Design of 5G Smart Pole System - Specifications

Version 0.3.0-20220915V1 (2022-09)

5G Smart Pole Standard Promotion Alliance

SIG1

September 15, 2022

Contents

Preface

Taiwan has always been the most important supply chain in the global telecommunications industry, and also an important city providing solutions for Smart Cities around the world. Today, the application of 5G has become an inevitable trend. The government is promoting the policies of "Taiwan 5G Action Plan" and "Forward looking Infrastructure Plan", and is also planning the development of six core strategic industries. We look forward to building a development environment for 5G innovative applications, promoting digital construction and setting a mart city model. At the same time, we will establish Taiwan's leading position in communications and continue to promote Taiwan to become a global digital base.

In recent years, many countries around the world have noticed the development of Multi-Function Smart Pole (smart pole). Various domestic regions have also successively demonstrated the erection and carried out projects such as Internet of Things street lamp posts and smart poles. However, due to the lack of consistent specifications and inspection standards for smart pole products, and the failure to focus on the connection with international specifications, there comes out a situation of going their own way. Meanwhile, the vertical integration of related industries is not easy, and the close connection of domestic supply chain cannot be established. In fact, the smart pole can be multiplex and used as the carrier of 5G small base station. Moreover, it can also be used to integrate other hardware equipment to play a role in the application of technologies such as environment sensing, mobile network, electric vehicle charging, artificial intelligence analysis, internet of vehicles and edge computing, thus playing an important role in networking and collecting big data.

With the background of the time, with the support of the BSMI (Bureau of Standards, Metrology and Inspection) of the Ministry of Economic Affairs and the Technology Department, the 5G Smart Pole Standards Promotion Alliance, which was established spontaneously in the industry, has programmed the "5G Smart Pole System Design Specifications". Such an event was organized by the Taipei Computer Association and invited Pegatron, Grand Eternity, ChungHwa Telecom, Auden, HwaCom

and other member manufacturers to serve as the main cadres for planning. It is expected that this specification can combine the basic spirit of completeness, inclusiveness, efficiency and internationalism, so that all cities can easily adopt this specification as a reference for the construction of smart pole system. The Alliance has also designed a variety of multi-functional poles to meet various potential and possible application needs. It also considers the cost and functions in designing, provides reasonable construction costs, and conforms to international standards, which makes it easier for the industry to expand the international market.

Appreciate for the concerted efforts of the Alliance cadres and members in planning and formulating industrial standards. In the process of writing, a great thank should be expressed to the Standards Inspection Bureau and the Technical Department of the Ministry of Economic Affairs for their guidance and assistance, and kindly express my special gratitude to them. It is expected to integrate the development of communication technology and innovative science and technology in the future, and use 5G smart poles to weave the basic network of smart cities, which will also become the cornerstone of the big data analysis platform. It is also hoped that the domestic supply chain of 5G smart rod industry can be established, and the export opportunities of 5G smart rod overall solutions can be expanded at the same time, to become an important promoter of global industrial technical specifications, and echo the government driven digital national innovation economic policies.

1. Coverage

This document contains relevant specifications and definitions of 5G smart pole system.

2. Norms Referenced

ANSI C136.41

CNS 10007 Hot Dip Galvanized Coatings on Iron and Steel

CNS 10522 Emergency Public Address Equipment

CNS 1157 Alkyd Resin Enamel

CNS 12390 A3288 Method of Test for Determining Degree of Pavement Compaction of Bituminous Aggregate Mixtures

CNS 1247 H2025 Methods of Test for Hot Dip Galvanized Coatings

CNS 13438 Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement

CNS 14115 Limits and Methods of Measurement of Radio Disturbance Characteristics of Electrical Lighting and Similar Equipment

CNS 14165 Degrees of Protection Provided by Enclosures (IP Code)

CNS 14335 Luminaires

CNS 14546 LED Traffic Signal Lanterns and Lamp Housing

CNS 14555 Road Traffic LED Display Panel

CNS 14657 Acoustics - Determination of Sound Power Levels of Noise Sources - Precision Methods for Anechoic and Semi-anechoic Rooms

CNS 14676 Electromagnetic Compatibility

CNS 14677 Sound System Equipment

CNS 15233 Technical Specification for LED Street Lights Set in The Whole Station

CNS 15233 Fixtures of Roadway Lighting with Light Emitting Diode Lamps

CNS 15511-2 Electric Vehicle Conductive Charging System – Part 2: Interface Requirements

CNS 16120 Video Surveillance System Security

CNS 2253 H3025 Aluminum and Aluminum Alloy Sheets, Strips and Plates

CNS 2253 H3027 Aluminum and Aluminum Alloy Extruded Products

CNS 2931 Molded Case Circuit Breakers

CNS 4908 Anticorrosive Primer for General Use

CNS 5422 Residual Current Operated Circuit Breakers

CNS 601 Ready Mixed Paint (Synthetic Resin Type)

CNS 61347-1 Lamp Controlgear − Part 1: General and Safety Requirements

CNS 61347-2-13 Lamp Controlgear − Part 2-13: Requirements for D.C. or A.C. Supplied Electronic Controlgear for LED Modules

CNS 62087 Audio, Video and Related Equipment – Determination of Power Consumption

CNS 8886 Methods of Salt Spray Testing

ITU-G.651

ITU-G.652 - International Telecommunication Union

MIL STD 810G Tai-Nei-Ying-Tzu No. 0940087319 Seismic Design Specifications and Commentary of Buildings

Tai-Nei-Ying-Tzu No. 0990807042 Design and Technique Specifications of Steel Structures for Buildings

Industrial Development Bureau, Ministry of Economic Affairs No.25 Regulations for Installation of User's Electricity Device

Section 2.1.4.3 of the National Highway Lighting Application LED Street Lamp Feasibility Assessment Difference Evaluation Report

Construction Specifications of Taipei City Government Chapter 02319

Construction Specifications of Taipei City Government Chapter 027265

Construction Specifications of Taipei City Government Chapter 03377

Huan-Shu-Kung-Tzu No.1091159220 Order, Air Quality Index

3. Abbreviations

The followings are the abbreviations used in this article:

AC: Asphalt Concrete

CLSM: Controlled Low Strength Materials

CPE：Customer Premise Equipment

DAS：Distributed Antenna Systems

FWA：Fixed Wireless Access

LPWAN： Low Power Wide Area Network

OLT：Optical Line Terminal

ONT：Optical Network Terminal

ONU：Optical Network Unit

RSU：Roadside Unit

WDM: Wavelength Division Multiplexing

4. Structural System

5G Smart Pole System Architecture:

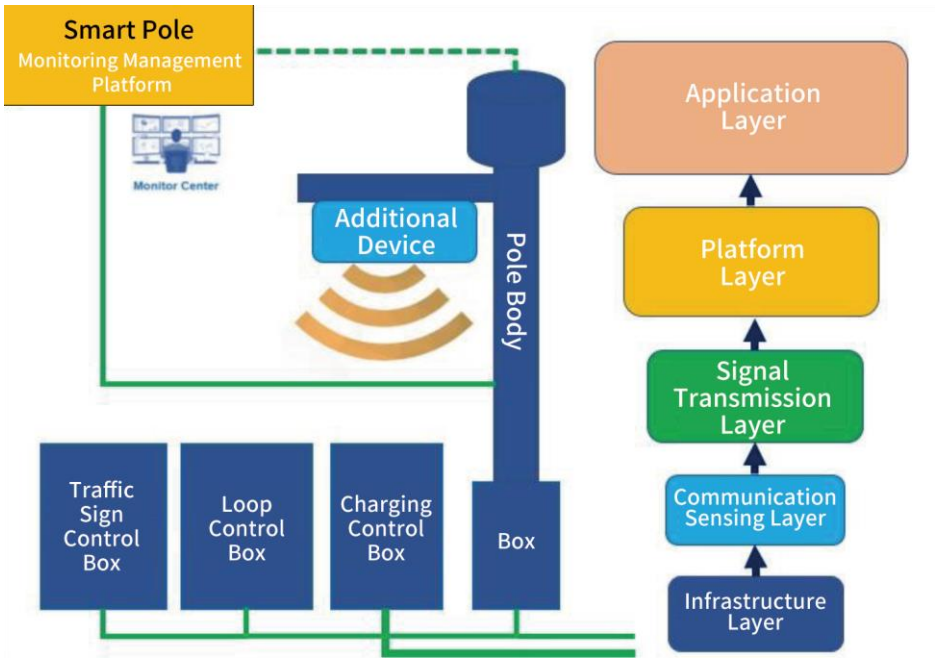


Figure 4-1 Schematic Diagram of 5G Smart Pole System Architecture

(a) Infrastructure layer:

The infrastructure of the pole structure system includes: communication equipment warehouse, pole, base, common pipeline, loop control box, charging control box, charging post, and monitoring data management center machine room.

(b) Communication awareness layer:

Equipment and systems integrating communication reception and environment awareness includes: camera lens, small base station, interactive digital billboard, digital road sign, antenna, environmental detection equipment, traffic sign, emergency call system, public promotion player, smart lamps, etc.

(c) Signal transmission layer:

The transmission layer can be broadly divided into wired and wireless transmission modes.

(d) Platform layer:

Including central control center, lighting management, warning management, scheduling management, traffic sign management, environmental detection data collection, camera monitoring management system.

(e) Application layer:

Street lighting, environmental detection, traffic sign management, Wi Fi sharing, signal transmission, emergency call, public announcement, digital advertising, etc., and corresponding services provided by the perception layer.

Designing Principles of 5G Smart Pole System:

(a) Because of the need to cope with the height requirements of different scenes, modular design is used in pole body.

(b) The 5G smart pole system includes the pole itself, external communication sensing equipment, bottom power distribution and each equipment warehouses.

(c) The height, arm length, spacing and other standards of the pole body shall be tested, and the relevant data shall comply with the relevant government regulations (CNS and the Construction Department of the Ministry of the Interior and other relevant units' regulations).

(d) The working environment, installation space, load bearing, overall safety, stability, maintenance, and other factors of the attached equipment shall be comprehensively evaluated.

(e) The materials of the pole body include hardness, strength, wind resistance, shock resistance, corrosion resistance and water resistance (CNS, Construction Department of the Ministry of the Interior and other relevant units).

(f) The appearance design shall be adjusted according to the surrounding environment, culture, landscape and other factors.

(g) It is necessary to evaluate the load bearing requirements, load design and the standard service life of the structural design of the external communication sensing equipment.

4.1 Pole System Design

Including design principles, pole body design, load weight setting, waterproof requirements, windproof requirements, shockproof requirements, anti-corrosion treatment, pole body height, other requirements, etc.

4.1.1 Pole Height

The height range of the pole should be 3 m~15 m. The height of the smart pole should be selected according to the actual application scenario.

Table 4.1.1-1 5G Smart Pole Application Scenarios

Scenarios		Height of 5G Smart Pole
Road	High, fast speed road	8-15
	Main, secondary road	8-12
	Branch road	6-8
Viaduct, bridge, interchange road		8-12
Commercial pedestrian street, park, community, sidewalk, small car lane		3-6

Layered design principle shall be used in 5G Smart Pole

(a) Lower layer: the height is less than 2.5m, suitable for supporting equipment (power supply, gateway, router, etc.), charging post, interactive digital signage, emergency call, equipment warehouse, etc.

(b) Upper layer: 2.5m-8m high, applicable to digital road signs, traffic signs, video surveillance, public push notification, Wi Fi equipment, FWA equipment and other facilities.

(c) Pole top: the height is generally more than 8m, and it is advisable to deploy telecommunications network, environmental monitoring, intelligent lighting, and other facilities.

4.1.2 Load Weight Setting

Weight, capacity, transmission interface and transmission mode of attached equipment:

Table 4.1.2-1 Relevant Values of Attached Equipment

Attached Equipment	Max Weight	Reference Power	Interface (Reference)	Transmission Mode (Reference)
Telecommunication network	90 kg	150W	Optical fiber	Wired
Wi-Fi device	3 kg	2W	Network port	Wireless or wired

LPWAN	1.3kg	12W	NB-IOT, LoRa…etc	Wireless
Road-Side Units (RSU)	15kg	26W	Network port	Wired
Intelligent lighting	15 kg	250W	RS485、NEMA Standard interface, 0-10V, PWM, DALI Output interface	Wireless or wired
Environmental monitoring	1.2 kg	2.5W	Network port or serial port	Wireless or wired
Video surveillance	3.2 kg	48W	Network port or optical fiber	Wired
Traffic sign	26 kg (5 lights)	50W	Network port or serial port	Wired
Public push notification (Host)	1 kg	36W	HDMI	Wired
Public push notification (loudspeaker)	2.02kg	13W	Network port	Wired
Emergency call for help	2.5 kg	12W	Network port	Wired
Road digital sign	46 kg	600W	Network port or serial port	Wired
Interactive digital signage	4.9 kg	70W	Network port or serial port	Wired
Charging post	6 kg	7k~17.6kW	Network port	Wired
Gateway	1.5kg	47W	Network port or serial port	Wired
Switch	1.5kg	20W	Network port or serial port	Wired
Edge computing	7kg	330W	Network port	Wired

The above table only shows the attached equipment inside the pole body, and the more detailed specification requirements of WG1 attached equipment are described in 4.2.3.

4.1.3 Composition of Pole System

The pole system is composed of pole body, foundation cage, cross arm, equipment warehouse (including expansion), door lock and other modules. Power distribution module, communication module, lightning protection module, grounding module, etc. are built in the equipment warehouse.

4.1.4 Pole Body Design

According to different use environments, the pole body can be circular or polygonal, and the appearance of the pole body can be designed according to the local cities and cultural characteristics. On the premise of effective economic scale and mass production cost, the following requirements shall be met:

(a) The pole structure and overall safety shall comply with the "Code for Design of Steel Structures of Steel Buildings (I) Code and Interpretation of Steel Structure Allowable Stress Design Method" issued by the Construction Department of the Ministry of the Interior [1],

which should be checked.

(b) The materials for the pole body design shall be carbon steel and low alloy steel. The steel plate material shall comply with the specification of "CNS-2473-G3039-SS400" [2], and the steel pipe shall comply with the specification of "CNS-4435-G3102" [3]. The height, structure, load and other factors shall be comprehensively considered in the design of pole thickness.

(c) When new materials such as high-strength aluminum alloy are used for pole body design, their performance shall comply with the relevant provisions of CNS 2253 H3025 [4] and CNS 2257 H3027 [5]. It is recommended to use SS400 mild steel with a thickness greater than or equal to 6mm.

(d) For the process and design of combined connection, such as the strength of welding seam and the strength of bolt connection, please read the design specifications or relevant technical regulations in detail.

(e) Nonfunctional reflective and anti-glare surface treatment process shall be used for the pole body.

(f) The pole body should also have anti pasting function, and the height of the anti-pasting area should not be less than 2.5m.

4.1.5 Anti-Corrosion Treatment

Shall meet the following requirements:

(a) Hot dip galvanizing or hot dip aluminum shall be used for anti-corrosion treatment of steel poles, and the surface can be painted or sprayed according to actual needs.

(b) The rust prevention treatment of hot-dip galvanizing and hot-dip aluminizing on the pole surface shall comply with the provisions of CNS 10007 [6] and CNS 1247 H2025 [7].

(c) The painting treatment shall comply with the provisions of CNS601 [8], CNS1157 [9] and CNS4908 [10];

(d) The corrosion resistance of the pole body shall be verified by CNS8886 " Methods of salt spray testing " [11].

4.1.6 Load Requirements

The actual load weight of the pole body shall match the load capacity of the pole body. In addition to integrating existing functional equipment loads, space shall be reserved for increasing

system loads in the future. The limit of pole top weight shall be designed according to different pole body design and size, which can be referred to relevant regulations.

4.1.7 Wind Resistance Requirements

In terms of wind resistance design, the design shall comply with the "Technical Code for Design of Steel Structures of Steel Buildings (I) Code and Interpretation of Allowable Stress Design Method for Steel Structures", "Code and Interpretation of Wind Resistance Design for Buildings" [12], "Code for Design of Building Foundations" [13] and "Code for Design of Concrete Structures" [14] issued by the Construction Department of the Ministry of the Interior, and meet the following requirements:

(a) The wind pressure standard is calculated as 60m/s (Grade 17), and the basic wind pressure shall not be less than 499kgf/m ² (Refer to P.51 Wind Speed and Pressure Conversion Table of "Typhoon 100 Q&A" issued by the Central Meteorological Administration), the time is 5 minutes or more.

(b) The design value of material strength shall be greater than the maximum stress of the base, pole, cantilever, equipment and its connecting accessories under the combined value of wind pressure;

(c) The deflection angle of the pole body caused by the maximum wind force shall not exceed the design value when the mounting equipment has requirements for deflection angle.

Table 4.1.7-1 Wind Resistance Design Parameters of Pole Body

Pole height (m)	Range of pole bottom diameter (mm)	Total windward area (m2)	Basic wind pressure (KN/m2)	Wind power level
3-6	≦280	≦5	0.65	≧17
6-10	≦350	≦3		
10-15	≦450	≦3		
15-20	≧450	≦3		

4.1.8 Seismic Requirements

It is necessary to consider the seismic capacity of the whole bearing bar. It shall comply with the provisions of "Code for Seismic Design of Buildings and Commentary" [15] revised by TNYZ ORDER No. 0990810250 of the Ministry of Interior on 100.1.19. If it is required to be able to

withstand an earthquake of magnitude 6 without collapse, it is recommended that the earthquake of magnitude 7 be used for seismic design. In case of modular multilayer design, the impact of shear stress on the structure shall be evaluated.

4.1.9 Other Requirements

When designing 5G smart poles, the expandability of functional equipment shall be fully considered, and processing interfaces and installation space shall be reserved for mounting equipment and supporting facilities. In the later stage, the equipment can be easily installed and replaced under the condition of meeting the load requirements of the pole body. The reserved processing interface and installation space of the pole body shall meet the following requirements:

(a) Equipment installation space shall be reserved on the pole body, and threading space shall be reserved inside.

(b) During the design of the pole body, the reserved threading holes shall be polished smooth without burrs and sharp edges, and waterproof rubber mud shall be added.

(c) The position of the supporting transmission cable shall be reserved inside the pole body, so that the supporting cable can be pre-installed as required. If the optical fiber distribution box cannot be mounted outside the pole, space should be reserved inside the pole to install the transmission optical fiber distribution box ODB.

(d) Flange installation position shall be reserved at the top of the pole body, which is convenient for installing small base station of telecommunication network, radio monitoring, meteorological monitoring, and other equipment. In addition, the installation position of lightning pole shall be reserved.

(e) The material of antenna outdoor protective cover must have such excellent properties as low dielectric, low loss, high strength, flame retardancy and heat resistance.

(f) As specified in CNS 15,200-7-7 [16], all equipment must meet UV resistance requirements.

(g) The dust-proof and waterproof grade of all attached equipment shall be at least IP65. Or other waterproof design methods such as waterproof boxes/boxes can be used to make the equipment pass the IP65 test.

4.2 Equipment Mounted

The design of 5G smart pole body can be divided into three layers according to the height: pole top, upper layer, and lower layer. Different layers mount different devices that support

various application functions:

- Pole top (above 8m): 5G related telecom network equipment, WiFi AP, antenna, FWA equipment, C-V2X (external light crossbar) and other related equipment are expected to be placed here.
- Upper layer (2.5m – 8m): For example, image monitoring, environmental monitoring, public push notification, traffic signs, digital road signs, optical and radar sensing application devices will be attached to this layer.
- Lower layer (2.5m): The attached equipment on this layer is emergency call, interactive digital billboard, charging post and other equipment. To facilitate people's daily use, its location should be designed at a height that people can touch.

The attached equipment shall comply with current standards and relevant laws and regulations. The attached equipment includes but is not limited to the equipment types mentioned in this specification. The height of the above equipment types can be adjusted according to different requirements of different counties and cities and different scenarios.

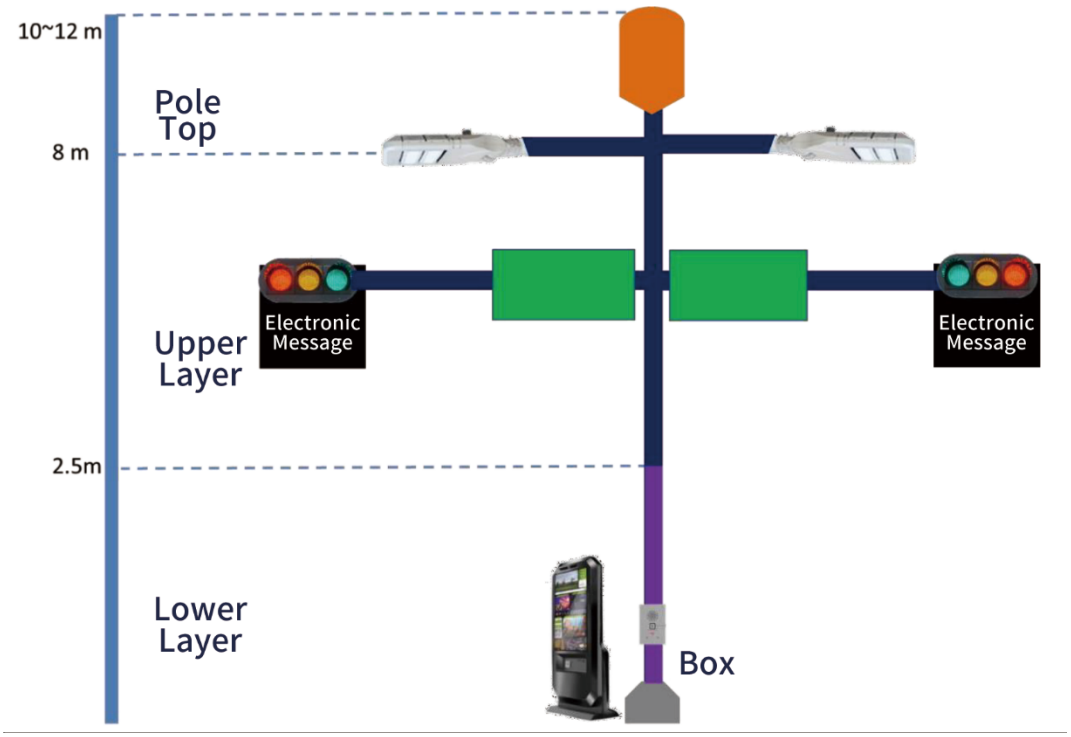


Figure 4.2-1 Layered Diagram of 5G Smart Pole

Figure 4.2-2 Schematic Diagram of 5G Smart Pole Mounting Device

(Quoted from the "Smart Pole Technical Specifications and Verification Industry Cooperation" of the Institute for Information Industry) [17]

4.2.1 Height Design Principle of Mounted Equipment

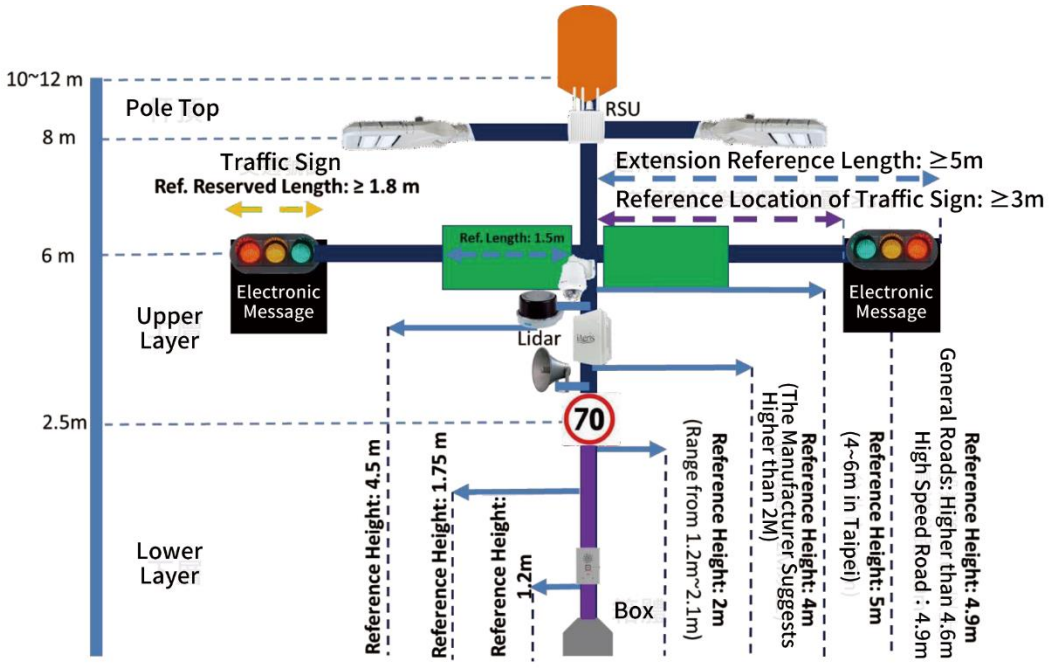


Figure 4.2.1-1 Schematic Diagram of 5G Smart Pole Mounting Device

(a) Communication device

The antenna and the small base station should be installed at the top of the pole at 10-12m.

