication media

3.9
demodulation
to restore original information from received modulated signals

3.10
pulse position modulation (PPM)
modulation system for representing information by time position of existence of pulse

3.11
frame
assembly of repetition of pulse insertion positions continued for a certain length of time

3.12
preamble
signal to inform reception side about preparation and time position of start of reception

3.13
payload
Part of communication frame usable for transmission of net data excluding preamble, frame form display, and parts for mounting additional information such as CRC

3.14
cyclic redundancy check (CRC)
Method for detection of error of redundant additions of cyclic codes generated from transmitted information for detection of transmission error

3.15
communication protocol
protocol decided for mutual communication between transmitters and receivers (procedures and rules of communication)

3.16
plane
group of lower to higher communication protocols providing specific communication service

3.17
encode
to encode data array to be transmitted by adapting them in forms conforming to transmission based on certain rules

4 System outline

4.1 Interface points and protocol rules

Fig. 2(a), (b), (c) and (d) are interface standard points between system structure figures and element systems of Visible light beacon system for multimedia applications.

Fig. 2 (a) is the whole structure (standard structure) of most common Visible light beacon system for multimedia applications. The visible light beacon receiver sends the beacon received from a visible light beacon transmitter to an ID resolution server, obtains the address of the information providing server where target information exists, and obtains the target information from the information providing server using the address.

Fig. 2(b) is the system structure (degeneracy system structure 1) for obtaining target information by implementing ID resolution in the beacon receiver referring to ID resolution table incorporated in the visible light beacon receiver, and directly accessing the information providing server based on the result.

Fig. 2(c) is the system structure (degeneracy system structure 2) for preliminarily caching target information in addition to ID resolution table in the visible light beacon receiver, and directly indicating the selected target information based on the received beacon.

Fig. 2(d) is the system structure (direct information delivery structure) for the visible light beacon receiver to directly receive delivery of target information itself from visible light beacon transmitter

This standard prescribes concerning the interface point (a) common to them.

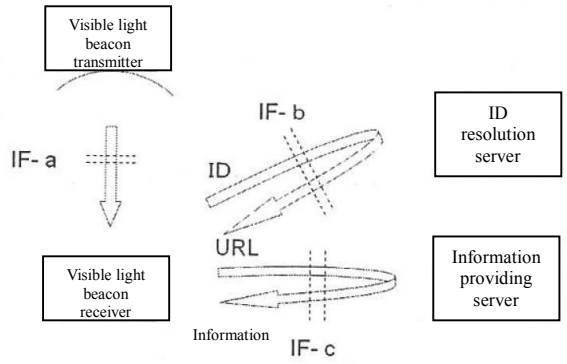

Fig. 2(a) Visible light beacon system for multimedia applications: structure and interface point

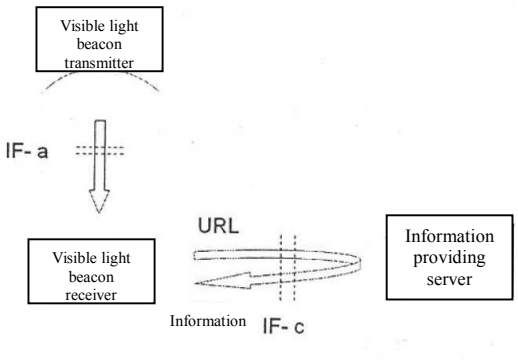

Fig. 2(b) Visible light beacon system for multimedia applications: structure and interface point (Degeneracy system structure 1)

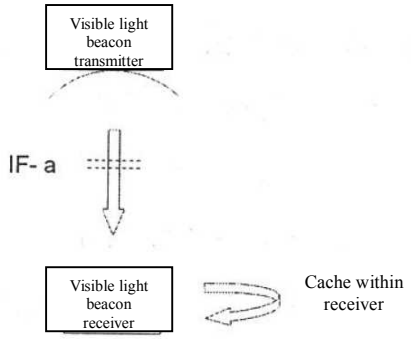

Fig. 2(c) Visible light beacon system for multimedia applications: structure and interface point (Degeneracy system structure 2)

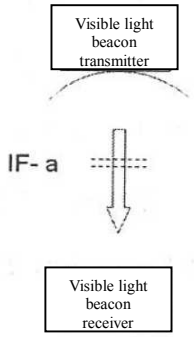

Fig. 2(d) Visible light beacon system for multimedia applications: structure and interface point (Direct information delivery structure)

