ISA Recommendation

Technical Specification for Smart Control System of Street Lighting Based on Narrow Band Internet of Things (NB-IoT)

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International Solid State Lighting Alliance

Technical Committee on Standardization

This recommendation is prepared by ISA Technical Committee on Standardization.
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“Technical specification for smart control system of street lighting based on Narrow Band Internet of Things (NB-IoT)”
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Contents

1 Scope

This standard specifies the general requirements, architecture, single light controller, communication network system and central management system of street lighting control system based on narrow-band Internet of Things (NB-IoT) technology.
This standard is applicable to the illumination of urban roads, tunnels, highways, and the related specific places. It can be referred to the illumination of other related places when the technical conditions are the same.

2 Terms and Definitions

2.1

Narrow Band Internet of Things

NB-IoT is an evolved universal terrestrial wireless access (E-UTRA) technology based on 3GPP evolution. It uses 180 kHz carrier transmission bandwidth to support cellular data connection of low-power devices in wide area network (WAN).

2.2

NB-IoT smart control system of street lighting

The smart control system of street lighting based on narrow-band Internet of Things (NB-IoT) technology is connected to the network through wireless communication to realize the functions of condition monitoring, lighting control, real-time management and other functions.

2.3

NB-IoT terminal chipset

An integrated circuit with NB-IoT terminal communication technology and communication protocol, which can support single light controller to realize NB-IoT wireless communication.

2.4

NB-IoT Communication module

The communication module based on NB-IoT chip is integrated in single light controller to complete the wireless communication function.

2.5

NB-IoT single light controller

The single light controller based on NB-IoT communication module, which communicates data with the central management system through NB-IoT wireless communication system and realizes the running state feedback and lighting control.

2.6

NB-IoT network

The wireless network provided by telecommunication operators that supports NB-IoT technology, including base stations and core network equipment.

2.7

IoT platform

Platform for NB-IoT network connection management, which supports the access of single light controller and other types of terminals.

Note to entry: The IoT platform supports the end to end network duplex communication. The IoT platform shields the different interface and network differences of various types of terminals for central management system, which provides the standard API to central management system.

2.8

Central management system

System composed of computer, database server, display terminal and other hardware supporting intelligent monitoring and management software that provides real-time monitoring, control and management of lighting system based on a unified human-machine user interface.

2.9

Single hop network

NB-IoT network that is provided and maintained by telecommunication operators and where NB-IoT single light controller and central management system in NB-IoT street lighting control system are directly connected by a single hop network through a wireless link in duplex communication.

2.10

Reference sensitivity level

The ability that NB-IoT single light controller receives data with a given average throughput for a specified reference measurement channel, under conditions of low signal level, ideal propagation and no added noise.

2.11

Online rate

The ratio of the number of terminal equipment in a control system to the number of the

whole terminals in use, excluding terminal equipment in a power outage and maintenance status.

3 Abbreviations

The abbreviations mentioned in this standard are shown in Table 1

Table 1 -The abbreviations

Abbreviation	Full term
3GPP	3rd Generation Partnership Project
API	Application Programming Interface
AWGN	Additive White Gaussian Noise
NB-IoT	Narrow-band Internet of Things
RSRP	Reference Signal Receiving Power
SINR	Signal to Interference plus Noise Ratio

4 Control system

4.1 General requirements

The street lighting control system adopts the NB-IoT communication technology, which is connected to mobile cellular network by wireless communication way. The network is built and maintained by telecommunication operators. The NB-IoT street lighting control system adopts single hop network control, which achieves the comprehensive monitoring, intelligent control, accurate management, on-demand lighting, energy saving, emission reduction and ensure the lighting rate and management requirements.

4.2 System architecture

The system architecture of NB-IoT based street lighting control system is shown in figure 1. From top to bottom are central management system, NB-IoT network communication system including NB-IoT network and IoT platform, and single street light including light controller. The central management system communicates with the single light controller in duplex communication through NB-IoT network.