(b) Intelligent lamps

The following two conditions shall be met for simulation by reference to the road setting parameter conditions in the documents of the Construction Department of the Ministry of the Interior "Code for Design of Urban Roads and Ancillary Works – Chapter 19" [18] and the Ministry of Economic Affairs Energy Administration "Technical Specification for Setting LED Street Lamps in Taiwan", such as pole height, road width, pole spacing and other parameters:

(1) Simulated illumination uniformity ≥ 0.33; (Simulated illumination uniformity=simulated minimum illumination/simulated average illumination)

(2) Simulated average illuminance ≥ 10 lx, or according to the road lighting demand specified by the procurement unit

(c) Extension pole

Adjust the lamp height in different environments according to the suggestions on the installation principles of street lamps provided by the Public Works Department of Taipei City Municipal Government [19]:

(1) Sidewalk: It is recommended that the mounting height of the light pole is 4 meters, and the distance between poles is suggested to be 16-35 meters.

(2) The road width is 8-11 meters street lane: the mounting height of lamp pole is recommended to be 8 meters or 5 meters, and the distance between poles is recommended to be 28-36 meters and 17.5-22.5 meters.

Road width 11-15 meters street lane: 10 meters or 8 meters is recommended for the height of light pole, and 35-45 meters and 28-36 meters are suggested for the distance between poles.

If the road width is more than 15 meters: the mounting height of the lamp pole is recommended to be more than 10 meters, and the distance between the poles is suggested to be about 35-45 meters.

With reference to the "Professional Services for the Integration of Taipei Street Lamps, Signage and Pole Attachment Facilities" issued by the Park Street Lamp Engineering Management Office of the Public Works Department of Taipei Municipal Government [20],

the height of the extension pole is tentatively determined to be 5m or more. At the position 6m above the ground, the length of the extension pole shall be adjusted after the pole body simulates the conditions of wind resistance, earthquake resistance and waterproof. Each county and city can also adjust the length and shape of the extension pole as required.

(d) Road Sign

With reference to the "Professional Services for the Integration of Street Lamps, Sign and Post Attaching Facilities in Taipei City" [21] and the "Kaohsiung City Comprehensive Replacement of Energy Saving (Smart) Street Lamps and Maintenance Plan" of the Park Street Lamp Engineering Management Office of the Public Works Department of Taipei Municipal Government, the length of the road sign is 1.5m~2m in principle, and the width is set at 1m in advance. The height of the device can be adjusted according to the requirements of the county and city governments.

In addition, according to Article 18 of the "Rules for the Setting of Road Traffic Signs" [22] of the Ministry of Transports, "as for the vertical clearance standard of hanging signs, the average road shall not be less than 4.60 m, and the expressway shall not be less than 4.90 m; The distance between the pillar or support and the edge of the shoulder shall not be less than 60cm. ", It is tentatively determined that the road sign is mounted at a height of 5m.

(e) Traffic Signs

According to the "Rules for the Setting of Road Traffic Signs and Signs" issued by the Ministry of Transport, the types of signs include warning, prohibition, indication and assistance. The size specification of each sign shall be set according to the regulations of the Ministry of Transport. According to Article 18 of the "Rules for the Setting of Road Traffic Signs and Signs", the setting of signs must meet the following requirements: "The setting height of vertical signs shall be 1.2 m to 2.1 m from the lower edge of the sign to the top of the road edge or side ditch, and the sign shall not interfere with pedestrian traffic. The same pillar in the same direction shall be limited to three sides at most and shall be arranged from top to bottom according to the order of prohibited signs, warning signs and indicator signs.", Therefore, the lowest traffic sign is placed about 1.2m above the ground. The number of traffic signs attached shall be determined according to the design of each county and city.

(f) Traffic light (Red & Green Signal Light)

The mirror size shall be marked in accordance with the "Rules for Setting Road Traffic Signs and Markings". In principle, it is based on the traffic signs of three traffic lights. However, considering that traffic lights have more functions, the number of lights varies from

three to five. After referring to the frame size of several manufacturers and the number of signal lamps, the length range can be between 1m and 2m, and the width can be set at 0.35m. It can be adjusted according to the needs of each county and city.

(g) Internet of Vehicles(C-V2X)

The equipment composition of the Internet of Vehicles includes Roadside Unit, Lidar, and Radar. At present, domestic manufacturers are still in the experimental stage, but it is likely to introduce the Internet of Vehicles into the application of smart poles in the future. Therefore, in the WG1 specification, the routing and placement space of Internet of Vehicles related equipment will be reserved first. The roadside unit is not only responsible for receiving and sending the information of the Internet of Vehicles related equipment, but also configured with an antenna, so it is recommended to place it on the top of the pole to avoid unnecessary interference to the traffic. According to the design of the pole body, the roadside unit will be placed at a height of more than 8m from the ground. Lidar and radar need to scan the real-time dynamics on the road, so they should be placed close to the ground. It is recommended to design the mount height above 3m. In the future, the mount height will be adjusted according to the design requirements of each county and city and the components used.

(h) Video surveillance

The monitoring system is divided into cameras belonging to the police and government units and cameras belonging to the Ministry of Transport. Because of their different purposes, their heights and placement positions are also different. The cameras belonging to the police and administrative units are used to assist in scientific and technological law enforcement. Therefore, they are required to have high definition and can distinguish the photography quality of the license plate level. The actual purpose of the Ministry of Transport is to observe the real-time images of traffic flow at important intersections. The surveillance camera belonging to the police unit is recommended to install an additional extension pole to adjust the angle to face the direction of traffic at each intersection, and it is recommended to install it at a height between 3~6 meters (according to the Public Works Department of Taipei Municipal Government's "Taipei City Street Light and No. 1 Pole with Hanging Facilities Common Pole Integration Professional Service Case __ Final Report").

(i) Environment Detection

It is recommended to be placed above 2m from the ground, which can be adjusted according

to the difference of each brand, or the different seat height of each county and city.

(j) Public push notification

At present, it is recommended to place it 2.5m above the ground.

(k) Emergency contact

It is recommended to install it somewhere people can reach. At present, it is recommended to install it somewhere 1.2m above the ground.

4.2.2 Function Configuration

According to the different application places of smart poles, there are five different situations in a broad sense, and the functional configurations of these five situations are shown in Table 4.2.2-1. Both the standard and optional functions will be designed into the smart pole together. The use of charging posts and solar energy is also added to the new category. If there are other needs, they can be discussed and updated to the specification. Here we take the application scenarios of Type 2, Type 3 and Type 4 as examples, attach the layout diagram of the smart pole, and provide the location, height, relevant reference regulations and actual cases of the mount.

Table 4.2.2-1 Reference Examples of Basic Application Scenarios of 5G Smart Pole

Type	Road Scene	Application Function Reference														Diameter (m)	Height (m)	Power (W)
		Telecommunication Network	FWA (WiFi)	Intelligent Lighting	Environmental Monitoring	Video Monitoring	Traffic Sign	Public Broadcast	Emergency Call	Road Sign	Digital Road Sign	Interactive Digital Board	Digital Advertising Billboard	Charging Post	Internet of Vehicle	Solar Power			
1	Expressway	▲		▲	△	▲			△						△			10+	Low
	High Speed Road	▲		▲	△	▲			△						△				
2	Sub Road	▲		▲	△	▲	▲			▲	▲				△			8+	Low
	Main Road	▲		▲	△	▲	▲			▲	▲				△				
	Crossroads	▲		▲	△	▲	▲			▲	▲				△				
3	Residential and Commercial Pedestrian Street	▲	△	▲	▲	▲		▲	▲			△	▲					3-8	High
	Park Scenery	▲	△	▲	▲	▲		▲	▲			△	▲						
4	Beside the Parking Lot	▲		▲		▲								▲				3-8	Mid
5	Main Road Area	▲		▲												▲		3-8	Mid

Remarks: ▲ Standard configuration; △ Optional; Scenario selected according to the actual application

4.2.2.1 Layout Diagram of Type 2 Smart Light Pole

Type 2 is used on primary and secondary roads and intersections. Besides providing communication services, attached devices and applications also provide traffic sign related attachments such as traffic lights, traffic signs, etc. This smart pole must also provide image monitoring, including image monitoring equipment belonging to the police and government units

and image monitoring equipment for the Ministry of Transport to observe real-time traffic flow. Due to the application scenario, most of the attached devices are installed on the upper layer and top of the smart pole. Smart pole is arranged as follow in Type 2 scenario:

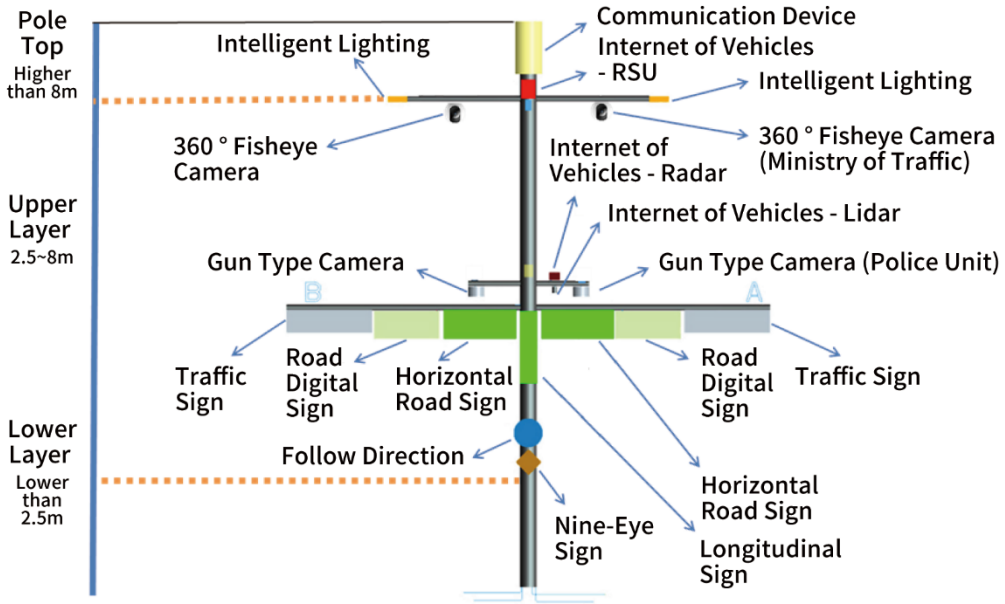


Figure. 4.2.2.1-1 Schematic Diagram of Type 2 Smart Pole

(a) Top of the pole

– **Telecommunication network:** small base stations, antennas and other equipment are installed at the top of the pole, which will not interfere with signal transmission. In addition, the RSU of C-V2X is also recommended to be installed at the top of the pole, so that the signal transmission is not easily interfered.

(b) **Upper layer**

– **Traffic sign:** It is recommended to set the traffic sign on the extension pole about 6m from the ground, and the height after mounting is about 5-5.5m from the ground.

– **Road sign:** it is mounted on the extension pole about 6 meters from the ground (refer to Figure. 4.2.2.1-1) as high as the traffic sign. The specification of road sign can refer to 4.2.3.9. In addition, the layout of the extension pole can be adjusted according to the design requirements of various counties and cities and manufacturers. At the same time, in order to avoid permanent deformation of the pole caused by external factors or the attached weight, the attached load of the extension pole must also be checked.

– **Smart lighting:** For the height setting of lighting equipment, please refer to the "Chapter

19 of the Code for Design of Urban Roads and Ancillary Works" issued by the Construction Department of the Ministry of the Interior. The erection height is converted from the road width, and then the installation distance between smart poles is calculated according to the height. Figure 4.2.2.1-1 shows that the intelligent lighting lamps are placed on the extension pole near the top of the pole before the height of 8 meters. The mounting height and distance of smart lamps can be appropriately adjusted according to the design requirements and cost assessment of each county and city.

- **Image monitoring:** Whether it is fish eye camera, PTZ, or gun camera, it is recommended to build an extension pole to make the camera in the best position to avoid other equipment on the pole blocking the shooting angle. As shown in Figure. 4.2.2.1-1, an extension pole shall be set up at a height of 6m to place the respective image monitoring equipment of different units, which shall be distinguished from other equipment. The height of the image monitoring extension pole is also different from that of other extension poles. No matter it is suspended or installed on the extension pole, space is reserved to prevent interference with other equipment.
- **Environmental monitoring:** In the Type 2 scenario, the smart pole is placed at a height of about 8 meters above the ground and close to the top of the pole. The pole body in the Type 2 scenario sets the environmental monitoring as optional.
- **Internet of Internet of Vehicles:** The equipment composition of the Internet of Vehicles includes the aforementioned RSU mounted on the top of the pole, as well as radar and optical data. Referring to the demonstration of smart poles near Huabo in Taichung by the Industrial Institute, it is recommended to place the radar and lidar on the extension poles near the road surface, so to scan the road surface for incoming vehicles and notify the RSU for transmission.

(c) **Lower Layer:** The pole body under 2.5m in principle.

- **Traffic signs:** the road signs with the lowest distance from the road surface can be placed from 1 to 1.2m from the pole, and at most three traffic signs can be placed on one smart pole.

The mount height in the Type 2 scenario is only the recommended height. If the counties, cities, and manufacturers have reasons for design needs and cost considerations, they can adjust the mount height and mount equipment.

4.2.2.2 Layout Diagram of Type 3 Smart Light Pole

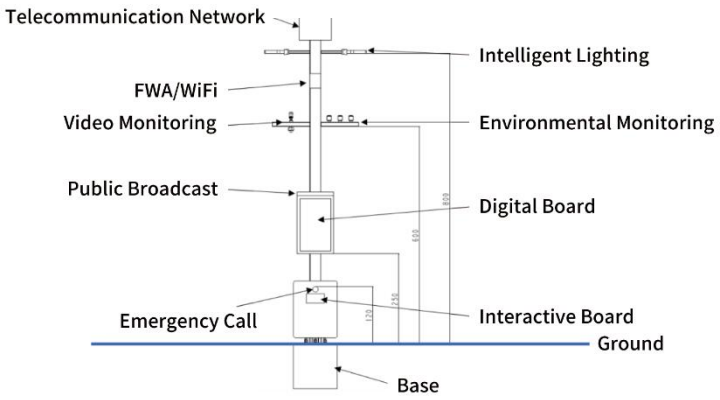


Figure. 4.2.2.2-1 Schematic Diagram of Type 3 Smart Pole

The Type 3 scenario is in the residential and commercial walkway and park scenic area, with many users and many application functions available. According to the location principle of attached equipment mentioned in 4.1.2, the layout is described as follows:

(a) **Top of the pole**

– Telecommunication network: small base station, antenna, CPE, WiFi AP and other devices are mounted at the top of the pole, which will not interfere with signal transmission.

(b) **Upper layer**

– **Smart lighting:** For the height setting of lighting equipment, please refer to the "Chapter 19 of the Code for Design of Urban Roads and Ancillary Works" issued by the Construction Department of the Ministry of the Interior. The erection height is converted from the road width, and then the installation distance between smart poles is calculated according to the height. The figure shows that the intelligent lighting lamps are placed on the extension pole near the top of the pole before the height of 8 meters. It can be appropriately adjusted according to the design requirements and cost assessment of each county and city.

– **Image monitoring:** Whether it is fish eye camera, PTZ, or gun camera, it is recommended to build an extension pole to make the camera in the best position to avoid other equipment on the pole blocking the shooting angle.

– **Environment detection:** It is recommended to use extension poles to increase the placement space. In the Type 3 scenario, poles are mostly used in parks and hiking areas.

The pole itself is low in height, so there is no extra space to place large equipment

(c) **Lower Layer:** The pole body under 2.5m in principle, most devices here are for human-computer interacting.

- **Public push notification:** announcement or emergency broadcasting.
- **Digital display board:** it can be used by manufacturers to advertise and charge advertising fees
- **Interactive digital billboards:** In the future, you can plan payment services or map guidance and other functions to provide services for pedestrians in pedestrian areas.
- **Emergency contact:** Emergency call can be used to request emergency assistance when needed and necessary.

4.2.2.3 Layout Diagram of Type 4 Smart Light Pole

The smart pole in the Type 4 scenario mainly integrates the attached charging post to the pole body. The current use scenarios of smart poles are designed in parking lots, roadside and other application scenarios. The field of charging posts is the future development trend. In the future, electric vehicles will be more popular, and the demand for charging posts will also increase. If the smart pole can be used to provide charging services for passers-by, the range of activities and convenience of electric vehicles can be improved, thus creating more business opportunities and cooperation models. Based on the above considerations, WG1 has designed the use situation of the Type 4 smart pole in advance for the reference of the county and city governments or manufacturers. The layout of the attached equipment is as follows:

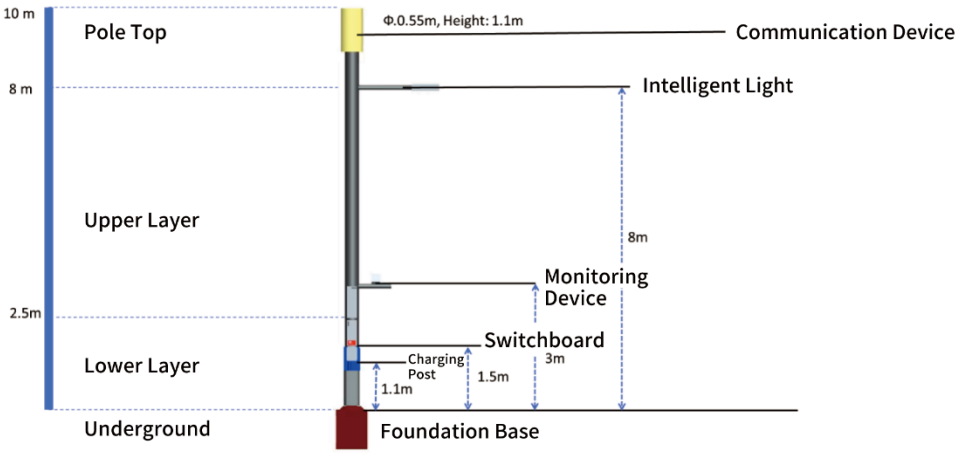


Figure 4.2.2.3-1 Schematic Diagram of Type 4 Smart Pole Mounting Device

(a) Pole top

- **Telecommunication network：** The mini base station, antenna, CPE, WiFi AP and other devices mounted on the top of the pole and will not interfere with the transmission of signals. Since the Type 4 smart pole will not be placed on the main roads or crossroads, temporarily it's not suggested to install the Internet of Vehicles , which is a relatively low frequency device.

(b) Upper layer

- **Smart lighting:** for the height of lighting equipment, it is recommended to convert the erection height from the pavement width according to the specifications in Chapter 19 of the "Design Specifications for Urban Roads and Ancillary Works". Then calculate the erection distance between poles according to the erection height. The schematic diagram shows that the smart lighting fixtures are first set up at a height of 8 meters, which can be adjusted according to the needs of various counties and cities.
- **Image monitoring:** Whether it is a fish eye camera, PTZ or gun type monitor, it is recommended to build an extension pole so that the monitor can be placed in the best position, so as to avoid other equipment on the pole blocking the camera angle.
- **Internal equipment:** It is recommended to place the network communication equipment, including gateways, switches, etc., above the power distribution panel, near the maintenance hole, which is more convenient for maintenance.

(c) Lower layer

- **Distribution board:** WG2 defines the power required by the Type 4 smart pole and turns out the mounted equipment connected to the pole through the distribution board. It is also recommended to place this switchboard near the maintenance hole for easy maintenance.
- **Charging post:** At present, there are two types of charging posts: AC charging post and DC charging post. The AC charging post is light in weight and small in size, and can be locked on the smart pole without affecting the load bearing structure of the pole. On the smart pole of Type 4, it is recommended that the AC charging post be the first choice for design.
- **Box:** In the Type 4 scenario, the solution to the new box is in the 5G communication equipment of WG3. Part of the equipment can be placed at the lower layer of the pole body, which can reduce the weight of the pole top, and if the internal equipment of the pole body fails or is temporarily adjusted, the lower layer box can be directly opened for

maintenance. This solution can also be used in the design of POC (Proof of Concept) in the future, which not only facilitates the adjustment of wiring and the elimination of errors, but also eliminates the need to adjust the elevator, thus saving POC funds and increasing security. In addition, such design is not limited to Type 4, but can also be designed in other situations if required by the designer.

–

4.2.2.4 Loop Control Box

The box shall be made of hot-dip galvanized plates with a thickness of 1.5mm or more, and the hot-dip galvanized plates shall be sprayed with outdoor powder after welding. The base of the box shall be made of cold rolled steel plates with a thickness of no less than 2mm, and the surface shall be hot-dip galvanized after welding. The chassis shall have the following design concepts: modular structural design, convenience of internal equipment installation and maintenance, strong and vandal resistant chassis, natural or forced cooling solutions, and a certain degree of waterproof function. Base station equipment, power supply equipment, storage battery, temperature control equipment, transmission equipment and other supporting equipment can be installed in the chassis or installation space can be reserved for the above equipment. The actual design requirements and restrictions can be customized according to different requirements.

4.2.3 Equipment Mounted and Functions

4.2.3.1 Pole Top

4.2.3.1.1 Requirements for Telecommunication Network Equipment

The telecom network equipment (including but not limited to 4G/5G small base station) shall be installed through the mounting space, threading hole and power supply capacity reserved by the 5G smart pole. The telecom network equipment shall comply with the relevant regulations in NCC. The telecommunication network equipment can be installed in the pole top chamber at the top of the 5G smart pole, which is connected with the top of the 5G smart pole through the flange structure. The pole top chamber supports 360-degree horizontal rotation angle adjustment and can ensure its strength. Refer to Appendix A for reference design of pole top chamber and flange plate. The pole body design shall consider the wind resistance of the pole top chamber. The outer mask of the pole top chamber of the telecommunications network equipment must be made of non-metallic materials to avoid the signal shielding effect. The waterproof design shall be considered

for the pole top compartment. The telecommunications equipment must function normally, and the outlet and grounding terminal shall be reserved.