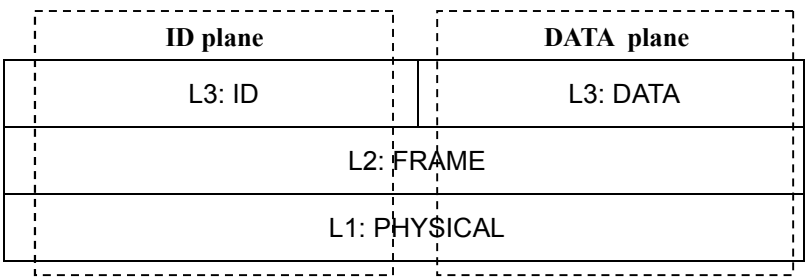

Fig. 3 Protocol structure of interface point a (IF-a)

Fig. 3 is the protocol structure of the above interface point (a) prescribed by this standard. The protocol structure consists of two planes, an ID plane for delivering ID and a DATA plane for delivering information directly.

Among them, physical layer of the first layer (L1: PHYSICAL) and frame layer of the second layer (L2: FRAME) are layers common to both ID plane and DATA plane. The third layer and the layer above it are separated into ID plane and DATA plane, delivery of visible light ID is positioned in the ID layer of the third layer (L3: ID), and direct information delivery from ID is constructed from the data layer (L3: DATA). It is possible use L3:ID and L3:DATA simultaneously in a single L2:FRAME.

4.2 Functions

The visible light beacon transmitter can transmit information. The transmitted information can be either arbitrary data or an ID code. The ID code system used is selectable, and various services can be provided or enjoyed through ID resolution (drawing information related to ID). Following usages can be assumed, for example.

(1) Equipment identification

The visible light beacon transmitter transmits product code of target equipment (Serial number, etc., can be included.). The receiver identifies equipment by ID resolution and can obtain information concerning the equipment. The information includes maker name, product name, specification sheet and manual of the equipment, information of consumables, use history, etc.

(2) Positional information

The visible light beacon transmitter transmits coded geographical information of the place where the instrument is installed (positional information ID). The receiver can obtain its positional information by ID resolution. Detection of peripheral services based on the present position, transmission position report function at the time of emergency report and so forth can be realized in buildings or underground malls where use of GPS is difficult. Further, the function can be used as the means for a robot to detect its position.

5 Physical layer

5.1 Wavelength

The wavelength of this system shall be visible light of peak wave length of 380~780 nm.

5.2 Data rate

Data rate shall be 4.8 kb/s. Tolerance of data rate shall be no more than 0.5%.

5.3 Transmission system

As the transmission system for modulation of visible light, Inverted 4PPM shall be used. Such a modulation method is called I-4PPM (Inverted 4PPM). Fig. 4 shows I-4PPM signal waveform (Note: Although signal is represented by square wave, actually waveform shaping is required to comply with spurious rules as individual electronic instruments. The same applies to Fig. 5, 9 and 12.).

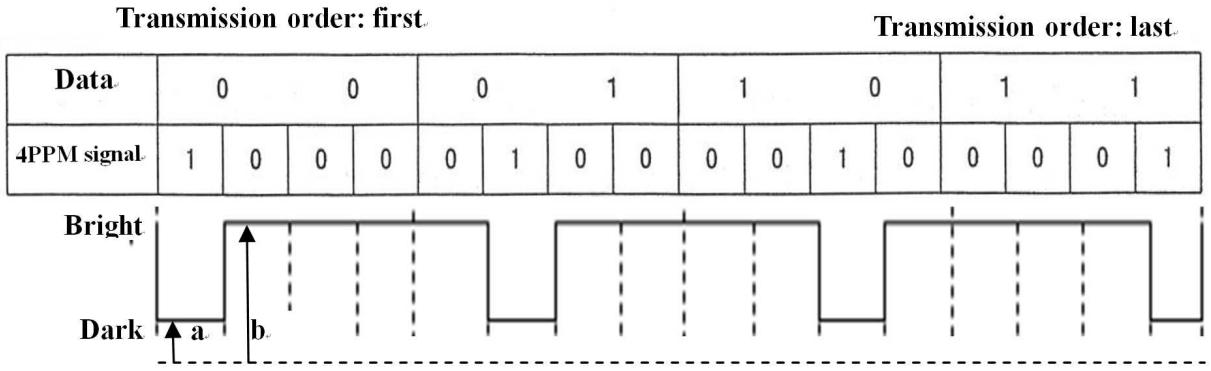

Fig. 4 I-4PPM signal waveform

When intensity of waveform a and b are defined as shown in Fig. 4, signal amplitude and modulation index are defined as below.

signal amplitude = b – a

modulation index = (b – a)/b.