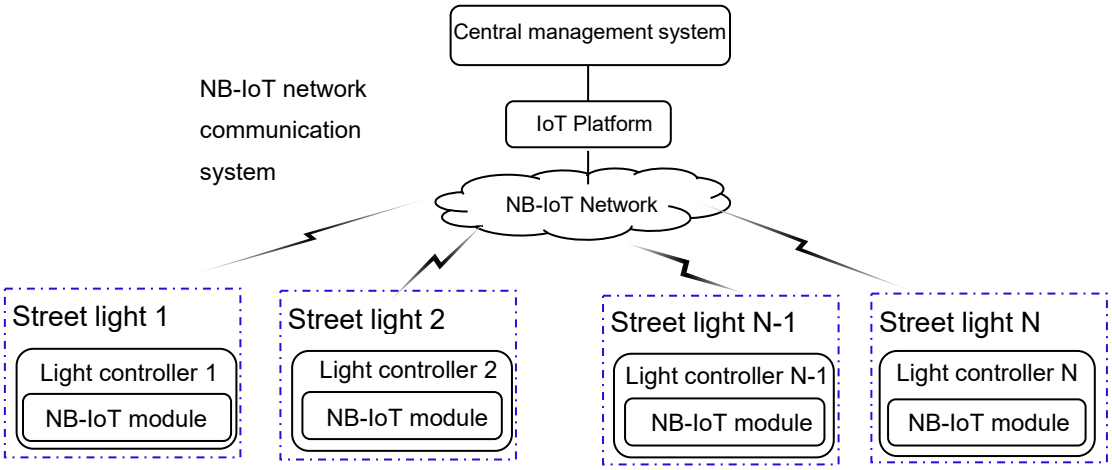

Figure 1 - The system architecture of NB-IoT based street lighting control system

4.3 System function

4.3.1 General requirements

NB-IoT based street lighting control system should realize the function of single light control, condition monitoring, parameter setting, data processing and system management.

4.3.2 Single light control

The control system should support the central management system to control the corresponding single light controller remotely, and realize the following control functions:

a) Switch control：can be used for light switch control;
b) Dimming control: can adjust the dimming level of light to achieve power control;
c) Single light and Group control: can achieve a single light control and group control;
d) Local control: can achieve decentralized control and centralized management;
e) Control strategy: can be controlled by setting control strategy, including the time period based control, the geographical position based control, the emergency condition based control, the off-line condition based control and the environment parameter based control.

4.3.3 Condition monitoring

The control system should monitor the running state of street light, including:

a) Running parameter: voltage, current, power, power factor and running status;
b) Energy consumption data: the period use of electricity and the total use of electricity;
c) Failure information: communication anomaly, power line anomaly and street light anomaly;

d) Wireless signal quality data: the data of RSRP, SINR and wireless signal coverage level;
e) Environment information: environmental parameters such as illuminance and ambient temperature.

4.3.4 Parameter setting

The control system should support the setting of related parameters, including:

a) Lighting parameters: can set up and record lighting parameters;
b) Time interval control parameters: can set the control of time slots;
c) Location parameters: can set up and record geographical location;
d) Dimming control parameters: can set the dimming ratio;
e) Environment parameters: can set illumination, temperature and humidity parameters for a certain scale of lighting control system.

4.3.5 Data processing

The control system should record and process data, including:

a) Lighting rate statistics: can determine whether the lighting rate statistics exceed the limit through the lighting rate limit setting, and record the relevant events;
b) Running time: can count the duration of running hours and the cumulative running hours;
c) Electricity statistics: statistics on electricity consumption;
d) Overrun alarm: can judge whether the voltage or current exceeds the limit by comparison of the voltage and current limit setting, and report in time;
e) Status record: can record the state of the street light reported by single light controller;
f) Data management: can support data backup, data retrieval, data export, data recovery, data statistics, tabulation and printing functions.

4.3.6 System management

System management has the following functions:

a) Online upgrade: single light controller supports online upgrade application program;
b) System clock acquisition: support the function of acquiring the network clock;
c) Equipment running management: can record the condition of the street light and set the single light controller operating parameters;
d) Running log management: including various user-created information, user login information, street light and single light controller running status, all kinds of failure information and alarm, and the parameters modified by the system administrator;
e) People authority management: support the function of authority management, all login operators should be authenticated and granted certain management authority, and operate according to the authority;

f) Asset management: including the file management of street light facilities, the addition, deletion, modification, and inquire function of street light facilities information;
g) Asset maintenance: when a fault occurs, the system will automatically report the failure and arrange the appropriate operators for maintenance.

4.4 System performance

4.4.1 General requirement

The NB-IoT based street lighting control system should ensure the accuracy and completeness of the data.

4.4.2 Data transmission success rate

The central management system should support the re-transmission mechanism. The success rate of data transmission in the system should not be less than 99%. The definition of the success rate of data transmission is in appendix A.1.

4.4.3 Online rate

The online rate of a single street light should not be less than 99%.

4.4.4 System real-time requirements

Central management system sends a real-time control instruction to single light controller for switching operation, the system response time of single light real-time control should not be more than 5s. The calculation method of control system response time is in appendix A.2.

5 Single light controller

5.1 Reliability

The mean time between failures of single light controller should not be less than 30000h. The single light controller should save the relative running data when power is off.

5.2 Safety

The safety of single light controller should comply with the requirements of IEC 61347-1 and IEC 61347-2-13.

5.3 Insulativity

The insulativity of single light controller should comply with IEC 61347-1 and IEC 61347-2-13.

5.4 Electromagnetic compatibility

5.4.1 The harmonic current of single light controller should comply with IEC 61000-3-2.

5.4.2 The radio disturbance characteristic of single light controller should comply with CISPR 15.

5.4.3 The electromagnetic compatibility immunity of single light controller should comply with IEC 61547.

5.4.4 The electromagnetic compatibility in NB-IoT mode should comply with ETSI TS 136.124.

5.5 Environment suitability

The single light controller should work properly at -35℃～+65℃.