Table 4.2.3.1.1-1 Parameters (Recommended Values) of Telecommunication Network Equipment (Small Base Station)

Pole height	Load bearing demand	Circuit breaker demand		Basic requirements for pole body		
		Power consumption requirements	Circuit breaker demand	Pole diameter (Top - Bottom)	Material	Thickness
≦15 m	90 kg	600 W	Input capacity 20A, output 1 ×16A + 3× 6A	≦550 mm	Carbon steel, high-strength aluminum alloy	≧6 mm

Table 4.2.3.1.1-2 Example of Telecommunication Network (4G/5G) Specifications

Telecommunication network& Wireless communication equipment (5G sub6G/mm Wave, CPE)	Working Voltage	DC12V/19V/48V PSU 85~277V AC
	Power Consumption	150W
	Size	Ø 550mm x 1100 mm
	Weight	90kg
	Working Temperature	-10º C ~ 60º C
	Communicate Interface	RJ45
	Ip Rating	IP65

Table 4.2.3.1.1-3 Example of telecommunication network (5G mm Wave) specification

Telecommunication network (5G Wave)		
	Operating Temperature	-10º C ~ 60º C
	Size	φ<350 mm
	Weight	<15 kg
	Power Consumption	<150 W
	Frequency	n257/n258/n260/n261
	Antenna Wire	128T/128R
	Wireless Communication Technology	5G NR FR2
	Maximum Output Power	43 dBm
	Communicate Interface	10Gbps RJ45
	Ip Rating	IP65

4.2.3.1.2 Requirements for Wi-Fi Equipment

Install Wi Fi devices on 5G smart poles to realize the function of public networking. Wi Fi

equipment shall comply with relevant regulations in NCC and IEEE 802.11 [23] series standards. The Wi Fi equipment should be installed on the top of the pole in an external way.

Table 4.2.3.1.2-1 Reference Example of Wi Fi Device Specifications

Wi-Fi Equipment	Working Voltage	802.3at PoE (30W)
	Power Consumption	2W
	Size	226.7mm x 256.7mm x 90.3mm
	Weight	3kg
	Working Temperature	-40º C ~ +85º C
	Communicating Interface	RJ45
	IP Rating	IP67

4.2.3.1.3 Requirements for Fixed Wireless Access Equipment

Install FWA (Outdoor AP Unit) on the 5G smart pole to access 4G/5G signals. This can be used to provide Wi Fi or transfer out RJ45 for control. FWA equipment shall comply with relevant provisions in NCC series standards. FWA equipment should be installed on the upper layer of the pole body in an external way. The following specifications are for reference only and can be adjusted appropriately with the design of each county and city government.

Table 4.2.3.1.3-1 Example of FWA Equipment Specifications

FWA Equipment	Working Voltage	12V/3A
	Power Consumption	30W
	Size	110mm x 105mm x 217mm
	Weight	2kg
	Working Temperature	Ethernet
	Communicating Interface	12V/3A
	IP Rating	IP66

4.2.3.1.4 Requirements for Roadside Equipment

With the development of Internet of Vehicles, communication between self-driving and other road users and traffic infrastructure is increasingly frequent. The installation of RSU on the pole in combination with 5G/WiFi, DSRC (Dedicated Short Range Communications) or C-V2X (Cellular Vehicle to Everything) helps to provide real-time traffic signals and road condition information to road vehicles and pedestrians, thus avoiding unnecessary accidents.

Table 4.2.3.1.4-1 Example of RSU specification

RSU	Working Voltage	802.3at PoE (30W)
	Power Consumption	26W
	Size	1.In the Pole：400mm x 300mm 2.Out of the Pole：<15 公升(liter)
	Weight	15kg
	Working Temperature	-40º C ~ +85º C
	Communicating Interface	RJ45
	IP Rating	IP67

4.2.3.2 Upper Layer

4.2.3.2.1 Requirements for Intelligent Lighting Equipment

Smart lighting includes lighting equipment and smart management. Intelligent lighting can realize remote centralized management and control, and support lighting status monitoring, lighting power monitoring, as well as convenient query, positioning and other functions. The design and device selection of intelligent lighting shall comply with the relevant requirements of CNS 15233 [24], electromagnetic interference shall comply with the relevant requirements of CNS 14115 [25], safety shall comply with the relevant requirements of CNS 61347-1 [26] and CNS 61347-2-13 [27], and dust and water prevention shall comply with the relevant requirements of CNS 14165 [28]. According to the Construction Department of the Ministry of the Interior - Chapter 19 of the Code for Design of Urban Roads and Ancillary Works, in order to control the dazzle, the lighting equipment should give priority to the use of shielded lamps on the main and secondary trunk roads and expressways, rather than the use of unshielded lamps. The service roads shall give priority to the sheltered or semi sheltered roads. The protection grade of the lamp shall not be lower than IP65, and the lamp wire shall be connected at the wiring terminal in the lamp, instead of wiring in the pole.

Table 4.2.3.2.1-1 Example of Smart Lighting Specifications

Intelligent lighting lamps	Working Voltage	100-277V
	Power Consumption	250W
	Size	710mm x 350mm x 169mm
	Weight	15kg
	Working Temperature	-30º C ~ 50º C
	Communicating Interface	1～10V、DALI (NEMA)
	IP Rating	IP66

Table 4.2.3.2.1-2 Street Lamp Controller

Street lamp controller	Working Voltage	90-264Vac
	Power Consumption	250W
	Size	Φ120mm x 108mm
	Weight	0.2kg
	Working Temperature	-40°C ~ 80°C
	Communicating Interface	RS485, LAWAN (NB-IOT, LORA, and more)
	IP Rating	IP66

Table 4.2.3.2.1-3 Ethernet to RS485 Converter

Ethernet to RS485 converter	Working Voltage	12-48Vdc
	Power Consumption	12W
	Size	45mm x 135mm x 130.6mm
	Weight	1kg
	Working Temperature	-20 ~ 70°C
	Communicating Interface	Ethernet
	IP Rating	IP66

4.2.3.2.2 Requirements for Network Power Supply Splitter

At present, the design of the switchboard on the smart pole only transfers AC power. Although the switch can transfer POE power, some devices can only accept DC power and limit it to a certain range of voltage levels. In order to meet the DC power supply requirements and signal supply of the device, the network power supply splitter (POE Splitter) must be used to separate the Ethernet and power supply. Ethernet is the signal interface of the attached device. The power supply is adjusted to the DC voltage range suitable for the attached device through the transformer inside the splitter, and then supplied to the attached device.

Table 4.2.3.2.2-1 Reference Specifications for Network Power Supply Splitter

Ethernet to RS485 Converter	Working Voltage	36 ~ 57 VDC on PoE
	Power Consumption	21.6W
	Size	26.1mm x 70mm x 95mm
	Weight	0.25kg
	Working Temperature	-20°C ~ 70°C
	Communicating Interface	Ethernet
	IP Rating	IP30

4.2.3.2.3 Requirements for Environmental Monitoring Equipment

Environmental monitoring equipment includes highway meteorological monitoring equipment. For the quality of highway meteorological environmental monitoring equipment, refer to the "Air Quality Standards" in Article 6 of the revised and issued Order 1091159 220 of the Environmental Protection Department of the Executive Yuan. The characteristics of the sensor (such as safety specifications) can be determined according to the relevant requirements and specifications of the general electronic sensor equipment of the Bureau of Standards and Inspection. The interface of meteorological environment monitoring equipment shall adopt RS485, RS235 or RJ45 specifications, and the meteorological monitoring equipment shall be tested and certified by the meteorological department.

Table 4.2.3.2.3-1 Example of Environmental Monitoring Specifications

Environmental monitoring	Working Voltage	100~240V AC
	Power Consumption	2.5W
	Size	180mm x 268mm x 138mm
	Weight	1.2kg
	Working Temperature	-10°C ~ 60°C
	Communicating Interface	RS485
	IP Rating	IP65

4.2.3.2.4 Requirements for Image Monitoring Equipment

As for the standards related to image monitoring, the ONVIF standard Open Network Video Interface Forum is more popular internationally, a lot of big international manufacturers support this standard mainly because of its high compatibility and integrity. Standards related to IP camera, NVR and other devices are defined in ONVIF profile S. For the security of image processing and network monitoring, it is recommended to review and strengthen the CNS16120 [30] series of standards issued in Taiwan.

The image monitoring on the smart pole can be divided into two types: one is under the jurisdiction of the police and the other is under the management of the Ministry of Transport. The differences in their functions and applications are as followings:

(a) Police monitor

- **Main functions**: cooperate with the police in handling cases, detect license plates, and improve public security.

- **Location**: in the roadway, the main intersection. Smart poles can be placed on the side of roads or in the middle of main roads.
- **Arrangement range**: It is recommended to place the incoming vehicles at each intersection. It is recommended to install an extension pole on a smart pole and adjust the lens direction to prevent interference from street lamps and other equipment on the smart pole.
- **Number of cameras required**: multiple cameras, which are installed in different directions at each intersection according to the needs of the police and government units, to facilitate scientific and technological law enforcement.
- **Erection height**: suggested to place it at a lower position to capture of license plates and faces on the road. According to the suggestions in the "Professional Service Plan for the Integration of Street Lamps, Signals and Posts Attaching Facilities -- Final Report" provided by the Park Street Lamp Engineering Management Office of the Public Works Department of Taipei Municipal Government, the monitor should be installed at a height of 3-6m above the light pole.
- **Camera quality:** HD quality, the license plate must be clearly captured, so the demand for bandwidth is also large.

(b) Ministry of Transport Monitor

- **Main functions**: to observe the running state of the traffic flow and the real-time image of the traffic flow.
- **Location**: mainly important road sections and intersections. The collection of traffic flow data at each intersection includes the collection of total flow, traffic by vehicle type (large, medium, small cars or locomotives can be judged) and turning traffic (straight, left turn, right turn). Dynamic instant messages can be reported according to the "transmission cycle". The transmission cycle can be set to 1 sec, 2 sec, 5 sec, 1 min and 5 min. Periodic information is suggested to be returned every 5 minutes.
- **Equipment range**: gun type fixed camera or fish eye adjustable angle camera can be used, covering a wide range.
- **Number of cameras required**: few seats, because the angle can be adjusted, and no image details are needed to observe the overall traffic flow.
- **Erection height:** it is recommended to place it at a higher position to observe the overall situation. It is suggested that the placement height should be more than 5m according to the "Continued expansion of domestic developed video vehicle

detectors" provided by the Transport Research Institute of the Ministry of Communications.

– **Camera quality:** generally, only the remote traffic flow needs to be photographed, so the demand for bandwidth is small.

Table 4.2.3.2.4-1 Example of Image Monitoring Specifications

Image monitoring	Working Voltage	802.3af PoE
	Power Consumption	4.8W
	Size	Ø 210 mm x 332mm
	Weight	3.2kg
	Working Temperature	-40°C ~ 50°C
	Communicating Interface	Ethernet
	IP Rating	IP66

The camera of the Ministry of Transport is a vehicle flow detection-oriented camera, which needs to collect and analyze the real-time information of traffic flow at important intersections 24 hours a day. Important images and data can be extracted and sent back to the network monitoring system host (NVR – Network Video Recorder) for access. The storage days shall be adjusted according to the unit demand of each county and city. The stored images can be provided to the Ministry of Transport and other units for the development of management strategies and relevant laws and regulations. At the same time, it can also meet the needs of science and technology law enforcement, and access and capture images.

The usage of cameras must comply with the administrative regulations of various counties and cities, such as the "Regulations of Taipei City on the Administration of the Setting of Video Surveillance Systems" [31] of Taipei City, the "Key Points for the Administration of the Setting of Public Security Surveillance Video Recording Systems in the Police Department of Xinbei Municipal Government" [32] of Xinbei City, and the "Regulations of Taoyuan City on the Administration of the Setting of Surveillance Video Recording Systems" [33] of Taoyuan City.

4.2.3.2.5 Requirements For Traffic Signal Equipment

The traffic signs on the 5G smart pole should give priority to the visibility of traffic signs, and then attach other equipment. Please refer to CNS14546 [34] for chromaticity range and central bright light, CNS14676-5 [35] for surge protection, CNS13438 [36] for electromagnetic noise, and CNS14165 [37] IP54 for water and dust prevention of lamp modules. It is suggested to refer to the "Rules for the Setting of Road Traffic Signs and Signs" issued by the Ministry of Transport

for the principles of attaching traffic signs and warning signs at intersections.

Table 4.2.3.2.5-1 Example of traffic sign specifications

Traffic sign	Working Voltage	80-240 Vac
	Power Consumption	50W
	Size	1775mm x 355mm x 470mm
	Weight	26kg
	Working Temperature	-20°C ~ 74°C
	Communicating Interface	Ethernet/ RS-232
	IP Rating	IP54

4.2.3.2.6 Requirements for Traffic Signs

According to the "Rules for Setting Road Traffic Signs and Signs" issued by the Ministry of Transport, the types of traffic signs include warning, prohibition, indication and assistance. The size specification of each traffic sign shall be set up according to the regulations of the Ministry of Transport. According to Article 18 of the Rules for the Setting of Road Traffic Signs and Signs, the setting of vertical traffic signs must meet the following requirements:

(a) The height of the vertical sign shall be 1.2m to 2.1m from the lower edge of the sign to the edge of the road or the top of the side ditch. The sign surface shall not interfere with pedestrian traffic. When the poles are set in the same direction, at most three sides of the same pole shall be arranged from top to bottom in the order of prohibition signs, warning signs and indication signs. (From the original document of the Ministry of Communications)

(b) 文 The vertical clearance of hanging signs shall not be less than 4.6 m for general roads and 4.9 m for expressways; The distance between the pillar or support and the edge of the shoulder shall not be less than 60cm. In case of special circumstances, appropriate changes can be made under the principle of not affecting vehicle traffic as much as possible. (From the original document of the Ministry of Transport)

(c) The signboards indicating the names of the intersecting roads shall be set at the appropriate locations of the intersections, and the locations along the whole line shall be consistent as far as possible. This sign is a white border with white characters on a green background. The size of the board should be adjusted according to the number of characters and their arrangement. If the road belongs to the highway system, the route number of the road shall be added to this sign, and the pattern and color of the route number shall be consistent with that of the highway number signs at all levels. (From the

original document of the Ministry of Transport)

Figure 4.2.3.2.6-1 Schematic Diagram of Intersection Road Sign

The use situation of 5G smart light pole includes expressway/expressway (Type1) and main/secondary trunk road (Type2), so the placement of traffic signs must be designed according to the above principles. It can be changed according to the current environment of each county and city.

4.2.3.3 Lower Layer

4.2.3.3.1 Requirements for Public Push Notification Equipment

The public push notification equipment on the 5G smart pole is usually used in special emergencies. The loudspeaker sound needs to be heard by the public, so the suggested sound pressure type can refer to the emergency broadcasting equipment specifications in Article 133 of the Fire Protection Law of the Ministry of the Interior [38] "Standards for the setting of fire safety equipment in various places". In addition, the fire protection unit uses the existing national verification standards such as CNS14657 [39] and CNS14677 [40] for voice pressure level accuracy, sound power, directional characteristic distinction test, frequency characteristic test. It is suggested to continue to use this standard, because it may be modified according to the actual situation.

Table 4.2.3.3.1-1 Reference Specifications of Public Push Dispenser (Host)

Public push notification	Working Voltage	100~240V AC
	Power Consumption	36W
	Size	154.2mm x 143.6mm x 37.8mm
	Weight	1kg
	Working Temperature	
	Communicating Interface	HDMI
	IP Rating	IP52

4.2.3.3.2 Requirements For Emergency Call Equipment

The emergency call equipment shall be installed at the bottom of the pole, and its performance and installation requirements shall comply with the relevant provisions of CNS10522 [41]. The emergency call equipment should be placed within the reach of people, so that people can directly use the emergency call equipment to contact in case of emergency.

Table 4.2.3.3.2-1 Emergency Call Reference Specifications

Emergency call	Working Voltage	90V ~ 240Vac
	Power Consumption	12W
	Size	150mm x 220mm x 250 mm
	Weight	2.5kg
	Working Temperature	-30℃~70℃,
	Communicating Interface	Ethernet
	IP Rating	IP55

4.2.3.3.3 Requirements for Digital Road Marking Equipment

The visibility of road digital signs should be given priority to for the road digital signs of 5G smart poles, and then other devices should be attached. It must comply with the relevant provisions in CNS 14555 [42].

Table 4.2.3.3.3-1 Example of specifications for digital road signs

Digital road sign	Working Voltage	110Vac/220Vac
	Power Consumption	600W
	Size	1350mm × 582mm × 90 mm
	Weight	46kg
	Working Temperature	-10℃ ~ 70℃
	Communicating Interface	Ethernet
	IP Rating	IP65

4.2.3.3.4 Requirements for Outdoor Display Board Equipment

The performance of outdoor billboards shall meet the relevant requirements of CNS 62087 [43]. Outdoor billboards can be used for policy advocacy, emergency broadcast and advertising. The communication interface shall be Ethernet interface, and the display interface can be VGA, HDMI, DP, DVI or SDI.

Table 4.2.3.3.4-1 Specifications of Digital Signage for Information Publishing

Digital Signage for Information Publishing	Working Voltage	100 ~ 240Vac
	Power Consumption	468W
	Size	1242.6mm x 713.6mm x 88mm
	Weight	110kg
	Working Temperature	-5°C ~ 50°C
	Communicating Interface	Ethernet
	IP Rating	IP56

4.2.3.3.5 Requirements for Interactive Digital Signage Equipment

The performance of screen interactive equipment shall meet the relevant requirements of CNS 12506 C5226 [44]. The waterproof and dust-proof model IDOOH-210-IR [45] is IP65.

Table 4.2.3.3.5-1 Example of Interactive Device Screen Specifications

Interactive Device Screen	Working Voltage	90V ~ 240Vac
	Power Consumption	120W
	Size	345mm x 265.3mm x 100 mm
	Weight	6.34kg
	Working Temperature	-20°C ~ 70°C
	Communicating Interface	Ethernet/RS-232/RS-422/RS-485
	IP Rating	IP65

4.2.3.3.6 Requirements for Charging Post Equipment

The performance of electric vehicle charging equipment shall meet the relevant requirements of CNS 15,511-2 [46].

Table 4.1.2.3.3.6-1 Charging Post Specification Reference

Charging post	Working Voltage	200-240Vac
	Power Consumption	17.6kW
	Size	272mm x 260mm x 371 mm
	Weight	6kg
	Working Temperature	-30°C ~ 50°C
	Communicating Interface	Ethernet
	IP Rating	IP55

4.2.3.3.7 Edge Computing Server Requirements

The reference specifications of Edge Computing are as follows:

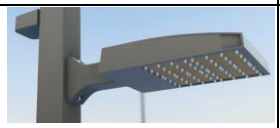
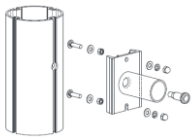
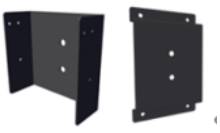
Table 4.2.3.3.7-1 Reference Specifications for Edge Computing

Edge Computing	Working Voltage	85~277V AC
	Power Consumption	330W
	Size	254mm x 244mm x 209mm
	Weight	7kg
	Working Temperature	-20°C ~ 60°C
	Communicating Interface	Ethernet
	IP Rating	IP65

4.2.4 Equipment Installation Requirements

See Table 4.2.4-1 for the general installation and fixing methods of 5G smart pole mounting equipment. The mounting equipment installation scheme shall be customized according to the pole type, which must meet the strength requirements.

Table 4.2.4-1 Installation Method of 5G Smart Pole Mounting Equipment

Mounting Equipment	General fixing accessories	General installation method
Telecom network （5G）		1) The installation methods of small base platform include top installation of pole body (recommended), side hanging installation, embedded installation at the bottom, etc. 2) There shall be no metal objects that block or affect the RF signal within 2m of the main beam direction of the antenna radiation of the small base station. If there is metal shelter, the installation position, direction angle, etc. of the small shielded base platform shall be adjusted. 3) Other equipment (such as Wi Fi) with antenna attached to the pole shall be installed in the middle or lower part of the pole. In addition, it is also necessary to avoid the direction of the main beam radiated by the antenna of the small base station and maintain a vertical distance of more than 1 m from the small base station. 4) Other electronic equipment mounted on the pole without antenna shall avoid the direction of main beam radiated by the antenna of small base station and shall keep a vertical distance of more than 0.5m from the small base station. 5) Fix the adapter flange with screws.
Wi-Fi Device		Most of them are fixed by clamps and screws
FWA Device		1) FWA equipment is installed in the middle layer of the pole body in the way of side hanging. 2) Other electronic equipment mounted on the pole shall be kept at a vertical distance of more than 0.5m from FWA equipment. 3) Fix with clamps and screws.
Light Device		The integral lamp is connected with the pole and fixed with screws. The lamp arm and the pole body are integrally formed, and the light source will be installed on site.
Image monitoring		Select the appropriate mounting bracket according to the shape of the pole, and the bracket is usually fixed with clamps and screws.
Traffic management		Fix of cross arm
Digital signage and interactive digital signage of roads		Designed according to the shape of the pole, and fixed with clamps and screws

4.3 Connector and Pipeline / Requirements

The pole body connectors can be divided into two categories: 1. Devices connected to the outside of the pole body. 2. Connections of equipment mounted inside the pole body. To prevent the liquid from being spilled on the smart pole due to weather or human factors, the connection of external mounting equipment on the 5G smart pole must be waterproof to a certain extent. The internal connector will not directly contact the external environment, so the waterproof level is lower than that of the external connector. However, the cement base will still be elevated inside the pole body, and drainage grooves will be made to prevent rainwater or liquid from seeping into the pole body through the heat dissipation holes. In addition, cable will reserve some length for bending wiring. The water drop can be drained to the bottom to prevent the liquid from directly pouring into the exchanger or important equipment inside the pole body.

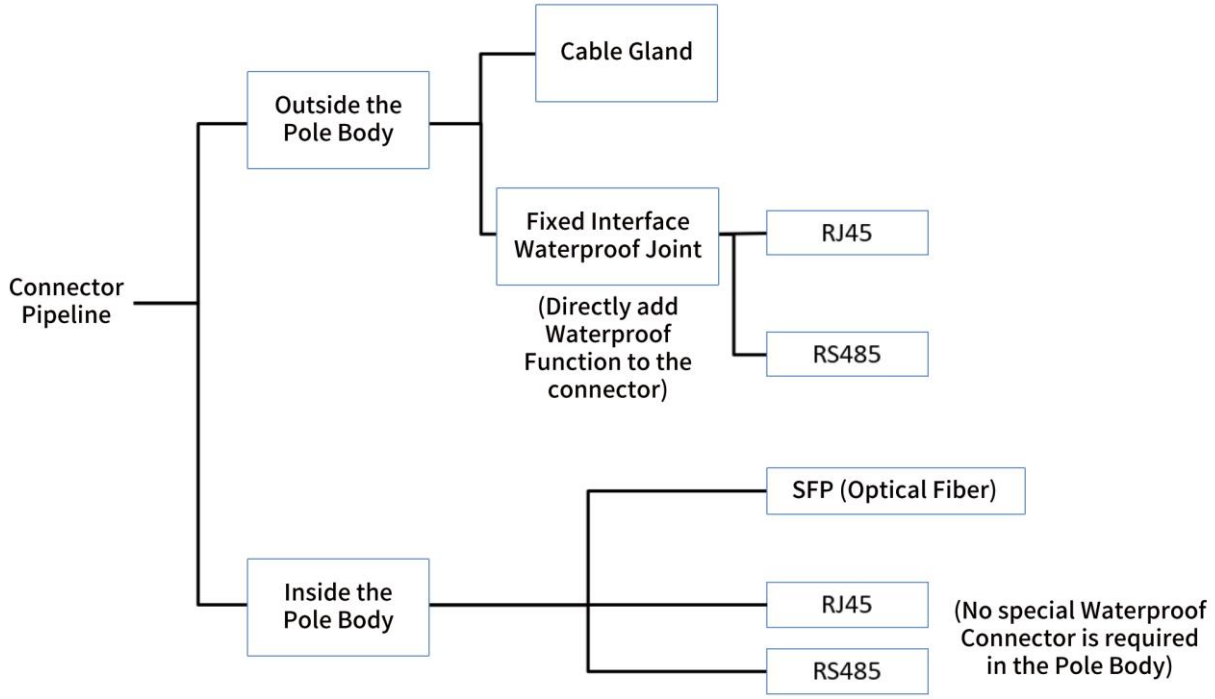


Figure 4.3-1 Schematic Diagram of 5G Smart Pole Connector and Pipeline Classification

4.3.1 Outside the Pole

The equipment outside the pole body will be directly connected with the outside, and there are mainly two different waterproof treatment methods:

(a) Cable Gland: Wrapped waterproof treatment shall be carried out for the pipeline at the rear end of the connector. It can accommodate cables with different interfaces for waterproof treatment.