The 4PPM encoding system evenly distribute a certain length of time defined as symbol time (D1) to 4 slots (C1), admits a pulse of 1 slot width in 1 symbol time, and transmits information of 2 bits assigned to existing slot time position of the pulse. Encoding rule of slot time position is prescribed in Fig. 5. Incidentally,

Symbol time D1 = 2*(1/4800) = 0.416 [ms] and

Slot time C1 = D1/4 = 0.104 [ms].

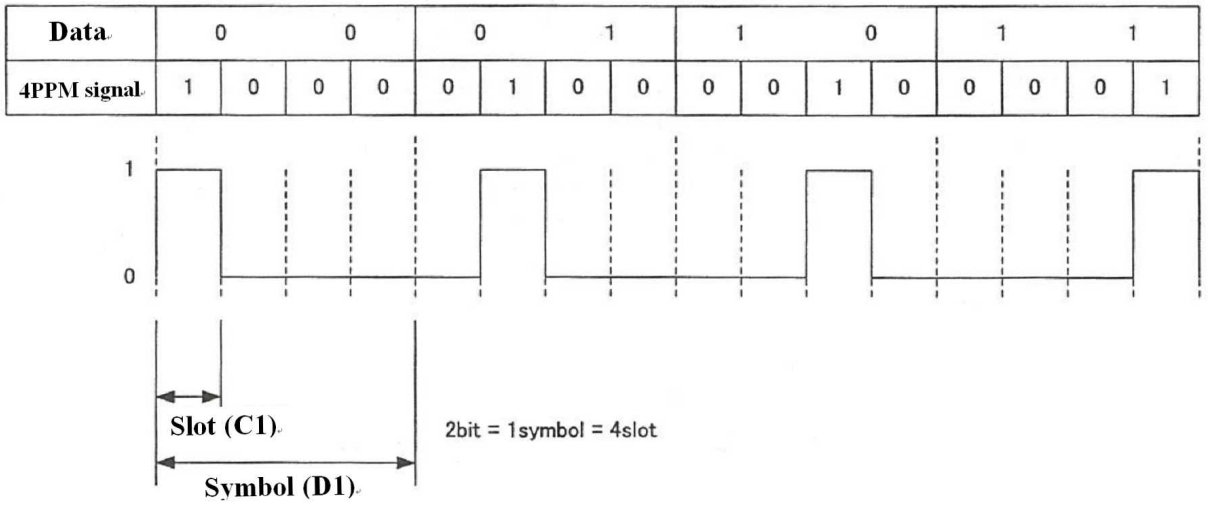

Fig. 5 4PPM

5.4 Spurious

Details of this item are prescribed in each application standard.

5.5 Transmission distance

Details of this item are prescribed in each application standard.

5.6 Service area

Details of this item are prescribed in each application standard.

6 Frame layer

6.1 Frame structure

Frame structure is shown in Fig. 6. The frame consists of start part (SOF), Payload, and end part (EOF). Further, SOF is divided into preamble (PRE) and Frame-type (F-TYPE), and information part consists of ID and/or DATA part. The EOF is cyclic redundancy check (CRC-16).

<table>
<tr><td colspan="2">SOF
(Start of Frame)</td><td>Payload</td><td>EOF
(End of Frame)</td></tr>
<tr><td>PRE(6 bit)</td><td>FTYPE(8 bit)</td><td>ID / DATA(128-bit)</td><td>CRC16(16 bit)</td></tr>
</table>

Fig. 6 Frame structure

6.1.1 Preamble (PRE)

The pattern of 1 in 3 sequential slots and 0 in 9 sequential slots (12 slots = 3symbols), which does not occur by 4PPM encode of data, is set as a preamble and the frame start position.