5.6 Structure requirements

The structure requirements of single light controller should comply with the requirements of IEC 61347-1 and IEC 61347-2-11.

5.7 Communication requirements

5.7.1 Reference sensitivity level

The reference sensitivity level of the single light controller should be less than -125dBm in AWGN channel. The test method should comply with 3GPP TS 36.521-1.

5.7.2 Other requirements

In addition to the requirements of this standard, modules and single light controllers supporting NB-IoT wireless communication systems should comply with 3GPP TS 36.521-1, 3GPP TS 36.521-3, 3GPP TS 36.523-1.

6 Communication requirements

6.1 Technical requirements of NB-IoT network

6.1.1 General requirements

NB-IoT equipment should comply with the requirements of following relevant standards: 3GPP TS 36.201, 3GPP TS 36.211, 3GPP TS 36.212, 3GPP TS 36.213, 3GPP TS 36.214, 3GPP TS 36.300, 3GPP TS 36.321, 3GPP TS 36.322, 3GPP TS 36.323, 3GPP TS 36.331.

6.1.2 Signal quality requirements

NB-IoT network signal quality should meet the following requirements：RSRP>-90 dBm; SINR>-3 dB.

6.1.3 IoT platform requirement

The IoT platform should have the functions of connection management and equipment management for a single light controller, including access control, group management, message flow control, terminal fault delimitation, security and privacy protection, equipment registration and configurations, multi-protocol adaptation, etc. The IoT platform should provide interface to central management system.

7 Central management system

7.1 Central management systems should be composed of computers, database servers, display terminals and other hardware and software which includes intelligent control algorithms, image processing technology, geographic information systems and location technology.

7.2 Implement real-time monitoring, control and management of lighting system with a unified human computer interface, which including single light control, state detection, parameter setting, data processing, system management, asset management and other functions.

Appendix A
(Informative Annex)
Descriptive provision

A.1 Data transmission success rate

NB-IoT adopts wireless communication technology, compared with the wired transmission scheme, it is easy to be disturbed by radio waves, resulting in the failure of data transmission. The data transmission success rate is calculated according to formula (1) in order to improve the reliability of data transmission. The test method of data transmission success rate for single light controller is shown in appendix B.

$$\eta_s = \frac{n_1}{n} \times 100\ \% \cdots\cdots\cdots\cdots （1）$$

where in:

η_s——data transmission success rate;

n_1——the number of successful controls (the controller application layer allows to re-transmit 3 times);

n ——the number of total controls.

A.2 Control system response time

Control system response time refers to the display or execution time required for the central management system to send information (or commands) to the single light controller. The single light control response time is calculated according to formula (2). General test method for field application is shown in appendix B.

$$T = T_2 - T_1 \cdots\cdots\cdots\cdots （2）$$

where in:

T——the system response time for the single control;

T_2——the time of receiving a single control command feedback from a single light controller by central management system;

T_1——the time of sending a control command to a single light controller by central management system.

Appendix B
（Normative Annex）
General test method for field application

B.1 Overview

The general test method is stated below in order to provide the reliable system and ensure the field application of the NB-IoT based street lighting control system based on this standard. This appendix lists the general test method for the field application, including the block diagram of the test system and the test procedure.

B.2 The block diagram of the testing system

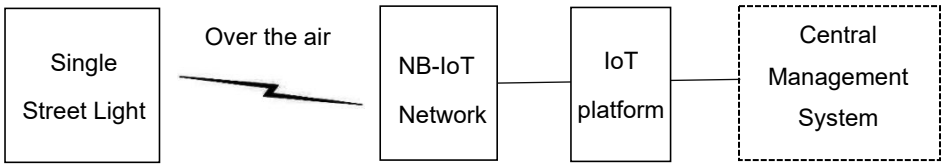

Figure B.1 - The test block diagram of system response time and data transmission integrity

B.3 Data transmission success rate test steps

a) Power on the system and run the central management system;
b) Set the test command to each single light controller in the system every 30 seconds, and reach a total control number not less than 200 times for a single light;
c) Check and record the number of the test command successfully executed by the single light controller through the central management system;
d) The method of calculating the data transmission success rate is illustrated in appendix A.1.

B.4 System response time test steps

a) While testing the data transmission success rate, check and record the time of sending test command and the time of receiving the feedback of test command through the central management system;
b) The method of calculating the system response time is illustrated in appendix A.2.

B.5 Single light controller wireless signal quality data reporting test steps

a) Power on the system and run the IoT platform;
b) Select the corresponding street lighting equipment on the IoT platform and check the wireless signal quality data;
c) Query the wireless signal intensity PSRP, SINR and the signal coverage level, and confirm that the data obtained from the IoT platform are consistent with the test data obtained from the test equipment USB dongle in the actual environment.