(b) Waterproof connector: waterproof treatment shall be carried out for the connector itself. Waterproof mechanism shall be added on the positive and negative connectors, and the connection shall be directly covered, and waterproof treatment shall be carried out.

4.3.1.1 Waterproof Connector of Cable Conduit

This waterproof treatment is to lock the cable connected to the attached device to isolate it from the outside world to have the waterproof function. Please refer to Figure 4.3.1.1-1:

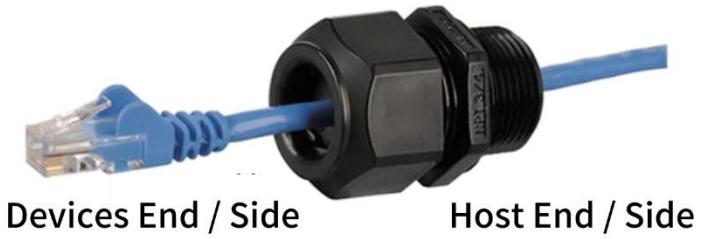


Figure 4.3.1.1-1 Schematic Diagram of Cable Gland (not an appointed manufacturer)

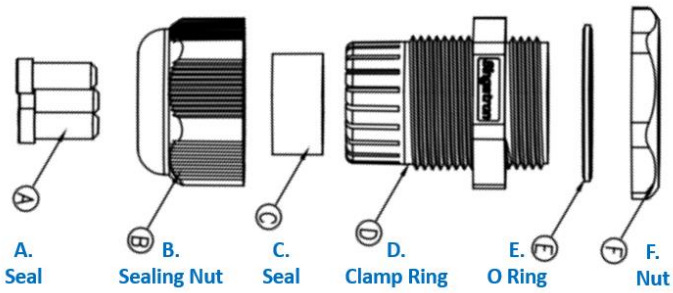


Figure 4.3.1.1-2 Internal Structure of Cable Gland

The cable connected to the mounting device needs to pass through the waterproof connector (cable Gland) first. At this time only the Cable is in the center of the connector. Use the Seal (A.) in the connector shown in Figure 4.3.1.1-2 to fix the position of the cable so that it will not easily shift or fall off, and then use the Seal nuts (B.) and the external nut (F.) to lock it, and to achieve the waterproof effect.

Cable Gland has different sizes (different diameters). Each county and city government and manufacturer can match connectors of different sizes according to the number of devices attached to the smart pole and different needs. Please refer to Figure 4.3.1.1-3. The waterproof grade is recommended to be IP65 or above. The county and city governments and manufacturers

can adjust the waterproof grade according to the current field and needs.

(For reference only，not an appointed manufacturer)
Figure 4.3.1.1-3 Diagram of Cable Gland with Different Sizes [47]
(For reference only，not an appointed manufacturer)

Figure 4.3.1.1-4 Cable Gland Application [48]
(For reference only，not an appointed manufacturer)

On the application level, connectors are different due to different signals of attached devices and different interfaces of Power. It is recommended to install a waterproof enclosure outside the attached equipment and install a waterproof connector on the enclosure for the cable gland. Then connect the cable with the correct interface from the main system through the cable gland and lock it (refers to Figure 4.3.1.1-4) to complete the waterproof.

- **Advantage**

  The focus is on the cable, so it will not be limited to a specific interface. As long as the cable can be locked and isolated from the outside through the cable gland, it can achieve waterproof effect and reduce costs.

4.3.1.2 Special Interface Waterproof Connector (fixed interface)

The basic system architecture of the 5G smart pole will pull the optical fiber into the pole body, connect the switch, then convert it to Ethernet, and then connect it to each mounted device. If the interface used by the attached device is different, the converter will be added for interface conversion. If the waterproof method of the cable gland mentioned above is not used, it is necessary to conduct waterproof treatment for the connectors of each interface to ensure that the cable and the attached equipment will not malfunction due to external environmental factors when connecting. The interface used by the 5G smart pole when connecting various attached devices is as follows:

(a) RJ45 (Ethernet) connector

After the switch is transferred out of Ethernet, connect the waterproof connector of the positive end. In addition, fasten the waterproof negative head to the reserved space on the mounting equipment. Connect the waterproof positive and negative heads and fasten the nuts to isolate the external environment. The waterproof grade is recommended to be above IP65, and some manufacturers may even go to IP66 or IP67. However, all counties and cities can make necessary adjustments according to the design and connector specifications of attached equipment.

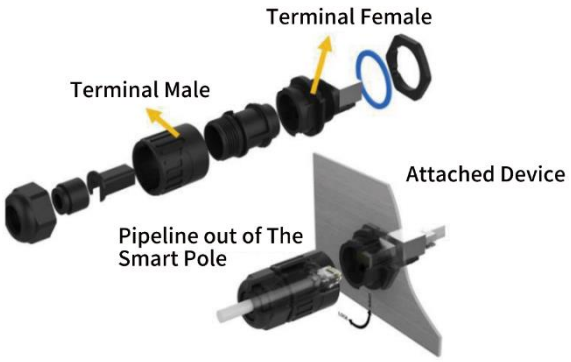


Figure 4.3.1.2-1 Schematic Diagram of Waterproof RJ45 Joint Mechanism

Ethernet cable can be configured with cables (CAT-5e, CAT-6, CAT-6A) of different categories (CAT) according to the bandwidth and speed required by each attached device. The design of the pipeline must meet the impedance requirements (100 Ω) of TIA-568-C.2, the color, stranded wire, and other requirements of the pipeline. RJ45 connectors must conform to T568A and T568B twisted wire and pipeline colors. T568B is used among most of the industry manufactures.

To avoid signal interference, it is recommended to use STP Cable (Shielded Twisted Pair) or SFTP (Shield Created Twisted Pair) when wiring twisted pairs. According to the requirements of counties, cities, and manufacturers, if cables above CAT6 are used, woven mesh and cross shape divider can also be added to the outer layer of the pipeline. In this way, the interference between twisted pairs can be isolated, and the balance structure inside the pipeline can also be maintained so that it is not easy to be damaged (see figure 4.3.1.2-2 below).

At present, POE (Power Over Ethernet) is the main connection of most attached devices in the smart pole, which can not only carry out Ethernet transmission, but also

provide power saving connectors and connectors. As mentioned in the previous paragraph, the transmission speed will increase in the future, so it is recommended that the network route should be above Category - 5e. It is recommended that according to the IEEE802.3bt protocol, at least Type 3 or above, with 4 twisted pairs (also defined in TIA-568-C.2). The minimum power consumption output requirements shall be changed according to the requirements of each county and city and the current design. The manufacturer recommends that the impedance of the POE strand be about 10 Ω.

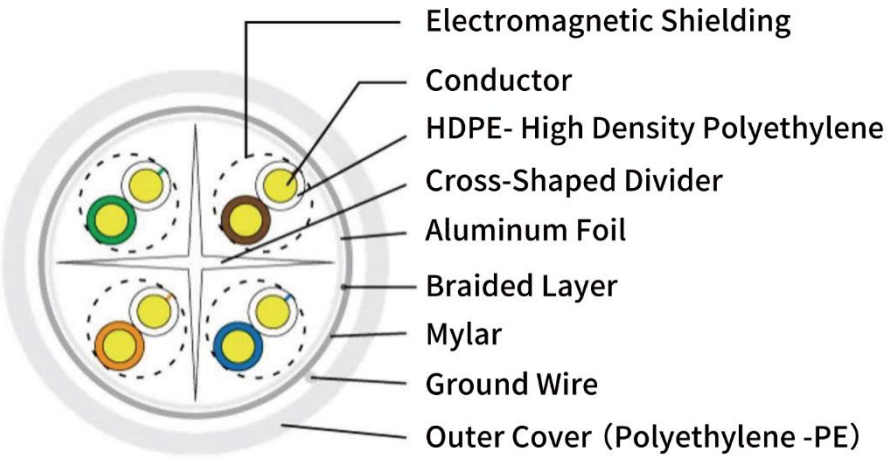


Figure 4.3.1.2-2 Schematic Diagram of Cat 6 or above Ethernet Cable Section (For Reference Only)

The following is the reference of Ethernet cable pinout, impedance, turn in wire, withstand current and wire diameter. The appropriate Ethernet cable can be selected according to the design requirements of the county and city governments and manufacturers.

Table 4.3.1.2-1 Ethernet T568B Cable Pinout Indication

Pin	Pair	Color	Description	Impedance Control	Gauge (AWG)
1	2	Orange White	TX+	100Ω	22, 24, 26, 28 (According to the manufacturing capability and design requirements of cable manufacturers)
2	2	Orange	TX-		
3	3	Green White	RX+		
4	1	Blue	TRD2+		
5	1	Blue White	TRD2-		
6	3	Green	RX-		
7	4	Brown White	TRS3+		
8	4	Brown	TRS3-		

The Ethernet cable is mostly placed inside the pole, connected to different mounting devices from the exchanger or gateway, and placed far from the ground (the upper layer or the top of the pole). Although a metal protective net has been installed at the bottom of the pole to prevent rodents from climbing up the inside of the pole, some Ethernet cable manufacturers will still add environmental rodent repellents on the outer PE material to avoid rodents from eating.

(b) RS485 connector

RS485 is divided into full duplex and half duplex. The external connection can be converted into M12 waterproof connector, and the other end can be adjusted according to the connector specification and pin of the internal converter or exchanger. At present, there are many kinds of connectors that can be used in the industry, such as 9 pin D-Sub, Terminal Contact and Wire to Board (WTB) connector. The waterproof grade is recommended to be above IP65, and some manufacturers can reach IP66~IP67. Counties and cities can make necessary adjustments according to the design and connector specifications of the attached equipment to ensure that the signal transmission is normal and meets the requirements of waterproof grade.

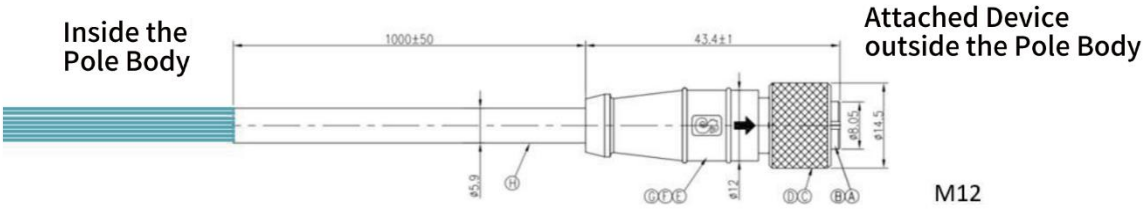


Figure 4.3.1.2-3 Diagram of M12 to RS486/RS232 Waterproof Adapter

Figure 4.3.1.2-4 M12 A-Coding Front View (Picture is for Reference Only)

Table 4.3.1.2-2 M12 RS485 Half-Duplex Pinout Diagram (picture is for reference only)

RS485		
Pin#	Description	Twisted Pair/ Impedance Control
1	RS485 GND	
2	PWR	
3	GND	
4	RS485+	120Ω
5	RS485-	

The sequence of the above pin Definition is not uniform, so the sequence should be changed according to the pin of the connector on the equipment of each network operator.

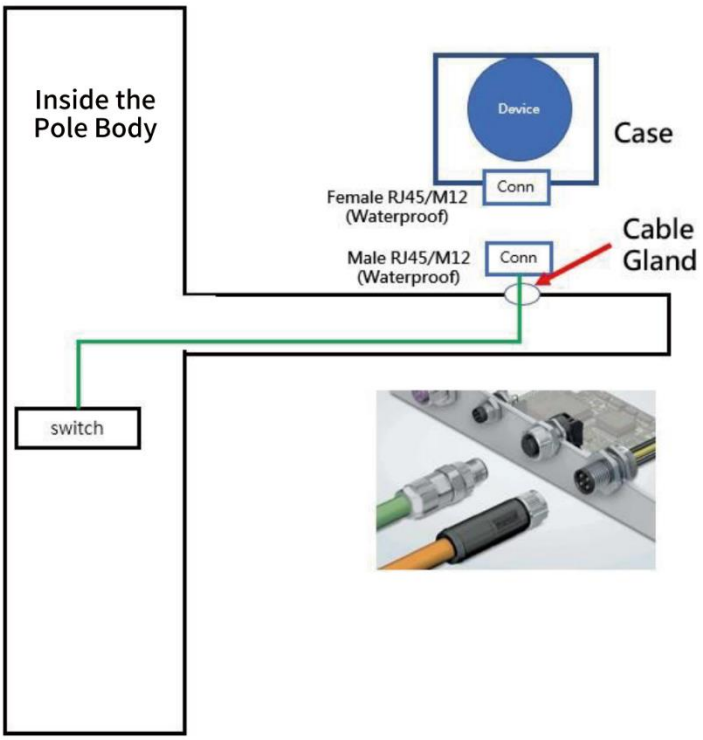


Figure 4.3.1.2-5 Diagram of Application of Specific Interface on Smart Pole

- **Advantage**

  The mounting equipment manufacturer does not need to reserve the length of the pipeline connected to the inside of the pole body, but only needs to connect the waterproof joint from the outside.

4.3.2 Inside the Pole

The inside of the pole body will not contact with the outside directly, and its waterproof requirement is lower than that of the outside, so it is not necessary to use waterproof joints for connectors.

4.3.2.1 General Connector

(a) SFP/SFP+

The optical fibers can be divided into two types, single mode and multi-mode. The switches inside the single-mode pole will choose different SFP (small form factor pluggable) transceivers according to the current optical fiber type and smart pole deployment distance. After the light is transferred to electricity, it is connected to the switch or gateway inside the pole body.

When designing the interior of the pole, attention shall be paid to the types of the optical fiber source (single mode or multi-mode), the transmission speed to be supported, the distance of wiring, etc. Select the correct SFP Transceiver according to these conditions and connect it to the switch or gateway in the pole. The connector of the optical fiber to SFP Transceiver is usually LC (Lucent Connector). Single mode and multi-mode optical fibers shall also comply with ITU-G 652 [49] (non dispersion shifted single-mode fiber), ITU-G 651G [50] (multi-mode fiber).

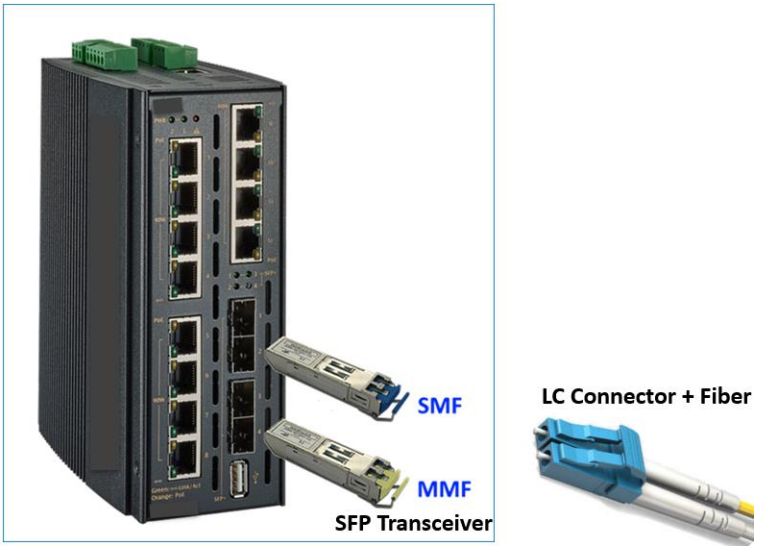


Figure 4.1.3.2.1-1 Schematic Diagram of SFP Optical Block Module

In addition to the advantages of transmission rate, the biggest feature of optical fiber is its long transmission distance. The wavelength of multimode optical fiber is generally between 850nm and 1300nm, and the wavelength of single-mode optical fiber is about 1310nm to 1550nm long. The larger the wavelength, the less the signal attenuation. For new cabling, it is recommended to give priority to single-mode fiber, because single-mode fiber can support transmission of longer distance. If the environment has already laid optical fiber cables, it is necessary to select the appropriate SFP Transceiver based on the original optical fiber type. The price difference between the two types of optical fibers is not significant, mainly depending on the distance of cabling. If the connection from the smart pole back to the monitoring management center basically exceeds 2km, it is recommended to use a relatively flexible single-mode optical fiber for cabling. The operation shall be carried out according to ANSI/TIA-598-D [51] (Telecommunication Industry Association and Electronic Industries Association), the pipeline color and relevant conditions shall be specified.

The optical fiber cable itself has no electrical characteristics and will not generate high heat. When deploying multimode optical fiber, it is recommended to use fiber categories of OM3 or above. Single mode OS1 and OS2 can be used as well. The connection distance of the optical fiber pipeline shall be considered, and the single-mode or multi-mode pipeline shall be considered when the pipeline is buried. The counties and cities can also adjust according to the current design needs.

Since most optical fibers are pulled to 5G smart poles from machine rooms far away, and some pipelines will be buried underground, it is necessary to consider the anti-rodent mechanism (such as rats or squirrels) when designing pipelines. It is recommended to place metal mesh at the bottom of the pole to prevent rodents from drilling in from the bottom and damaging the pipeline inside the pole. For the buried optical fiber from the remote-control platform to the 5G smart pole, there are two common practices in the industry:

(1) Metal Free Anti Rodent Bite Material

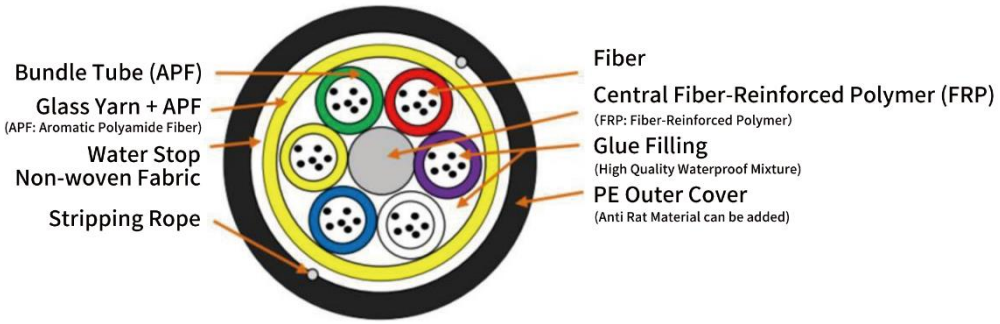


Figure 4.1.3.2.1-2 Diagram of Optical Fiber Metal-Free Anti-Rat Bite Cable (For Reference Only)

(1.1) Environmentally friendly capsaicin

Mix environment-friendly capsaicin into the PE outer wrapping (Polyethylene: PE) of the cable (please refer to the PE outer wrapping position above). However, the effective period of this material cannot be determined, and it may lose the function of rat protection after installation as time goes by. The manufacturer does not recommend using this material. The manufacturer suggests using physical methods to effectively withstand rodent bites.

(1.2) Glass yarn

In this way, the glass yarn material is directly incorporated into the yellow Aromatic Polyamide Fiber to enhance the toughness and firmness of the cable. In addition to preventing the expansion of optical fiber cable, it also has the effect of withstanding rodent bites.

(2) Metal Anti Rodent Bite Material

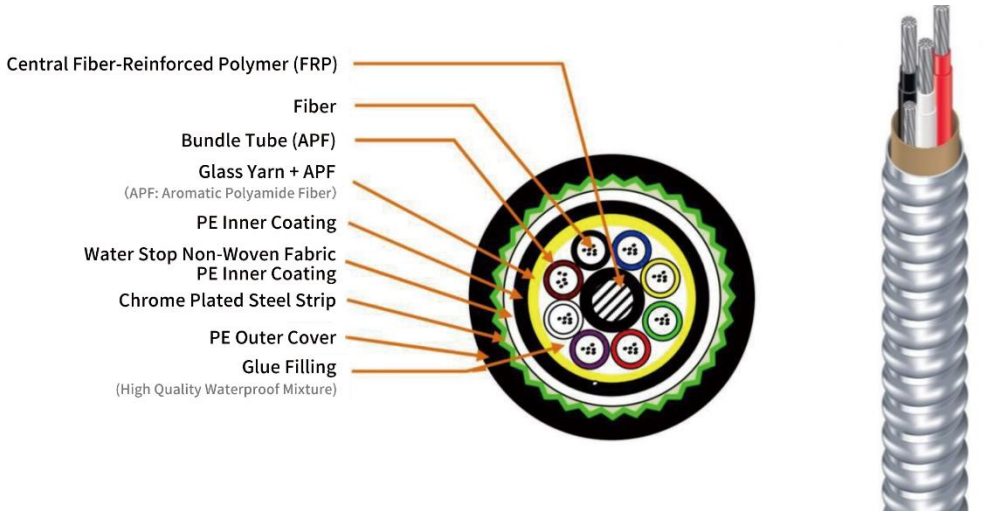


Figure 4.1.3.2.1-3 Diagram of Optical Fiber Metal Anti Rodent Bite Cable (For Reference Only)

(2.1) Armor

A layer of chrome plated steel strip is added between the outer coating and waterproof non-woven fabric. The purpose is to increase the hardness. On the one hand, the pipeline is not easy to be compressed and deformed by external forces, and on the other hand, it is also used to prevent rodents from biting. The purpose of chrome plating on the outer layer of the steel strip is to improve the surface hardness, beauty, rust prevention, and other functions.

(3) Waterproof

The waterproof treatment of optical fiber pipeline is shown in the figure of transition of metal free and metal anti rodent materials. There are two methods:

(3.1) Glue filling and fiber paste

The gap between the innermost bundle tubes is filled with glue and fiber paste, which can not only achieve waterproof effect, but also prevent external forces from causing optical fibers to vibrate, be hit, or be bent.

(3.2) Waterproof non-woven fabric

A layer of waterproof non-woven fabric is added between the fiber-reinforced polymer and the outer covering to increase the waterproof effect.

There will be differences in the way different manufacturers produce this.

4.3.2.2 Waterproof Mechanism Inside The Pole

Although there is little contact with the external environment inside the pole, there will still be some moisture inside the pole. In addition, heat conduction is required inside the pole to discharge the heat energy of the internal equipment through the gap and opening, a small amount of moisture will certainly enter the pole. In addition to increasing the waterproof performance of pipelines and connections, some manufacturers suggest adding drainage ditches on the cement base at the bottom of the pole. At the same time, bend the pipeline so that the water drops do not flow directly into the equipment along the pipeline, but drop into the ground against the drain tank and out of the pole.

4.3.3 Test Methods and Specifications for Cable and Pipeline Outside The Pole

The cable is responsible for the wired transmission of signals and power within and between smart poles. It includes power cable, communication cable and optical fiber cable. It is recommended to meet the requirements of environmental protection regulations such as RoSH directive. Lead free, low smoke and halogen-free materials should be used in the design.

For smart pole cables used outdoors, it is recommended that the following specifications should be met (or other specifications corresponding to the same level) to ensure transmission quality and safe use.

4.3.3.1 Power Cable

Take PVC insulated and covered cable as an example:

(a) **Conductor resistance test:** CNS 3301 Section [52]，CNS 689 [53]

The conductor resistance test must be carried out in accordance with the provisions of Section 6 of CNS 689, and the test results must conform to the values specified in Tables 1 to 6 of CNS 3301.

(b) **AC withstand voltage test:** Section 6.4 of CNS 3301, CNS 689

The test shall be conducted in accordance with 8.1 (water test) of CNS 689 or 8.2 (air test) of CNS 689.。

(c) **Insulation resistance test:** Section 6.5 of CNS 3301, CNS 689

The test shall be conducted in accordance with 9.1 of CNS 689, and the measured results shall conform to the values specified in Tables 1 to 6 of CNS 3301.