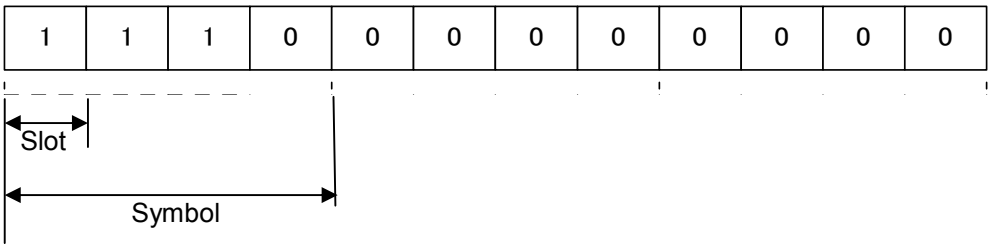

Fig. 7 Preamble structure (by 4PPM encoding rule violation)

6.1.2 Frame type (F-TYPE)

In the F-TYPE, the codes indicating kinds of payload are represented by 8 bits in order to enable use of IDs and codes of different plural systems and transmission of data.

Examples of the assignment of frame types are

- A frame type that allows any bit patterns
- A frame type that specifies a type of character strings such as ISO/IEC 646 character set
- A frame type that specifies an authorized ID code, such as ucode (an idenfitication

number system supported by uID Center)

Issuance and management of frame types are separately set (See Commentary).

6.1.3 Payload

The Payload consists of 128 bits ID and/or data.

6.1.4 CRC

CRC field length shall be 16 bits. Reception side judges whether frame data were correctly received. Since Visible light beacon system for multimedia applications is single directional communication incapable of re-transmission request, received data are discarded if error was detected. Calculation results of CRC are stored in CRC field. CRC-16 is given by the following generator polynomial.

X16 + X15 + X2 + 1

Calculation ranges of CRC are F-TYPE and Payload. Registers of CRC calculating units are all set in “1” before CRC calculation of transmission data array.

6.1.5 Data transmission sequence

Data are transmitted by frame units and without interruption in terms of time within every frame. Within frames, data are transmitted in the order corresponding to preamble (PRE), frame type (F-TYPE), payload, and CRC.

Data transmission order and CRC calculation order are shown in Fig. 8. Input in CRC calculation units starts from the least significant bit (LSB) of the least significant bite of each field of frame type (F-TYPE) and payload. In the figure, the data are input from the left. After completion of output of F-TYPE and PAYLOAD, CRC calculation results are copied in 16 bit shift register, and output after the output is switched to 16 bit shift register output. The 16 bit shift register outputs from the left in the figure.

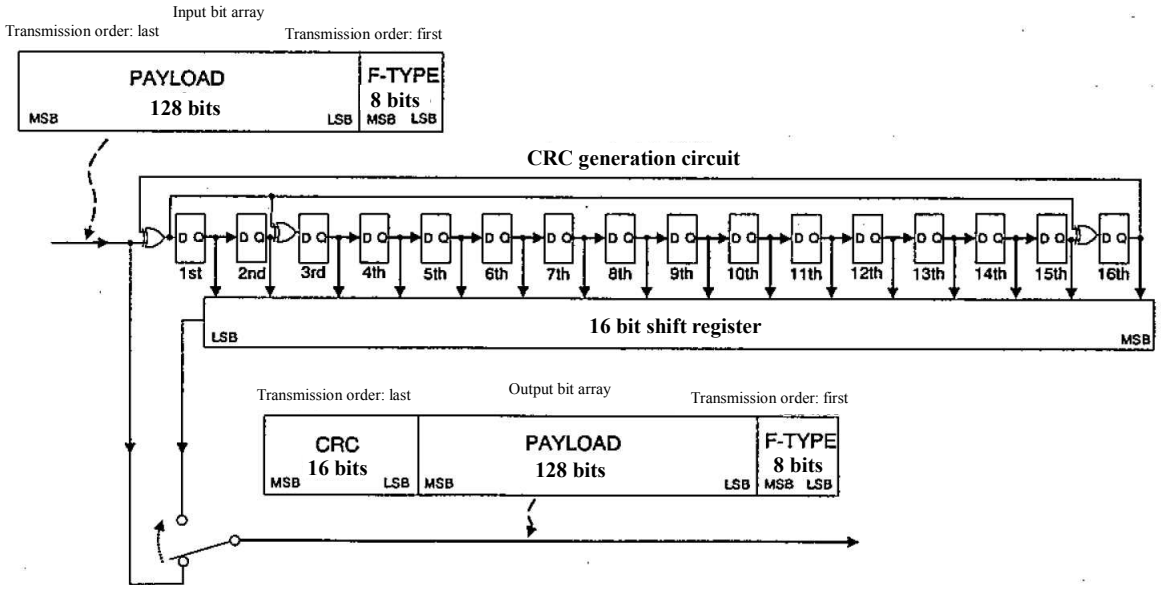

Fig. 8 Data transmission order and CRC calculation order

Down-times between frames are free. However, shortening of information acquisition time is desirable since in case terminals are held by humans, reception in about 0.03 second per frame is possible when a frame is repeated.