(d) **Flame resistance test:** Section 6.14 of CNS 3301

Cut the test sample with a length of about 300 mm from the finished product, place it at an angle of 60 degrees with the horizontal plane, burn it for 30 seconds at the oxidation flame of the gas burner at 20 mm from its lower end, then slowly remove the flame, measure the time when the cable flame goes out naturally, and the flame must be stable and not affected by breeze in an appropriate way.

(e) **Aging resistance test:** Section 6.7 of CNS 3301, CNS689

The test shall be conducted according to the provisions of Section 17 of CNS 689, and the heating temperature and time shall be in accordance with the provisions of Table 5 of 17.2 in CNS 689.

(f) **Tensile strength and elongation test:** Section 6.6 of CNS 3301, CNS 689

The tensile strength test must be carried out in accordance with the provisions of Section 16 of CNS 689, and the tensile speed shall be in accordance with the provisions of Category A in Table 4 of 16.3 of CNS 689.

(g) **Other items:** please refer to CNS 3301

4.3.3.2 Communication Cable

(a) **Ethernet**

Cables for communication network shall conform to relevant performance specifications of ISO/IEC 11801 [54] (or other cable performance specifications of the same level) and relevant safety specifications of UL444 [55] (or other safety specifications of the same level). The type of terminal connector shall conform to ANSI/TIA-568 [56] or T568A [57].

4.4 Pipeline Arrangement in Pole

At present, when the smart pole is built, there is no specific sorting requirement for the internal pipelines. After the attached equipment is connected, the pipeline is not hung inside the pole in a specific way. Since the control of different devices integrated in the smart pole is in a centralized switch or gateway, and there are many connection ports of the switch or gateway, the pipelines are easily entangled, thus two problems will occur:

(a) Signal disturbed

When the signal line and power line are twisted, it can possibly affect the signal quality. Meanwhile, the space in the pole cannot be effectively utilized.

(b) Difficulty in maintenance

Due to excessive winding of pipelines, construction operators are easy to touch or pull irrelevant pipelines by mistake when replacing specific pipelines, thus causing unnecessary system damage.

Therefore, WG1 is recommended to make preliminary arrangement of the pipelines inside the pole body in addition to reserving the space for drawing the pipeline during the pole body design. At present, the suggestions discussed within the alliance are as follows, but they still need to adapt to the current design environment. Design changes can be made to meet the needs of counties, cities, and manufacturers.

4.4.1 Splitting of Cable Clamp

At present, when the smart pole is built, there is no specific sorting requirement for the internal pipelines. After the pipeline is connected to the equipment, it is suspended inside the pole body and is not fixed in a specific way. It is recommended to use cable management clamps to bundle the same type of pipeline pipes together and separate them from the power pipeline. At present, there are many kinds of wire clips on the market. It is recommended to use a wire clip that is easy to unlock when selecting, place it near the maintenance hole where the installation and maintenance personnel can reach. There is no mechanism that can be fixed or supported on the inner wall of the pole, so it is recommended to use Din Rail to install it inside, and the wire clip can be fastened on the rail. The material and number of holes shall be adjusted according to the current design.

Figure 4.4.1-1 Wire holder (for reference only)

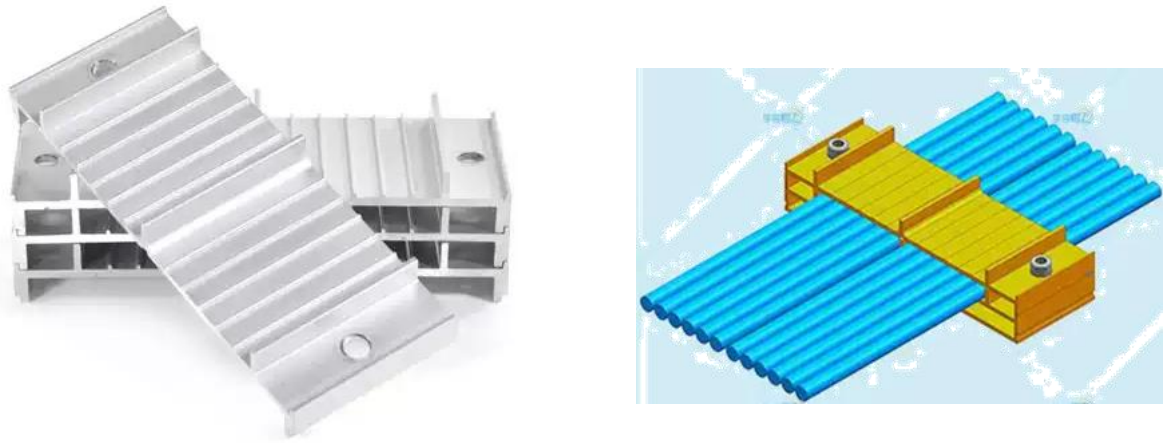


Figure 4.4.1-2 Screw lock with wire fixing device (for reference only)

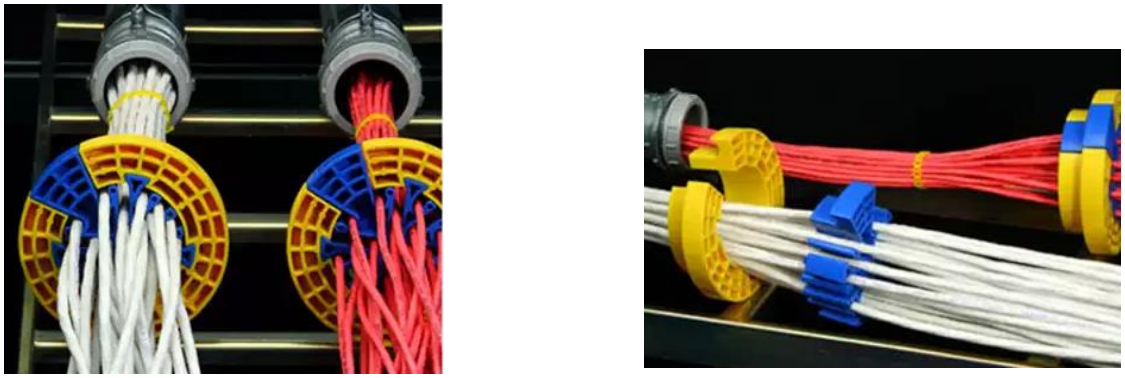


Figure. 4.4.1-3 Wire Combiner [58] (for reference only)

4.4.2 Subsystem Shunting

If there are many devices attached to the pole body (Type 2 smart pole), there are many switches or gateways required, and most manufacturers will make the connection on the same side of the product. However, due to the different placement positions of the attached equipment, some of them are even attached to the left and right sides of the smart pole respectively, and the pulled pipelines are easy to wind and difficult to arrange. Therefore, it is recommended to add an additional exchanger to hang on the left and right sides of the smart pole respectively, classify the mounting equipment into left and right sides, connect the left mounting equipment to the left one, and connect the right mounting equipment to the right one, stagger the left and right wiring, and reduce the possibility of pipeline entanglement. Refer to Figure 4.4.2-1.

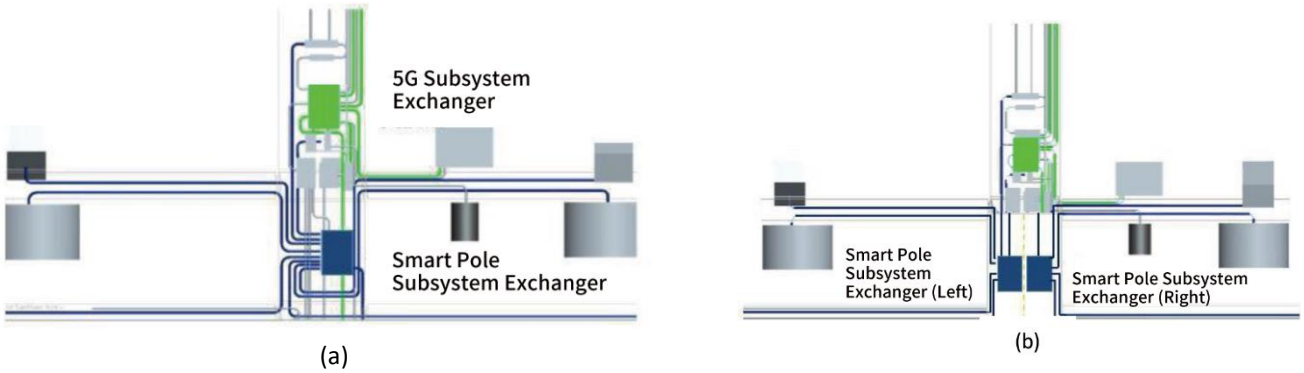


Figure 4.4.2-1 Differences before and after modification of analog signal routing

If the routing and layout according to this strategy are as follows, please refer to Figure 4.4.2-1. On the left side (a) all the connection ports of the subsystem switches of the smart pole are concentrated on the left side. If the mounting device is on the right side, the connection can only

be made successfully by winding. If the power cord near the bottom of the pole body is connected to the equipment, the winding of the pipeline will be more obvious. (b) The split flow strategy is adopted. After adding a switch of the subsystem of the smart pole (left and right). In the simulated wiring diagram, the wiring is significantly improved.

If the left and right power lines are separated after being pulled out from the lower transformer panel, the wiring inside the pole body will be more orderly. Please refer to Figure 4.4.2-2:

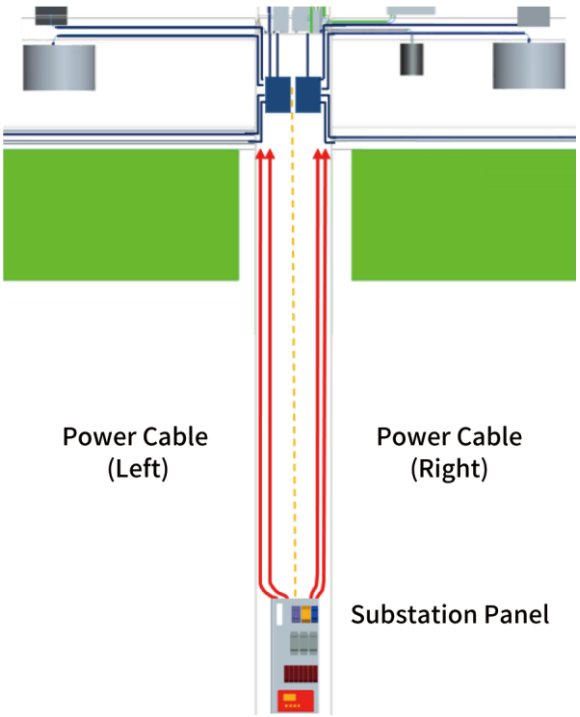


Figure 4.4.2-2 Power Line Shunt Diagram

Although this diversion method is conducive to the diversion of pipelines, the cost of an additional switch or gateway will increase. It is also necessary to evaluate whether there is enough space inside the pole body to accommodate so many Netcom equipment and its power supply (standby power supply is required), and whether it is convenient to disassemble and install them when maintenance.

4.4.3 Split Flexible Conduit

The wiring arrangement method of the above wire clips needs to be locked inside the pole body, but the thickness and material of the pole body will vary according to the requirements of different counties and cities. Locking the wire clip may cause perforation and damage the

waterproof mechanism, and it is also necessary to consider that the wire management should also be divided into power cables and signal cables. If too many wire clips are used, space will be wasted, and the locking holes of the smart pole will become more, which will affect the overall supporting force of the pole, and it is easy for water to seep into the interior of the pole. Therefore, it is not recommended to use the wire clips mentioned above for wire sorting.

Another method of wire arrangement is to use wave pipes wrapped by perforated discs connected from the base of the pole body. At the maintenance hole of the switchboard and exchanger, wrap the wave tube for the same type of pipeline to separate the strong current and weak current. The cost of wave tube is not too high, and it does not need to be locked on the smart pole, which will not cause leaks in the waterproof mechanism. The installation is also very convenient and fast.

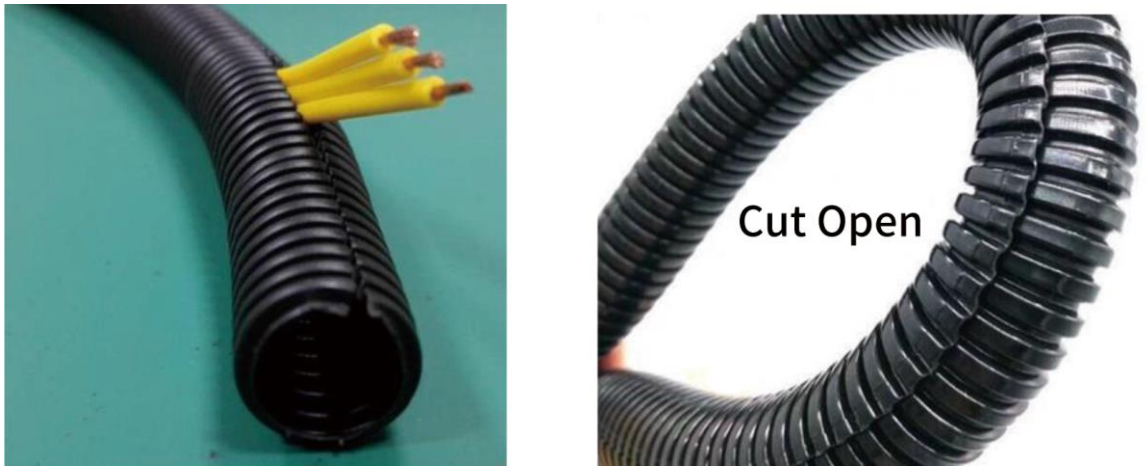


Figure 4.4.3-1 Diagram of Split Wave Pipe [59] (for reference only)

4.5 Reference Design

According to the joint consultation results of the 5G Smart Pole Alliance, the use scenarios of smart poles are divided into five categories (Type 1~5), of which the use scenarios of Type 2 are located at intersections and trunk roads, and the design is the most complex. Therefore, we first provide the first version of the reference design based on the use situation of Type 2. The purpose is to provide each county and city government or designer with a preliminary reference and framework, and not to make any manufacturer profit. Therefore, the information provided by the manufacturer is put in the appendix of the specification. In the text, only the proposed framework and design concept are provided, without manufacturer information. The structure and smart pole

design shall be changed according to the current design requirements of each county and city government, and the reference design in the alliance is unnecessary.

In addition to the use situation of Type 2, we also provide the internal reference design of the loop control box for reference only. If the counties and cities have other needs, they can make changes according to the current situation.

4.5.1 Type 2 Traffic Trunk Road

4.5.1.1 Layout and Height of Mounted Equipment

According to the use situation of Type 2, it is mainly on the main roads and intersections. The attached equipment is listed in 4.2.2.1, which is divided into pole top, upper layer, and lower layer. The attached equipment diagram is as follows:

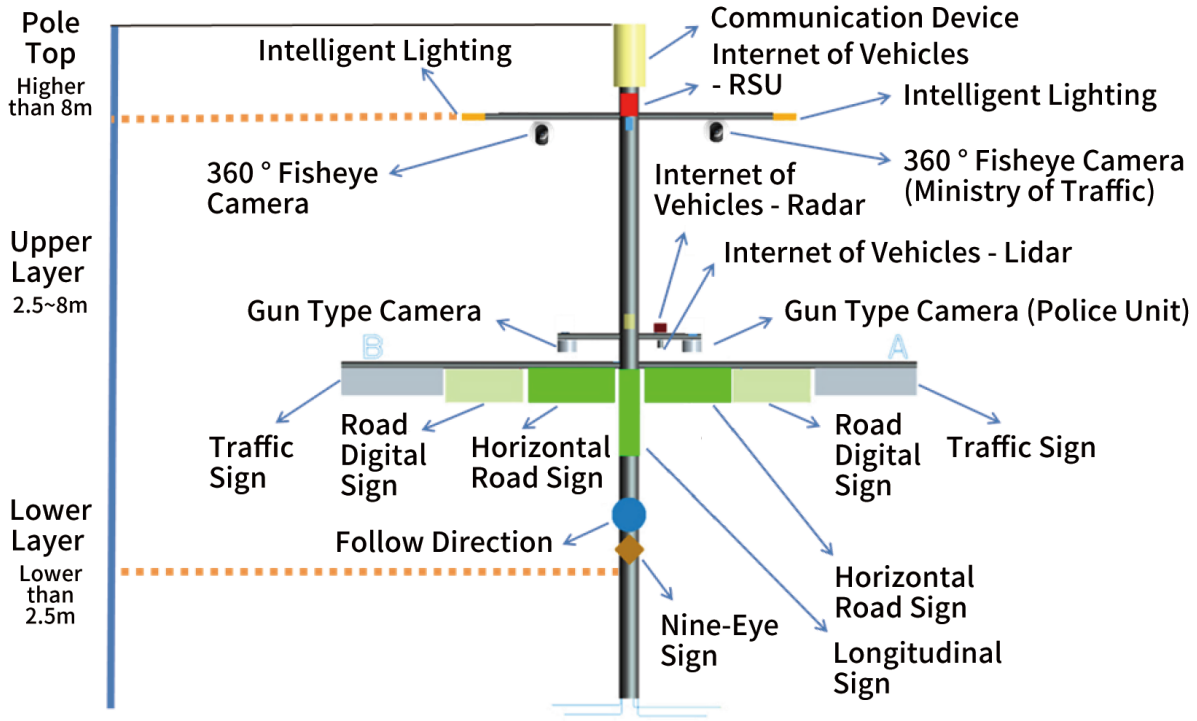


Figure 4.5.1.1-1 Schematic Diagram of Type 2 Mounting Device

Each mounting device has its mounting height and its laws and regulations or refer to the construction drawings and Proposal of each county and city. The following pages are classified according to the application scenarios of each attached device. List the mounting equipment required for each application scenario and list the mounting height and calculation method

recommended in domestic specifications and construction drawings, and then list the source of specifications and construction drawings for reference. This design is based on the use situation classification discussed by the 5G Smart Pole Alliance as a design reference. In the future, counties and cities can make changes according to the current design needs, and non-mandatory specifications to be followed.

Table 4.5.1-1

Application field	Equipment mounted	Reference height range	Recommended height	References
Intelligent lighting	Intelligent lamps	Urban roads Road width (W) * 1	Street lamp mounting: 8m	➢ Construction Department of the Ministry of the Interior - Code for Design of Urban Roads and Ancillary Works, Chapter 19 ➢ Energy Administration of the Ministry of Economic Affairs "Technical Specifications for Setting LED Street Lights in Taiwan"
Monitoring system	360 ° fish eye photography; Gun camera	Ministry of Transport ≥ 5m Police administration units: 3-6m	360 ° fish eye: 7.5m Gun camera: 6m	➢ Operation Research Institute of the Ministry of Transport - continued expansion of domestic R&D video vehicle detector ➢ References provided by the manufacturer
Traffic signal	Traffic signal (Traffic lights) Traffic signs (Suspension/Vertical)	**Traffic signal:** 4.6m~5.6m **Traffic signs:** ➢ Expressway: ≧ 4.9m ➢ General roads≧ 4.6m	Traffic signal: 4.9m Traffic sign: 4.9m	Rules for setting road traffic signs, markings, and signals ➢ Chapter II Signs (18, 202) ➢ Chapter IV Sihnals (Article 220)
C-V2X	RSU-Road Side Unit Radar Lidar	RSU: Pole Top Radar≧3m (for reference only) Lidar ≧3m (for reference only)	RSU: 8m Radar: 6.7m Lidar: 6.16m	In the experimental stage, the height is still being adjusted
Environmental detection	Environment detector	2m	2m	Manufacturer's advice

(a) Pole body inner diameter

Since there is no fixed code for the diameter of extension pole and pole, the design of pipe diameter can be appropriately adjusted according to the actual situation. The design of the pipe body of the smart pole in the type 2 scenario at the main roads and intersections should support the weight of the above attached equipment, not hinder the beauty of the city and the vision of road users, so the pipe diameter should not be too long. With reference to the "Summary Report of Professional Services for the Integration of Taipei Street Lights, Signage and Pole Attaching Facilities" issued by the Park Street Lights Engineering Management Office of the Public Works Bureau of the Taipei Municipal Government, the pipe diameter is set to 35.5cm. Therefore, the Type 2 pole is also being designed with the diameter of 35cm as

the benchmark. At present, the space can accommodate the internal mounting equipment, so this pipe diameter is temporarily taken as the design reference.

(b) Intelligent lighting

The height of lamps and the spacing between poles shall be matched with the simulation of average illuminance and uniformity of illuminance, and the height and spacing can be adjusted under different roads and environments. Please refer to 4.2.1 (b) for explanation.

In accordance with the "Code for Design of Urban Roads and Ancillary Works – Chapter 19" issued by the Construction Department of the Ministry of the Interior, to reduce glare on expressways or main roads, the type of lamps should be mainly shielded lamps. The service road or road can allow more glare, and the semi shielded type is preferred.

If the lamps are mainly on trunk roads, the above reference data also mentioned that to prevent glare from interfering with the vision of pedestrians, or even causing unnecessary traffic accidents, it is recommended to give priority to the selection of shielded lamps.

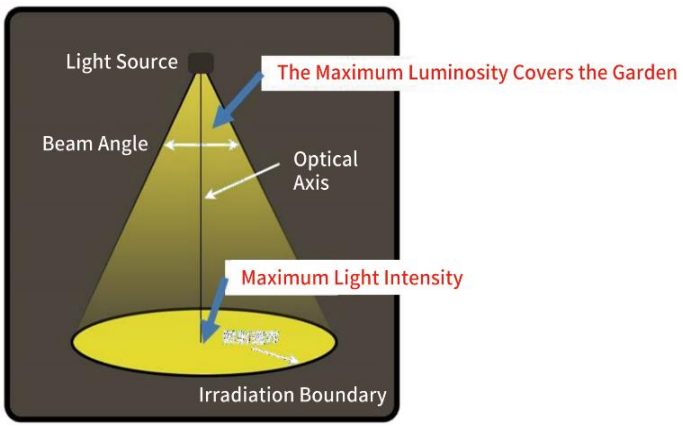


Figure 4.5.1.1-2 Diagram of Maximum Photometric Coverage

The biggest difference between shielded, semi shielded and unshielded lamps lies in the maximum photometric coverage of the light source. The maximum photometric coverage of shielded lamps is 0 °~65 °, that of semi shielded lamps is 0 °~75 °, and that of unshielded lamps is 0 °~90 °. Due to the small coverage of the maximum luminosity, the light of the fully shielded lamps has less chance to directly shine on the eyes of passers-by, causing glare, affecting vision and causing unnecessary traffic accidents, while the unshielded lamps are easy to directly shine on the eyes of passers-by, causing discomfort because of the large coverage of the luminosity.

(c) Monitoring system

The monitoring equipment on the smart pole is maintained and operated by two units: the police administration unit and the Ministry of Transport. According to the "subsequent expansion of domestically developed image vehicle detectors" provided by the Operation Research Institute of the Ministry of Communications, compare the differences between the cameras of the two units in terms of use, mounting height and application scenarios:

According to the above reference specifications, we will mount the gun camera used by the police station on the extension pole 6m above the ground, and set the fish eye 360 ° camera of the Ministry of Transport on the lamp extension pole 7.5m above the ground. This mounting height is only for reference and can be adjusted according to the design requirements of each county and city and the use situation of the manufacturer.

Table 4.5.1.1-2 Comparison of Monitoring System Equipment

	Police administration unit	Ministry of Transport
Aim	Improving public security (Vehicle license plate identification)	Observe the running state of vehicle flow (Traffic flow)
Position	Mainly roadway, supplemented by main road mouth	Major road sections and road interfaces
Height	Relatively low position (3-6m)	Relatively high position (above 5m)
Camera range	Small range, fixed (Because the camera angle is locked to a single lane, which is mainly used to identify the vehicle license plate, multiple cameras are required)	Large scope and changeable (The picture covers multiple lanes and a wide range. The camera lens has the functions of moving, zooming in and zooming out)
Number of cameras required at the interface	Multiple seats (In principle, it is necessary to set fixed lenses for the lanes in each direction of the road entrance)	1 set (It can be remotely controlled, and the angle can be changed as required, so one seat is enough)
Quality requirements	High quality	General

(d) Traffic signals

– Traffic signals

According to Article 18 of Chapter II of the "Rules for the Setting of Road Traffic Signs and Signs" issued by the Ministry of Transport, the vertical clearance of suspended signs shall not be less than 4m (≥ 4.6m) for general roads and 4m (≥ 4.9m) for expressways

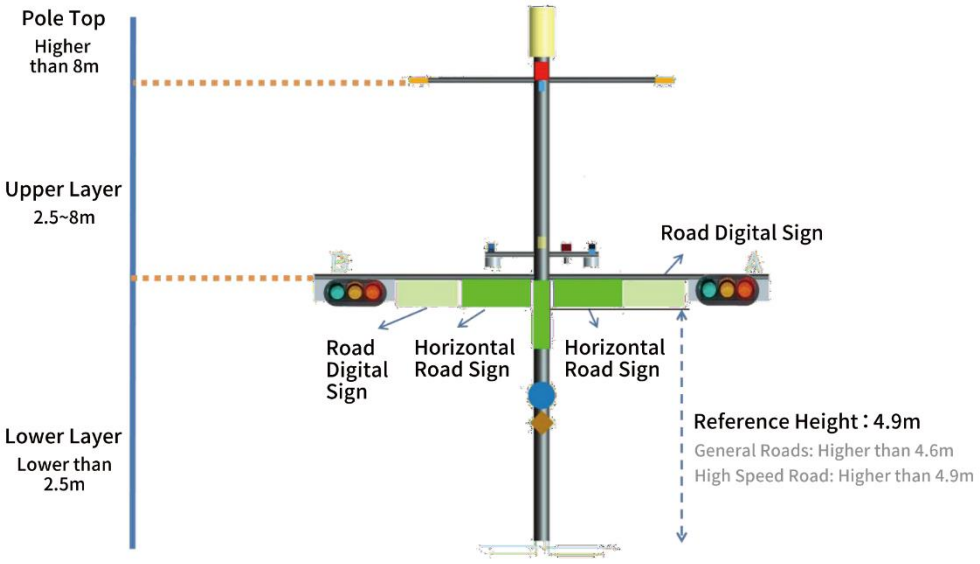


Figure 4.5.1.1-4 Diagram of Type 2 Hanging Mount Equipment

Considering that the reference design of Type 1 may also be provided later, the use situation of Type 1 is in the expressway scene. According to the regulations of the Ministry of Transport, the hanging signs on the expressway should be more than 4.9m. In order to continue the design of traffic signs and traffic signs to the Type 1 smart pole, Type 2 also uses the same mounting height.

– Traffic signals

According to the "Rules for Setting Road Traffic Signs and Signs" issued by the Ministry of Transport

Article 202, Section II, Chapter II:

The light colors of traffic control signs shall be red, yellow and green, and shall be limited to six mirrors (left and right up arrows), except that red and green are used for one-way traffic rotation control on ramps, narrow roads, narrow bridges, tunnels or construction sections.

Article 220, Section VI, Chapter IV

If cantilever, portal, or suspension type is adopted, the bottom of the light box shall be 4.6 m to 5.6 m higher than the road surface to maintain the safety clearance of the vehicle.

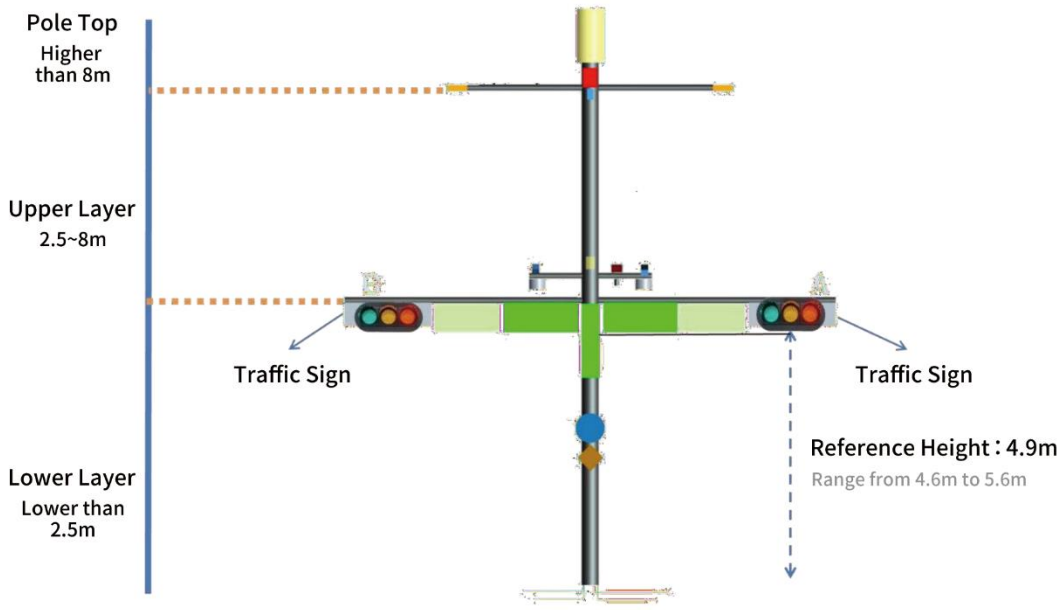


Figure 4.5.1.1-5 Diagram of Type 2 Traffic Sign Mounting

The height of the type 2 traffic sign is currently set to 4.9m, which is the same as the mounting height of the suspended mounting device.

The traffic lights, commonly known as Red & Green lights, are set according to the rules of the Ministry of Transport on the setting of road traffic signs and signs

Article 202, Section II, Chapter II:

The light colors of traffic control signs shall be red, yellow and green, and shall be limited to six mirrors, except that red and green are used for one-way traffic rotation control on ramps, narrow roads, narrow bridges, tunnels or construction sections.

Article 204, Section II, Chapter II

The side length of the mirror is 30cm (0.3m) for general roads; For high (fast) speed highways or special sections, it depends on the actual situation.

In principle, take 30cm as an example for one mirror, and at most six traffic sign mirrors with a total length of 180cm. The length of Type 2 smart pole is also designed according to this regulation. In addition, the pole body design in the "Summary Report on Professional Services for the Common Pole Integration of Taipei Street Lamps, Signs

and Pole Attachments" of the Park Street Lamp Engineering Management Office of the Public Works Department of Taipei City Municipal Government is also based on this design specification. One side is 30cm, the number is 6, and the total length is 180cm.

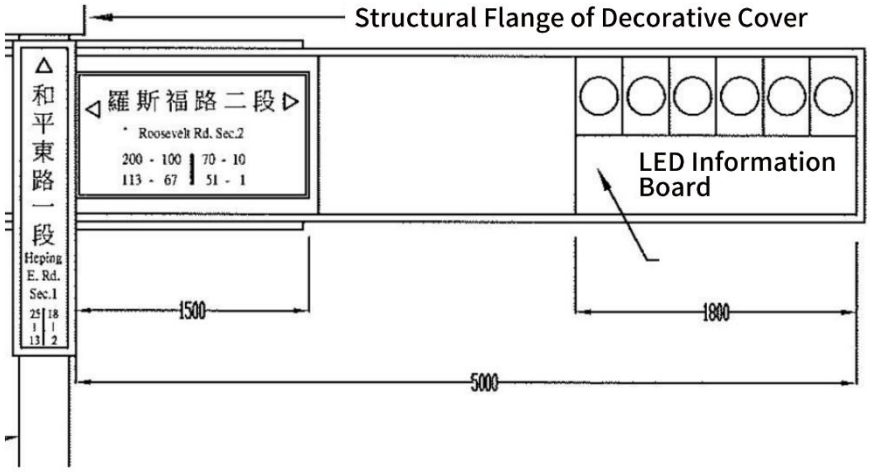


Figure 4.5.1.1-5 Design Reference of Traffic Sign of the Public Works Department of Taipei City Municipal Government

(Cites the "Summary Report on Professional Services of the Public Works Department of Taipei City Municipal Government on the Integration of Street Lamps, Signage and Post Attachments in Taipei City")

– Traffic Sign

According to Article 18 of Chapter II of the "Rules for the Setting of Road Traffic Signs and Signs" issued by the Ministry of Communications, the vertical clearance of hanging signs shall not be less than 4m (≥ 4.6m) for general roads and 4m (≥ 4.9m) for expressways.

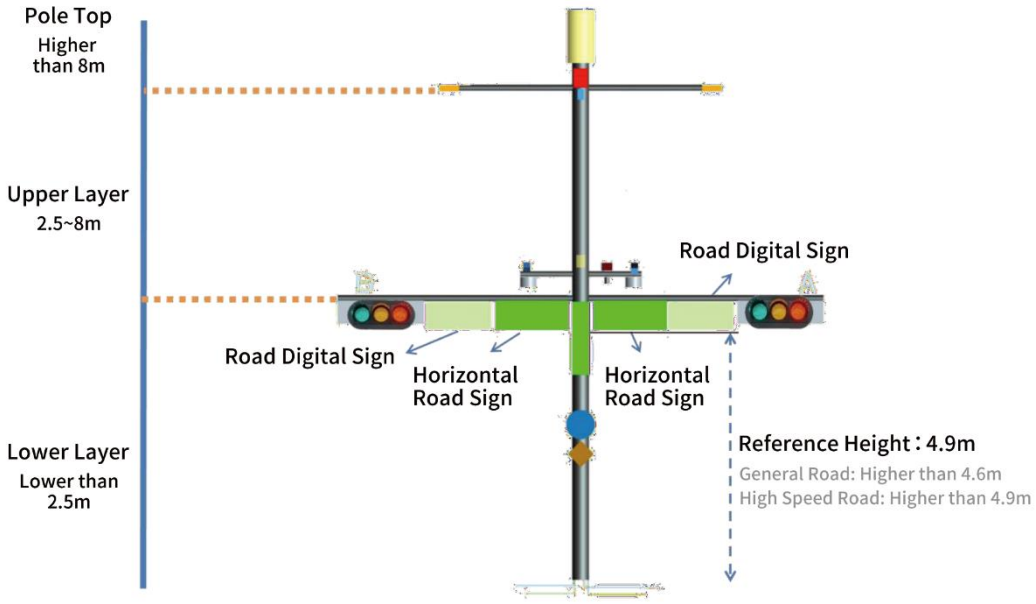


Figure 4.1.4.1.1-6 Diagram of Type 2 Hanging Mount Equipment

Considering that the reference design of Type 1 may also be provided later, the use situation of Type 1 is in the expressway scenario. According to the regulations of the Ministry of Communications, the hanging signs on expressways should be more than 4.9m. In order to use the design of traffic signs and traffic signs for the smart poles in the Type 1 scenario, the Type 2 also uses a mounting height of 4.9m.

(e) C-V2X

– Road Side Unit

Through discussion with other alliance members, the antenna on the roadside unit is also a kind of communication equipment, so it is recommended to place the top of the pole and place it outside the pole according to Type 2.

– Radar and Lidar

It is recommended to hang it above 3m, and there should be no obstacle blocking the scanning range, otherwise it may cause wrong action.

4.5.1.2 Pipeline Management

The use situation of Type 2 is the most complex. After the design of mounting and line management, it can be extended to other types of smart poles. Or, if each county, city or

manufacturer has their own design needs, it can also be adjusted according to the actual situation.

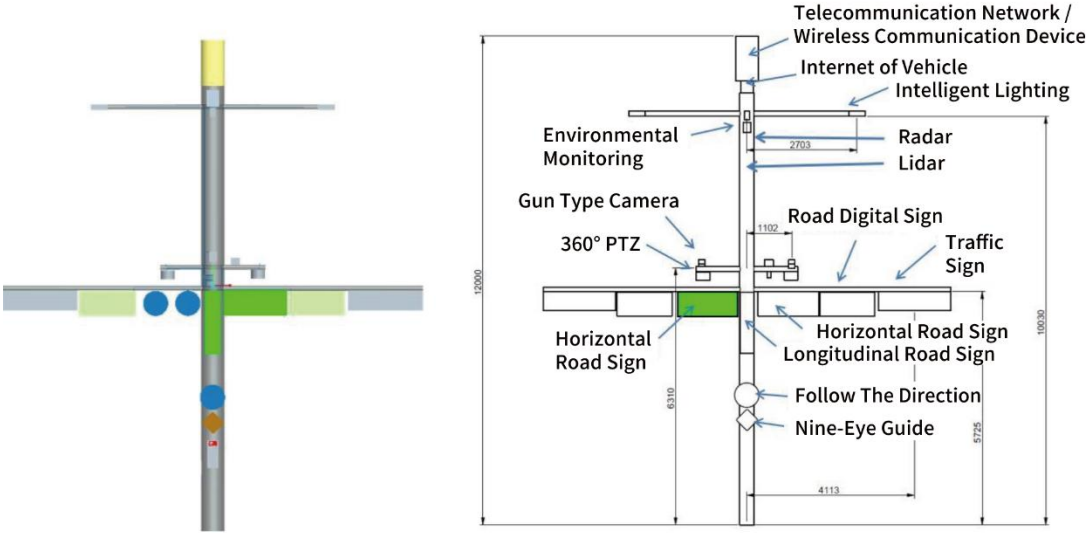


Figure 4.5.1.2-1 Diagram of Type 2 Attachment

The overall system pipeline can be divided into strong current and weak current. Strong current refers to the AC power directly pulled into the smart pole from the switchboard, and weak current refers to the signal pipeline, which is connected to other attached equipment from the exchanger or gateway. In the Working Group 2 specification, there will be a detailed description of the strong current Power cable, while the signal Cable and its connector have been described in detail in the previous chapter. The external materials (PVC and XLPE) and current demand of the strong current pipeline are large, so the diameter of the line is relatively thick, taking up more space. The weak current pipelines are mostly made of PE, and the current gauge is also small, so the pipe diameter is also small. The interface and requirements of connectors and pipelines are described in the subsequent Appendix chapter.

4.5.2 Type 4 Charging Post Smart Pole

4.5.2.1 Layout and Height of Mounted Equipment

Type 4 is used in the parking space on the road. The biggest feature of Type 4 is that the pole is equipped with an electric vehicle charging pile, which can be used by electric vehicle owners while parking at the roadside. In addition, the pole body is also equipped with surveillance video equipment, which can provide license plate identification information of passing vehicles to assist scientific and technological law enforcement.

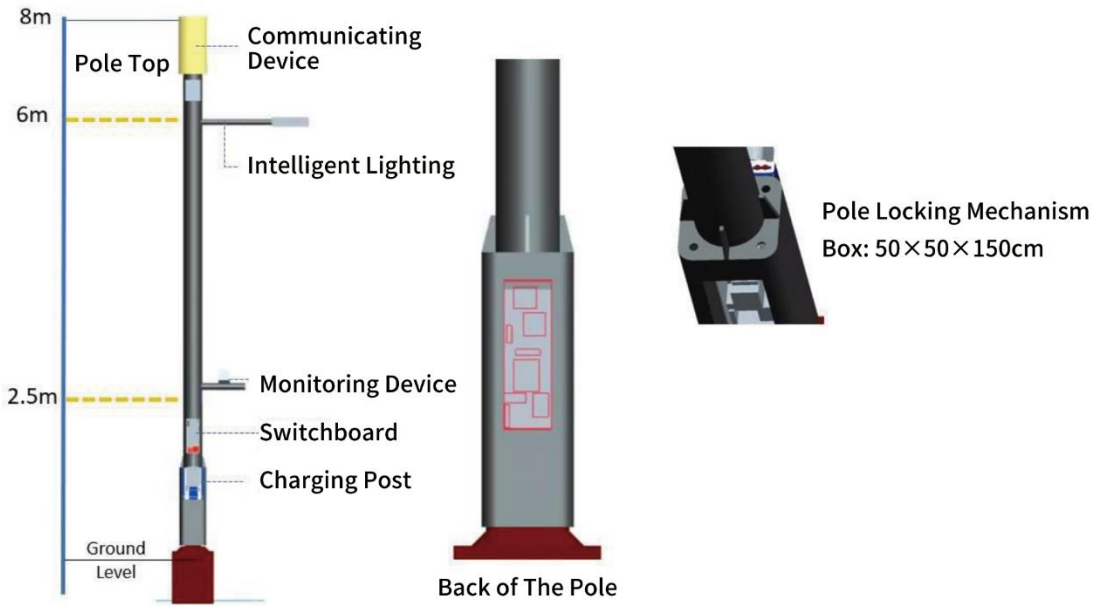


Figure 4.5.2.1-1 Type 4 Smart Pole Mounting Intention

(a) Pole body inner diameter

- The design of the pole body is slightly different from that of Type 2. The upper part of the pole body is mainly columnar, with an inner diameter of 35cm, but a control box will be added to the lower part, with a length of 50cm x 50cm and a height of 120cm. The lower half of the box can be used to place communication equipment such as O-RAN or DAS communication equipment, and then pull the pipeline to the pole top chamber to connect the antenna. The lock design and space size inside the control box can be adjusted, and further discussion will be made according to the design requirements of each county and city.
- Type 4 is designed as a two-part type, so it is recommended to add more cable glands at the outlet to increase the probability of waterproofing.

(b) Charging post

- There are several manufacturers in the charging pile field in the alliance, they suggest that the height of the charging gun should be higher than 1.1m. It should not be too close to the ground. If it is flooded, there is still a distance to prevent the charging post from being damaged by flooding. Due to the limited plane area of the control box at the bottom of the pole body, and without affecting the overall stress and the pressure resistance of the overall structure, the current design first adopts AC charging posts. The charging wattage is between 7kW and 10kW, and the weight and size are lighter than

DC charging posts.

(c) Intelligent lighting

- Since the field of Type 4 smart pole is not on the main road, the height of lighting equipment is reduced to 6 meters. In the actual design, the road width and the placement position of the smart pole must be evaluated first, and then the height of the smart lamp can be calculated.

(d) Switchboard:

- The height of the switchboard is still 1.5m above the ground. Ask the county and city governments for their opinions according to WG2 and place the switchboard above the highest flooding height.

4.5.2.2 Pipeline Management

Please refer to the design concept in 4.5.1.2 for line management.

4.5.3 Loop Control Box

4.5.3.1 Layout and Height of Mounted Equipment

The loop control box is located near the smart pole. A Taipower meter will be placed on the top layer, which can not only facilitate recording the power consumption of the smart pole, but also serve as the responsibility dividing point for fixed network operators and smart poles. In addition, some edge computing servers can also be placed in the loop control box to reduce the traffic back to the cloud. It can not only provide the instant response of the smart pole mounted device, but also increase the efficiency and efficiency of the attached device service.

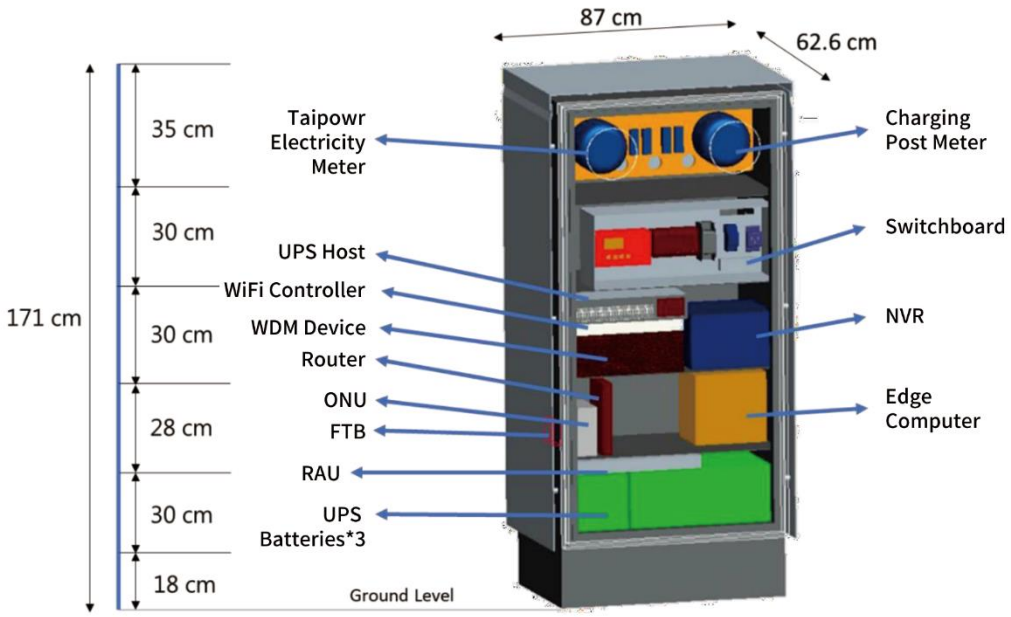


Figure 4.5.3.1-1 Diagram of Circuit Control Box

(a) Size and layer of loop control box

- There is no fixed form and specification for the size and layering of the loop control box, but it is determined according to the size of the actual field. It should be noted that the height and width of the placement should not block the sight and use space of pedestrians and drivers.
- The current circuit control box design refers to the equipment supply box on Zhongxiao East Road, as well as the internal waterproof and heat dissipation design.
- The current control box is managed by one office on each floor. Each floor has a door lock or anti-theft mechanism. Only the floor under the jurisdiction of the office can open the door lock on the current floor. However, it is still necessary to change the design and properly use the space inside the pole according to the future POC (Proof of Concept) or the needs of various counties and cities and innovate methods to achieve the anti-theft mechanism and replace the door lock management.

(b) Placement position

- Central separation lane: the circuit control box placed on the central separation island must pay attention to the opening position of the control box. The door opening position shall not be close to the road as far as possible to prevent the maintenance personnel from colliding with the incoming vehicles on the road when operating the equipment inside the control box.

Please refer to figure 4.5.3.1-2 below. The green tick is the recommended opening position, and the red cross is the non-recommended opening position.

Figure 4.5.3.1-2 Door opening direction design of circuit control box

- Sidewalk: if the circuit control box is to be placed on the sidewalk, the sidewalk must be cleared more than 1.2m to ensure the safety and basic rights and interests of pedestrians.

(c) Equipment mounted in the box

- **Taipower electricity meter**

  The ammeter in the loop control box is divided into two parts. One is used by the mounting device on the smart pole. Because the work consumption of the charging post is large, another independent ammeter is used for the charging post.

- **Switchboard**

  After the introduction of Taipower meters, the power distribution panel is also required for power protection, and then sent to the attached equipment in the loop control box.

- **Fixed network equipment**

  The optical fiber is needed if the smart pole needs a fixed network connection back to the remote-control platform. In case of GPON architecture, the loop control box must be equipped with optical fiber junction box and Optical Network Terminal (ONT).

- **Uninterruptible Power System – UPS**

  If the normal power supply and transmission is short due to force majeure, the uninterruptible power supply system can temporarily provide power until the power supply and transmission return to normal. Each county and city government can choose which use scenarios of attached equipment are more important and give priority to providing power to maintain the normal

operation of the equipment. For example, on the main roads with heavy traffic, the traffic signs need to normally operate no matter whether the power output is normal or not, so as not to cause traffic accidents. Therefore, the traffic signal can be connected to the uninterruptible power system to switch and provide temporary power until it returns to normal in case of power supply problems. The uninterruptible power supply system includes the host and three batteries. Because of the large volume and weight of the batteries, they are placed at the bottom of the box.

- **Network Video Recorder – NVR**

  The video images of the monitoring system can be stored in the loop control box near the smart pole, which can reduce the flow of the image stream back to the control platform in the background. According to the current design of the county and city governments, decide whether the network video recorder should be placed near the smart pole or in the back-end computer room.

- **Edge Computing**

  It can provide data analysis and more immediate services on the devices mounted on the smart pole. For example, license plate identification and vehicle flow identification, or other scientific and technological law enforcement analysis can be performed on edge computing devices, and the results will be sent back to the back-end platform.