In the case of intermittent transmission with breaks between frames, it is recommended either to insert “1000” data sequentially in the I-4PPM form to fill the down-times in order to prevent flickering of light source, or to set the signal level in frame transmission down-time at the average value of signal level during frame transmission time,

$b' = a + 3b/4$.

(Refer to 5.4 for a, b levels of signal waveform.)

7 Measurement method

In visible light communication, it is necessary to carry out measurement under predetermined measurement conditions in order to obtain characteristic values of light emitting elements and light receiving elements or in order to confirm if given requirement is satisfied. Specific measurement conditions are determined by each application standard.

Commentary

This commentary only explains matters described in the main body and related matters, and is not a part of the standard.

1. Idea of establishment

This standard prescribes concerning communication method of single directional Visible light beacon system for multimedia applications. Visible light beacon system for multimedia applications is a system for providing various applications exemplified in the next section such as identification of matters, providing positional information, and establishment of various guiding systems by radiation transmission of simple information or ID information unique to the visible light sources ubiquitously surrounding us. Although system structures, etc., have conventionally been discussed by individual applications, necessity of a protocol commonly utilizable for any application on assumption that it will be widely utilized in various places has been pointed out. Under such a circumstance, this standard aims at establishment of a unified standard concerning lower communication layer common to various applications such as lighting, visible light signals and home appliances to utilize it commonly. Therefore, matters concerning upper communication layer which depends upon individual applications are left to each application standard.

2. Application examples

Visible light communication is suitable for local information delivery or information reception from specified correspondents, since easiness of control of communicable range for transmitting side and easiness of specifying transmitter for reception side can be named as its characteristics. Visible light communication system provides vital means for multimedia application services.

2.1 Multimedia Applications utilizing positional information

Transmission of information from public facilities such as traffic signals enables delivery of information deeply related to the place including directions such as information concerning stores in the neighbourhood, area map information, navigation information, route maps and time tables of trains and buses and traffic information.

2.2 Application in public spaces

Information transmission in places where various people visit has difficulty in transmitting all information appropriately, since the kind of information people want to receive varies depending upon their attributes (age, gender, taste, physical condition, language, etc.). Therefore, appropriate information transmission without damaging scenery will be made possible by indicating only the point from which information is output using visible information such as signals easily understood by everybody, and receiving actual information by visible light communication.

2.3 Cooperation with other services

In case services are provided by other media or means at certain places, transmission of information for accessing the services (for example, setting values for utilizing wireless LAN at hot spot) is possible.

2.4 Application to setting of equipment

In photography studios, information received from lighting appliances will enable appropriate setting (such as white balance) of cameras.

2.5 Application to AV and multimedia devices

Easy-to-understand application associating light and AV signals can be expected by transmitting and receiving AV signals using visible light (infrared light headphones, etc.).

2.6 Application to entertainment

Based on an assumption that information can be received from light-emitting matters, games of reaching goals while obtaining information with a receiver are possible, for example. Alternatively, reversing the situation, games in which the player loads information on beam of light to transmit the information to a fixed sensor to generate change is also possible.

3. Safety

Safety of visible light beacon products follows IEC 62471 and IEC TR62471-2 standards. Further, class 1 products by both of the standards are desirable both at normal and abnormal states. Since main objects of the standards are laser light and LED, and the contents may be revised in the future concerning treatment of LED, it is always necessary to grasp latest situation.

Further, concerning equipment having other functions (hereinafter referred to as main functions) together with that of visible light communication such as lightings and signals, safety standard concerning the main functions should be observed.

4. Code management concerning frame type, ID and DATA

Global scale integrated continuous issuance and management of codes concerning frame type, ID and DATA are necessary in order to secure freedom of installation of visible light beacon transmitters and transfer of receiver terminals, and to respond to expansion of use applications. For the purpose, establishment of management policy of these codes and fair registration and publication of the codes by the Visible Light Communication Consortium (VLCC) are necessary. It is also necessary to establish an administrative operation organization by the VLCC that operates server system for ID resolution, inspects conformance of compatibility among application apparatuses, issues certificates of conformance, and leads smooth market construction.

5. Industrial property rights

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.”