- **Communication equipment**

  Communication equipment includes three different 5G architectures proposed by various manufacturers (Small Cell, O-RAN, DAS)

4.5.2.3 Pipeline Management

Please refer to the design concept in 4.5.1.2 for line adjustment.

4.6 System Engineering

4.6.1 Pole Foundation Construction

4.6.1.1 Foundation Pedestal

The base is designed at the bottom of 5G smart pole, which is mostly buried underground. Its functions mainly include:

(e) Support the weight of the pole itself and various attached equipment on the ground, and transfer the attached weight of the entire smart pole to the lower soil and rock plate (foundation).

(f) The additional load and pressure caused by environmental factors on the overall structure of the support, such as the size and support of the maintenance hole, whether the depth and material strength of the base are enough to carry the load and the weight of the pole, and the calculation of the head-on wind resistance, in order to avoid typhoon or strong wind, casualties and accidents caused by the collapse of the smart pole due to excessive wind.

The load weight and relevant assessment of the above foundation base will be simulated and calculated by the structural experts first, and the project can be formally started only after the certificate is presented after the conditions are met.

4.6.1.1.1 Classification of Foundation Pedestal

At present, the fabrication methods of foundation pedestal can be divided into two categories: independent foundation and raft foundation. Each has its own advantages and disadvantages in terms of construction. The county and municipal governments and contractors need to evaluate the appropriate type of construction according to the current environmental needs.

- Independent foundation

  The independent foundation is the design used by most smart poles at present. The foundation seat directly transfers the weight of the smart pole and the stress on the pole to the soil layer below through the independent foundation. This method is applicable to the condition that the soil layer is hard enough to bear the stress of the pole, and the load above the building is relatively light. Smart poles are relatively small and light in the category of buildings, so at present, most smart poles, street lamps and electric poles use this kind of independent base. The reinforcement method of independent foundation is simple, and the materials can also be saved, which is also one of the important investigations of SI companies. As for the size of the foundation base and the amount of concrete to be poured to support the weight of the overall smart pole, the construction can only be carried out according to the drawing after the structural technician conducts simulation calculation and gets certification.

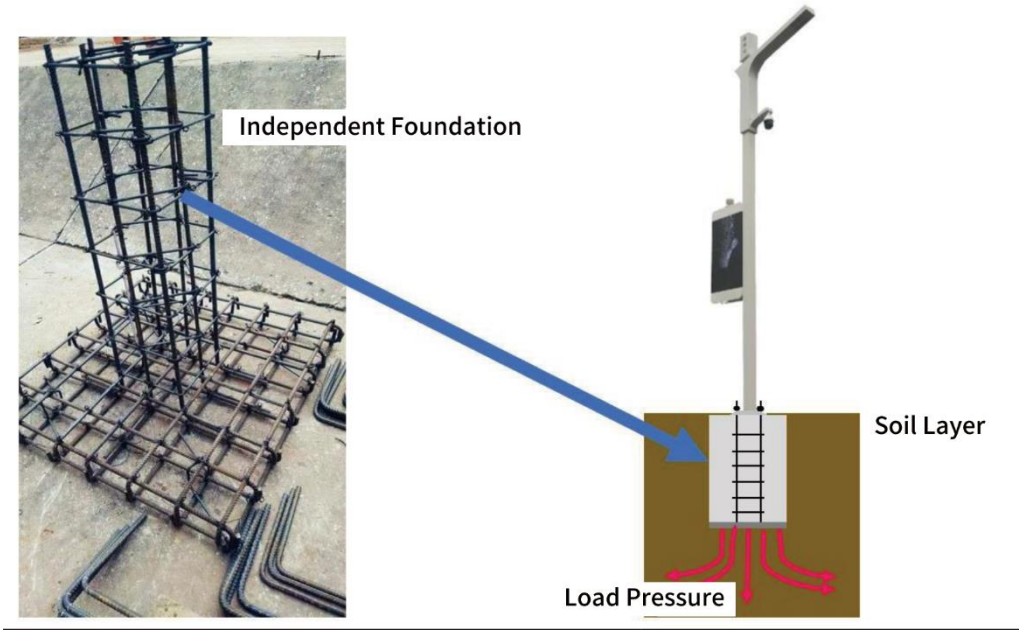


Figure 4.6.1.1.1-1 Diagram of Independent Foundation (for reference only)

– Raft foundation

The area of raft foundation base is larger than that of independent foundation, and the area contacting the bottom foundation is also larger, which can bear the average force, so that the foundation base is stable and not easy to collapse when bearing external forces and attached weight, so the seismic effect is also good. If the foundation of the current design section is relatively soft and difficult to bear the attached weight, it is recommended to use raft foundation. In terms of cost, the raft foundation has a large area and requires more reinforcement, so the demand for cost will increase and the construction method will be complex. As for the size of the foundation base and the amount of concrete to be poured to support the weight of the overall smart pole, the construction can only be carried out according to the drawings after the structural experts are current environment and design requirements for simulation and certification.

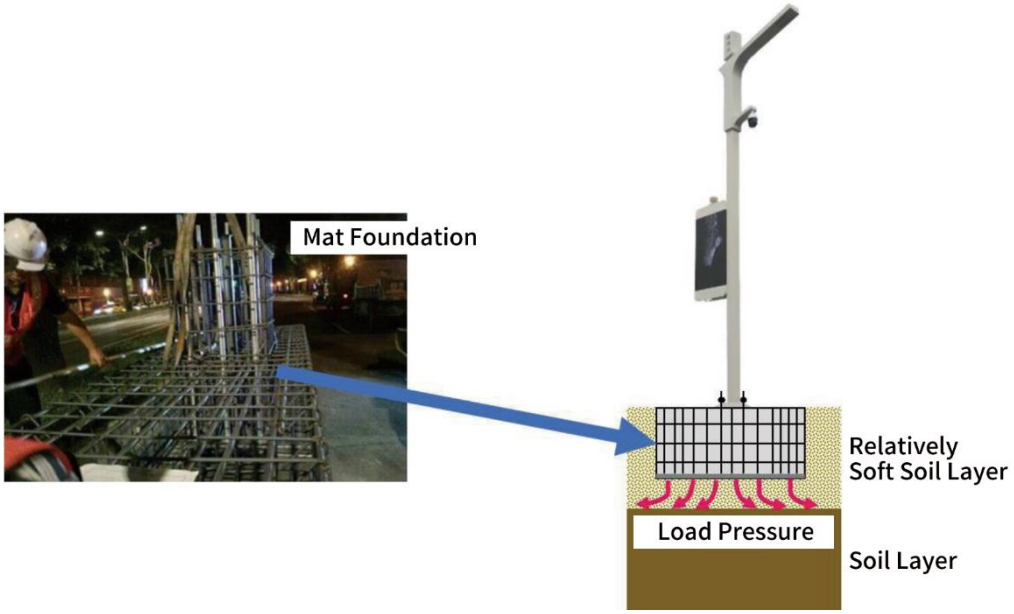


Figure 4.6.1.1.1-2 Diagram of Raft Foundation (only for reference)

4.6.1.1.2 Basic Construction Procedures

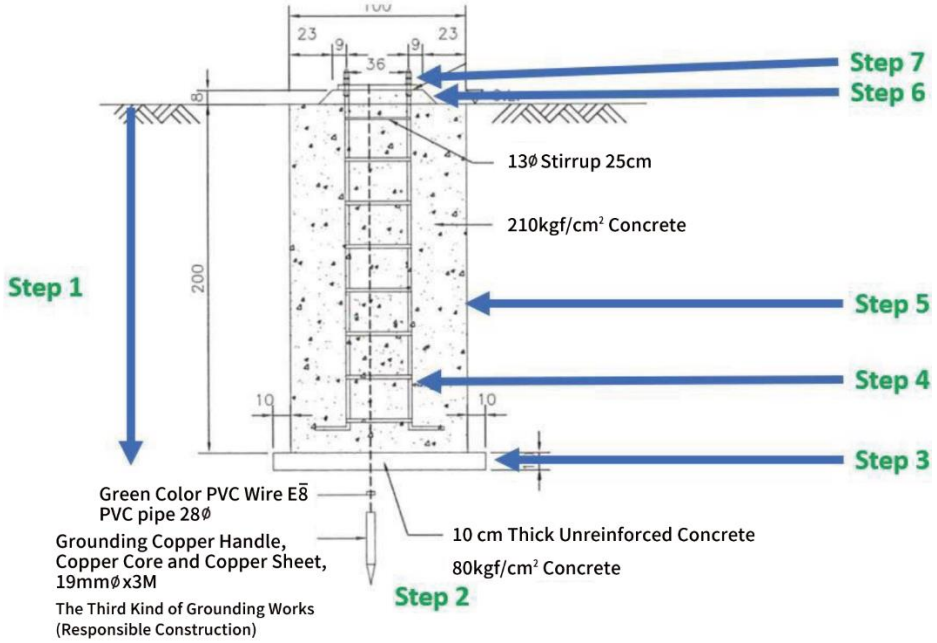


Figure 4.6.1.1.2-1 Diagram of Foundation Base Construction

(a) Depth of foundation base excavated first

The foundation base of the reference example has a depth of 2m, plus a PC base plate with a thickness of 10cm. It is estimated that the overall depth must be at least 2.1m. During excavation, some deep space must be reserved for the next step of grounding and related construction. Therefore, the overall excavation depth can be about 2.2.

(b) Implantation of grounding wire and grounding copper pole

The grounding pole is one of the important constructions of the foundation base, connecting the energy equipment of the pole body and the grounding conductor. In addition to being embedded deeper than the low strength backfill materials (CLSM – Controlled Low Strength Materials) base plate, the grounding wire should also be reserved 2~3m long behind the ground level, so as to connect the power distribution panel under the smart pole or other equipment that needs grounding. Taking the example, the buried depth is 2.1~2.2m, the manufacturer suggests reserving 2~3m on the pavement, and the total length of the grounding wire is estimated to be about 5.1~5.2m. The depth of grounding shall be adjusted according to the current design requirements of the county and municipal governments. The depth of the foundation base and the length of the underground and above ground wires of the buried ground wire shall be adjusted.

(c) Bottom layer concrete (PC - Precast Concrete) backfill

Low strength backfill material (CLSM) is mostly used for the bottom layer of the foundation pedestal according to the manufacturer's recommendations, because the foundation pedestal itself will be filled with Reinforced Concrete (RC) of higher strength to support the weight of the pole body and the overall stress. The compressive strength of low strength backfill concrete provided by the manufacturer shall not exceed 84kgf/cm2 at most. According to the construction example in the above figure, backfill 10cm of concrete.

(d) Erection of reinforcement base

Wait for the initial setting of the bottom layer of the low strength backfill material. The setting time will vary depending on the backfill material. The average type can last for 12~36 hours, and the early strength type can last for 3~6 hours. After setting, fix the reinforcement keel on the bottom layer, install the reinforcement, measure the horizontal angle with a level ruler, and make appropriate adjustment to ensure that the balance is achieved. Do not tilt, otherwise the mounting equipment on the smart pole and the weight

of the pole itself will easily topple or even bend, causing unnecessary injuries and traffic accidents.

(e) Pouring concrete

After binding the steel bars, the poured concrete solidifies into reinforced concrete, which bears higher pressure than the low strength backfill material, and is enough to support the overall weight and stress of the smart pole. Establish the foundation base according to the above reference.

(f) Pour in non-shrinking cement mortar for cushion thickness

The characteristic of non-shrinkage cement mortar is that it will not shrink in volume, and it is resistant to impact and early drying (rapid setting) and has strong pressure resistance. Therefore, it is placed between the smart pole and the base to bear part of the mount and the weight of the pole. Cross drainage ditch shall also be added on the base poured with non-shrinking cement, which can drain the water drops left inside the pole body and drain the pole out of the body.

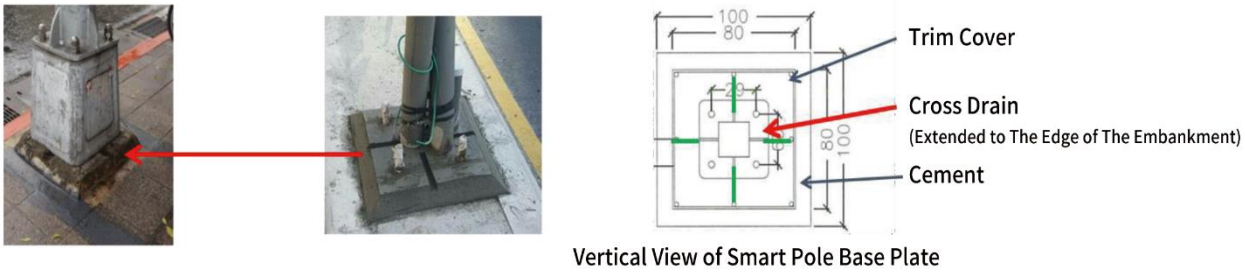


Figure 4.6.1.1.2-2 Diagram of Cross Drainage Ditch

(g) Lock base plate

After the non-shrinking cement mortar is grouted, lock the nut on the base plate of the smart pole on the ground. One of the main reasons for locking nuts is to increase safety and prevent the reinforcement of locking nuts at the accident scene from being inserted into the human body to cause more serious casualties.

4.6.1.1.3 Grounding Construction

The Construction Department of the Ministry of the Interior [Chapter 16062 Grounding and Connection of Electric Equipment - Chapter 1 General Rules] [60] can use welding powder fusion and copper clip to fix the copper grounding pole and grounding pipeline. Copper clamp is

preferred by the industry. According to the general rules of the Construction Department, it is recommended to use green PVC insulated wires for grounding pipelines. The diameter of green PVC insulated wire pipe can be selected from 8mm 2/14 mm2/19 mm2/22 mm2 according to the manufacturer's recommendations, and the recommended diameter of grounding copper bar is 19mm. However, the size and length of pipelines and copper poles should be adjusted according to the current use situation and design space of the county and city governments and manufacturers. According to the grounding design of WG2, the power supply deployment inside the smart pole is three-phase three wire, which belongs to the second type of grounding in the specifications of the "Rules of the Ministry of Economic Affairs of the Executive Yuan - Electric Equipment and Devices for Users" [61]:

– "In the power supply area of three-phase three wire ungrounded system of electric power industry, the low-voltage power supply system of user transformer shall be grounded. The resistance value shall be less than 50 Ω."
– No matter how the diameter and pipe diameter of grounding pipeline and copper grounding pole change, the most important thing is that the resistance to ground must be below 50 Ω.

The depth of the grounding copper pole also needs to evaluate the soil material. It is generally recommended to dig 2 to 3 meters deeper. If necessary, the grounding resistance improver can be used. The main function of the earth resistance improver is to reduce the soil resistance around the grounding electrode, so that the total resistance to ground can be controlled within the required range.

4.6.2 Pipeline Construction

4.6.2.1 Demarcation of Responsibility

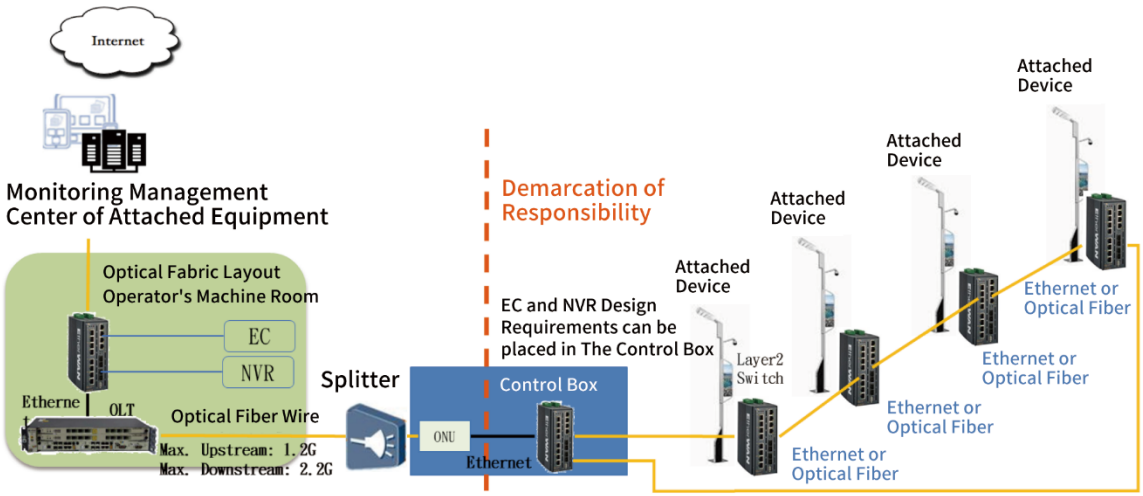


Figure 4.6.2.1 Diagram of Responsibility Boundary

At present, there are two kinds of manufacturers will participate in the construction of smart pole bodies and related pipelines. One is the SI company that undertakes pole body design and erection, equipment weight mounting, overall structure trial calculation, pipeline laying and other projects, and the optical fiber layout company that is responsible for laying optical fiber and other communication pipelines. After determining the bid, SI Company will contract to its related downstream manufacturers to complete the whole project construction. Optical fiber layout operators cover a wide range, and communication operators will also participate in the laying layout of optical fiber. Taking the fixed network system architecture as an example, the dividing point between the responsibilities of SI Company and the optical fiber layout operator starts roughly after the ONU transfers the Ethernet signal, as shown in Figure 4.6.2.1. SI Company will pull the optical fiber and cable near the smart pole to be built through the common pipeline leased by the county and municipal governments, then start the construction of pipe laying and lead up.

Basically, PVC pipes are the main pipelines in the buried pipe design, and cables and optical fibers can be pulled inside. The ideal design is that one pipe and one line are recommended, and one cable or optical fiber is pulled in a PVC pipe. However, in some use situations, more attached equipment is required, and the power consumption requirements are greater. In addition, WG2 is designed as three-phase and three lines, so the pipeline design is unlikely to be the same as the most ideal design, one pipe and one line. Moreover, if the first line meets the requirements of the current smart pole design, the cost is also high. After discussion with the manufacturer, in terms

of the design of the power cord, it is recommended that three cables be in the same PVC pipe, and two PVC pipes on a smart pole, one in and one out. A detailed description will be given in 4.6.2.5.

4.6.2.2 Common Pipeline and Divergent Parts

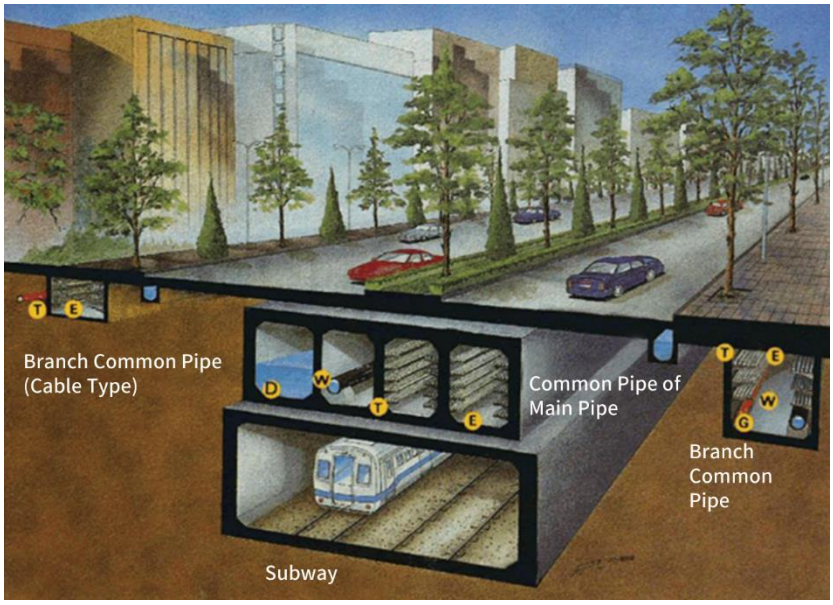


Figure 4.6.2.2-1 Diagram of Common Pipeline and Branch (refer to "Planning and Design Concept of Songshan Line Common Pipeline Project")

Common pipeline is a comprehensive channel that is planned by the government to accommodate pipelines and configurations of different units underground in the construction of emerging cities such as new towns, new communities, and redevelopment areas, to facilitate unified management and maintenance of underground facilities. In the common pipeline, different pipelines such as power, telecommunications (including military and police telecommunications), tap water, sewer, gas, waste, oil, gas, cable TV, street lamps, traffic signs, etc. will be managed by layers and zones. Its purpose is not only to facilitate the management and transportation of all bureaus and offices, but also to reduce the construction scope of contractors. It can not only reduce the number of road renovations and refills, and damage other pipelines due to construction, but also do not affect the city appearance and the road use right of the general public. The relevant regulations can refer to the "Common Pipeline Law" issued by the Construction Department of the Ministry of the Interior.

Common pipes are classified as main pipes and supply pipes:

(a) Main pipes

Most of them are arranged under the driveway, mainly to accommodate the main cables or trunk pipes that do not directly supply the service areas along the line. The pipeline shall have the functions of monitoring, lighting, drainage, and ventilation to facilitate the maintenance personnel to enter the repair and installation of new pipelines.

(b) Supply pipes

The main pipe branches out to provide nearby pipelines and services, mostly under the sidewalk and slow lane. It can also be divided into branch pipe, cable trench and cable run.

(1) Branch pipe

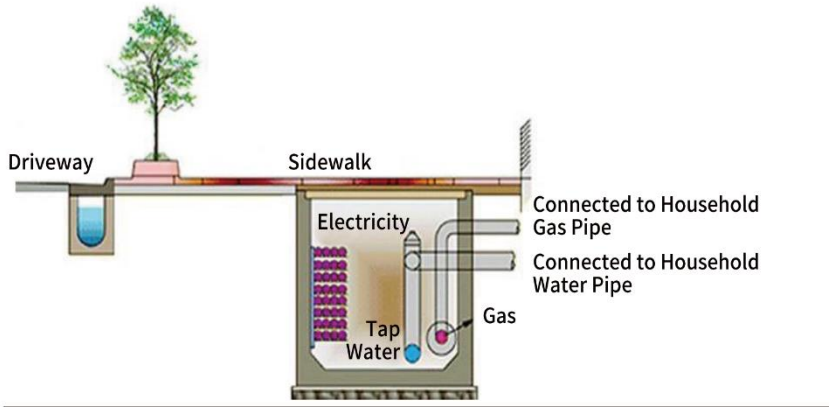


Figure 4.6.2.2-2 Diagram of Branch Pipe [62]

The pipeline channel branching from the main pipe can support the energy demand of nearby facilities along the road. Pipelines such as cables, tap water, gas, etc. can be directly led up and pulled to the wisdom pole or used by each household.

(2) Cable trench

It can provide cable, optical fiber, traffic sign, local telephone and other cable requirements, suitable for placing under the sidewalk, and can provide relevant services at any time. Space must be reserved in the middle structure for maintenance personnel to take shelter and carry out maintenance.

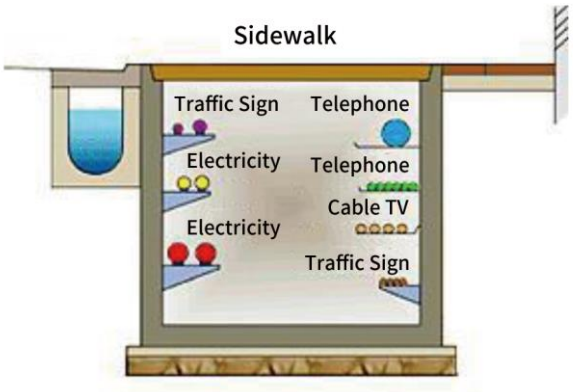


Figure 4.6.2.2-2 Diagram of Cable Trench [62]

(3) Cable run

Street lamp cable, fixed network optical fiber, communication optical fiber, and related cables can be provided. It can be placed under the lane to provide the services required by the sidewalks on both sides.

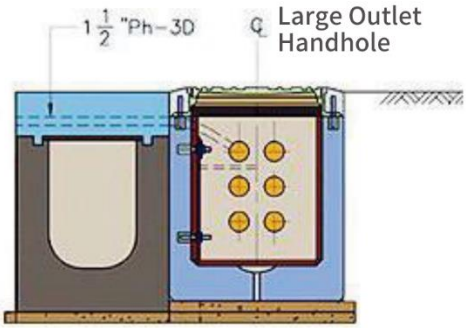


Figure 4.6.2.2-3 Schematic Diagram of Cable Pipeline [62]

The erection of the smart pole will be diverted from the main pipe to the supply pipe. The supply pipe will be led up and buried under the pavement or pedestrian walkway through the branch part, and then connected to the loop control box and smart pole.

The cables and optical fibers used by most control boxes and smart poles will be pulled from the supply pipe to the bottom of the smart pole through the handhole or buried PVC pipe, then connected to provide strong and weak current signals, so that the smart pole can operate normally.

For the relevant construction manufacturers of smart poles, the county and municipal governments are open to SI companies and optical fiber layout operators to rent common pipes. They can set up necessary pipelines in the common pipes to the vicinity of the contract project, and then "lead up" to the branch part. Through the branch part, PVC pipes are pulled through the waterproof casing to the soil layer and then connected to the lower part of the smart pole.

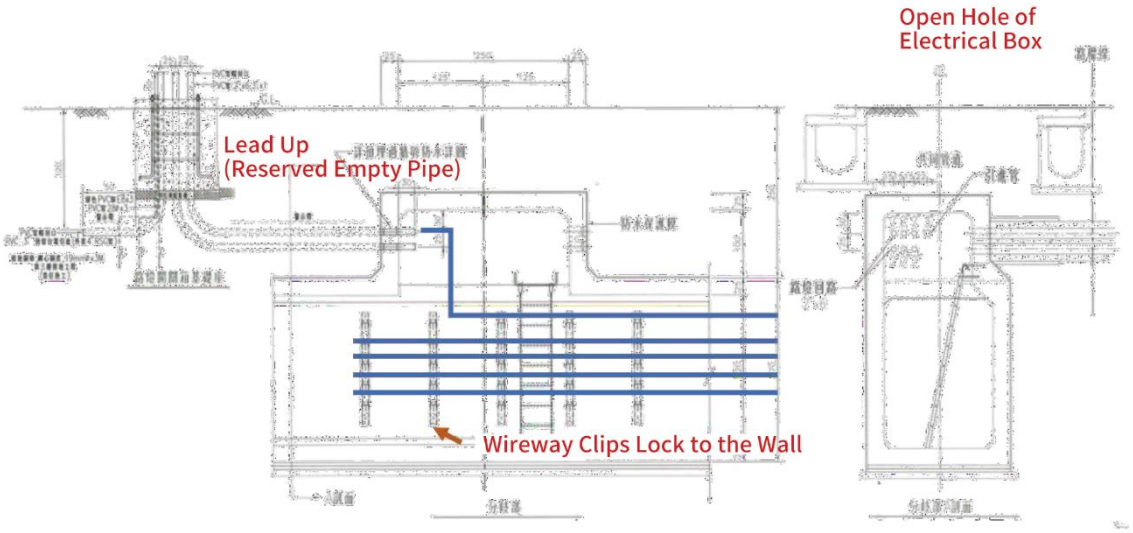


Figure 4.6.2.2-4 Example of Actual Construction Drawing of Common Pipeline and Division

Please refer to Figure 4.6.2.2-4. The pipe trenches of cable lines (strong current) and signal lines (weak current) will be separated and attached to the wall of the common pipe with the fixing clip of the wire slot to prevent the pipeline from falling off and twisting. When it gets near the smart pole, it is led up and connected to the smart pole through PVC pipeline. The function of the branching part is to "lead up" the pipeline required by the smart pole from the relay station in the common pipeline, and then through this branching part, extend outward to its destination to complete the wiring.

4.6.2.3 Pipeline Planning

It is pulled to the branch part through the common pipe and led up to the control box. The pipeline planning from the control box to the smart pole can be divided into power cable and weak current signal cable. The two cables are pulled into the bottom of the smart pole by different PVC pipes, and the pulled signal and power cable also changes due to different scenarios (Types 1-5).

(a) Power pipeline planning

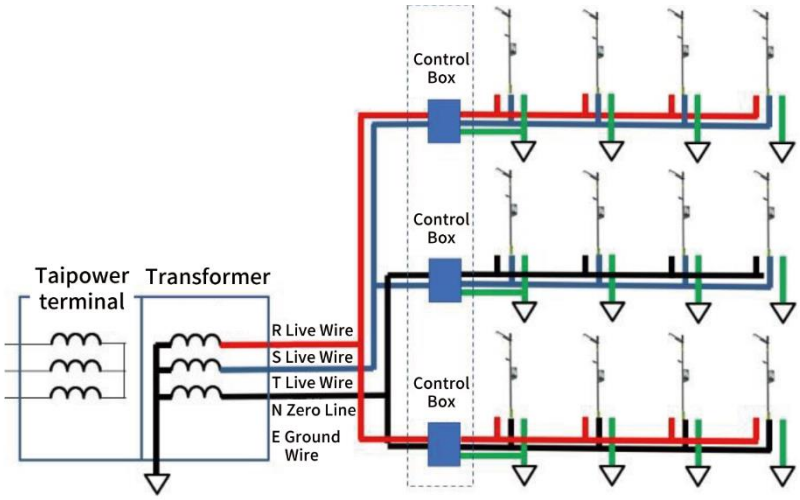


Figure 4.6.2.3-1 Schematic diagram of three-phase three wire power supply pipeline distribution (refer to WG2)

The power line part is designed according to WG2. Three phase three wire is used without grounding, and the voltage inside the input pole is 220Vac. Please refer to Figure 4.6.2.3-1. Three three-phase three wire cables will be pulled into the control box in turn and connected in series with the smart pole behind the control box. Therefore, there will be two bundles of PVC pipelines on the smart pole: one is "input PVC pipeline", and the other is "output PVC pipeline"

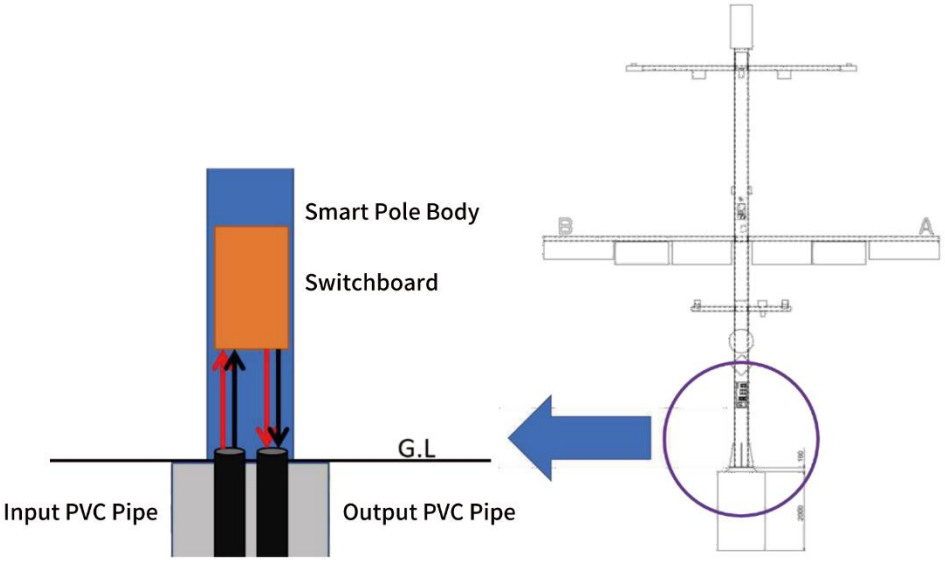


Figure 4.6.2.3-2 Diagram of Three phase Three wire Power Cable Lead Up

According to WG2's demand for the number of power cables and the manufacturer's recommendations, one "input PCV pipe" and one "output PVC pipe" of the power supply

contain three three-phase three wire power cables. The manufacturer suggests that the inner diameter of 10kW pipeline pipe is 55 mm2, the outer diameter thickness is 20 mm2, and the total outer diameter is 70 mm2. Considering that Type 4 has a charging pile, there will be an additional power cable, but it will also be put into the same PVC pipe at the same time. Therefore, the diameter of the PVC pipe is not fixed, and appropriate adjustment and modification can be made according to the current design environment and conditions.

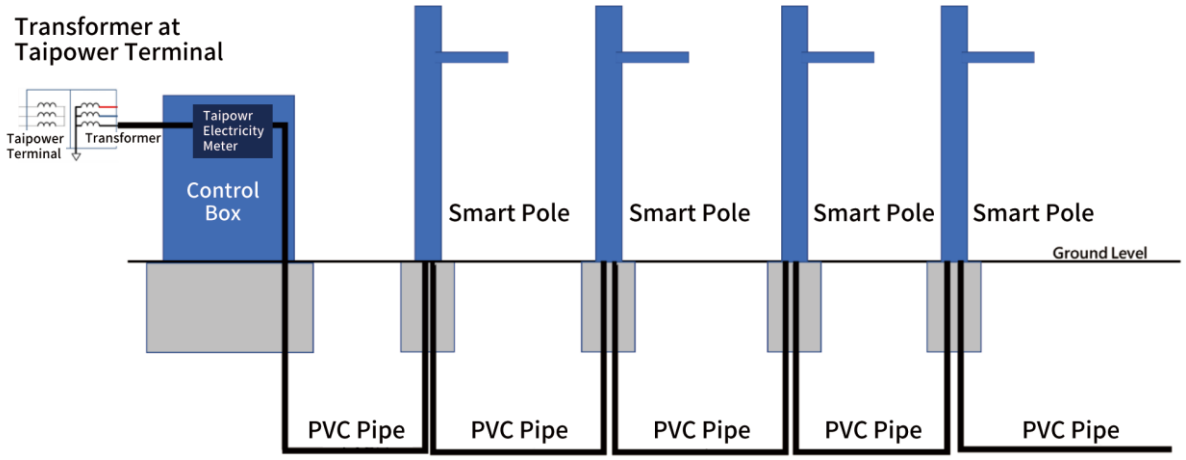


Figure 4.6.2.3-3 Diagram of Power Pipeline Planning

A little gap will be left at the junction of PVC pipe input and output, and at the opening of reinforced cement, so that rodents and insects can easily drill into the smart pole. For this reason, the manufacturer suggests that the outlet on the PVC pipe should be coated with foaming agent, which will harden after solidification and fill the gap beside the PVC pipe to prevent the invasion of pests or reptiles, causing unnecessary damage and short circuit of pole equipment. In addition, during the whole construction process, PVC adhesive must also be used to closely connect PVC pipes to prevent unnecessary fracture and water leakage caused by gaps.

(b) Smart pole subsystem: fixed network

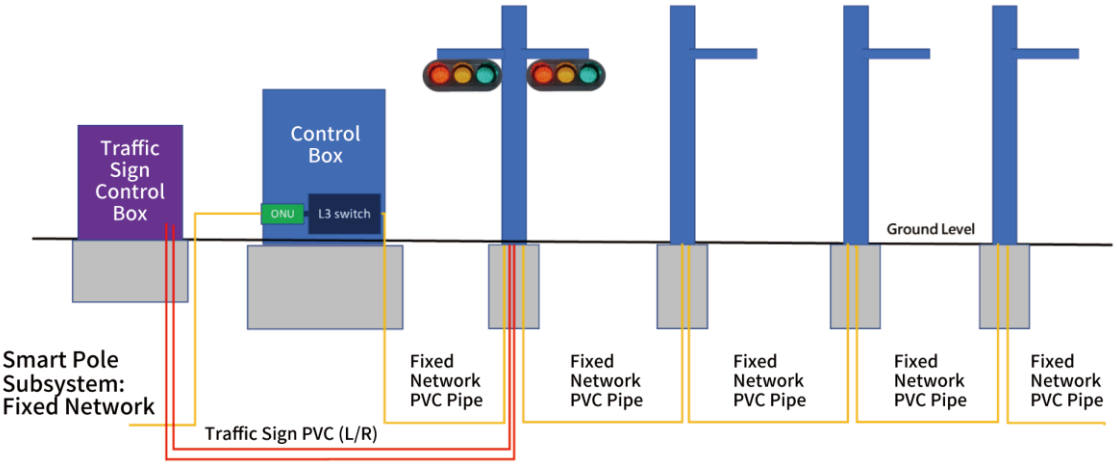


Figure 4.6.2.3-4 Diagram of Fixed Network and Traffic Sign PVC Pipeline

The fixed network is connected to the loop control box through the GPON architecture, and then connected to the next smart pole through the L3 switch. Since the fixed network optical fibers between poles are connected in series, two PVC pipes for input and output must be reserved under each smart pole base. If multiple optical fibers need to be placed in the smart pole, they can also be placed in the same PVC pipe, and the optical fibers will not affect each other. In addition, if there are traffic lights of traffic signs on the smart pole, the power cord will also be pulled from the traffic sign control box to connect the light mirror of each traffic sign. According to the actual construction cases of manufacturers in the alliance, each traffic sign mirror is controlled in the traffic sign control box, and each mirror pulled from the traffic sign control box will pull out a power supply and a ground wire. The sectional area of power line for each traffic sign is recommended to be 3.5mm2. There is one traffic sign for each two-way road, and each traffic sign has at most six mirrors. Therefore, each traffic sign will have 12 pipelines, which will be concentrated into cables and pulled outward to the traffic sign control box. Therefore, two PVC sleeves for traffic signs will be reserved in the PVC pipeline design, one for the power supply and control of traffic signs on the left and the other for the power supply and control of traffic signs on the right.

(c) 5G Communication

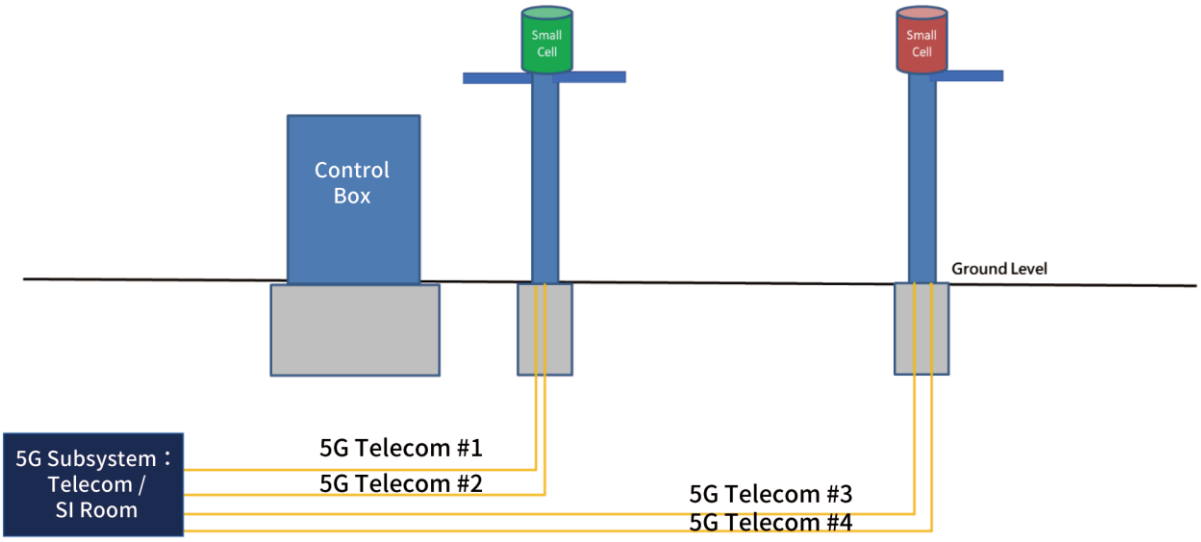


Figure 4.6.2.3-5 Diagram of Small Cell PVC Pipeline Embedding

No matter Small Cell, O-RAN or DAS will pull the optical cable into the smart pole. After internal discussion, it is recommended that a telecommunications company provide a PVC conduit. The optical cables of telecom operators and optical fiber distributors can be led up from the side ditch or common pipe and then connected from the PVC bundle pipe to the optical fiber splice box (FTB). If the communication equipment on the smart pole needs more than one optical fiber, it can be welded from the core bundle in the optical cable and connected to the communication equipment. As the internal consensus of the Alliance is that the communication equipment of two telecom operators can be placed on one smart pole at most, two optical fiber PVC conduits will be pulled first, and managed by two telecom operators or optical fiber distributors respectively, which is convenient for management and will not be responsible for ownership.

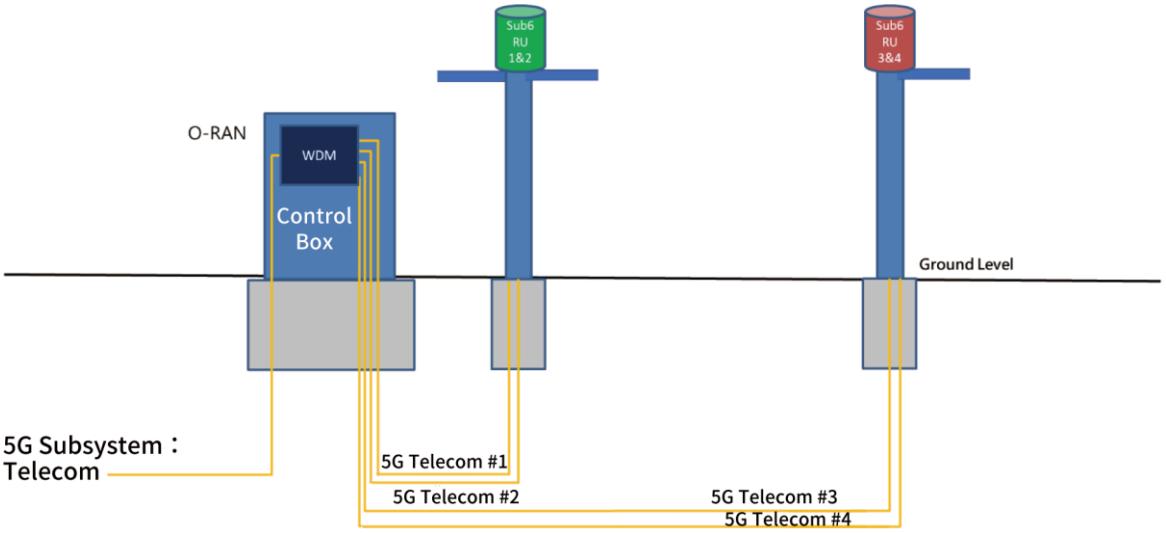


Figure 4.6.2.3-6 Diagram of O-RAN PVC Pipeline Embedding

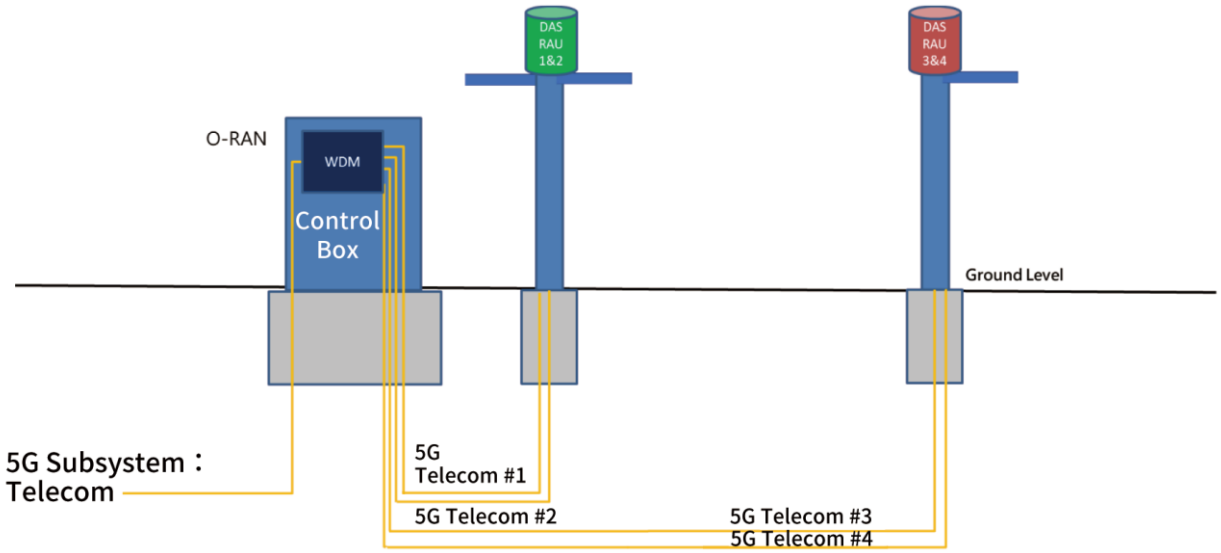


Figure 4.6.2.3-7 Diagram of DAS PVC Pipeline Embedding

(DAS RAU can be placed on the top of the pole or the lower control box according to the different design of the manufacturer)

The embedding of the O-RAN and DAS structures on the PVC pipeline is slightly different from that of the Small Cell. The WDM connected to the control box is connected to the communication device on the smart pole. The Small Cell only needs to directly pull the optical cable from the computer room of the telecommunications company to the smart pole. The optical cable pulled from the control box still adheres to the principle of

one PVC bundle pipe for one telecommunications company. A smart pole can contain at most two telecommunications company's equipment.

4.6.2.4 Side Ditch Wiring

Roadside ditches were originally used to remove rainwater or other liquids accumulated on the ground by environmental or human factors. At the same time, the upper part of the side ditch is close to both sides of the ground, which can also be used for pipeline laying. The optical fiber cable can be pulled up from the side ditch to the base of the smart pole. Taking Taipei City as an example, according to Article 5 of the Administrative Measures for the Construction of Cables Attached to Sewer Bridge Tunnels in Taipei City [63], cables can be suspended on both sides of the side ditch 20cm below the surface of the ditch cover. If the width of side ditch is less than 30cm~40cm, no cable or optical fiber cable can be laid. In addition, up to 8 cables can be placed in the side ditch. Except for one cable reserved by the county and municipal governments, each telecom company can only apply for one cable at most. However, if there are major facilities and cable telecom companies, they can add a second cable after application approval. In addition, according to Article 5 of the "Regulations on the Administration of Cables Attached to Sewer Bridges and Tunnels in Taipei City" [64], the diameter of the cables attached to the side ditch shall not exceed 2.3cm, and the total area of the overall cross section shall not exceed 1% of the area of the side ditch.

The above are the specifications and regulations of Taipei City. The county and city governments can adjust according to the current laws and regulations or the actual situation. This specification is only for reference, and the contractor should also be consulted to meet the design requirements.

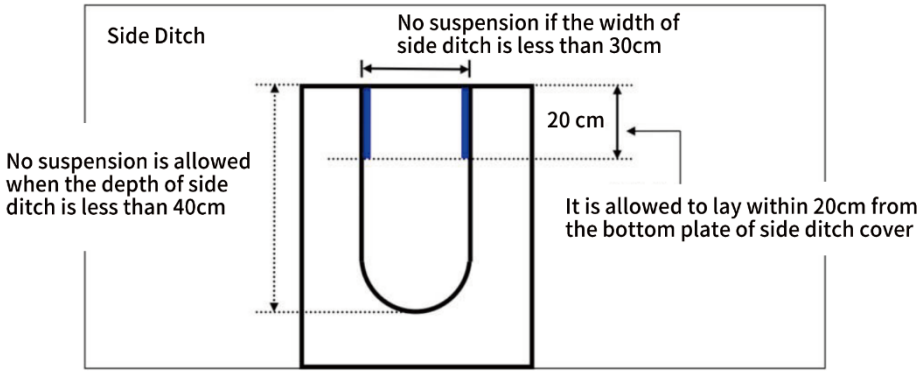


Figure 4.6.2.4-1 Diagram of Side Ditch 1 [65]

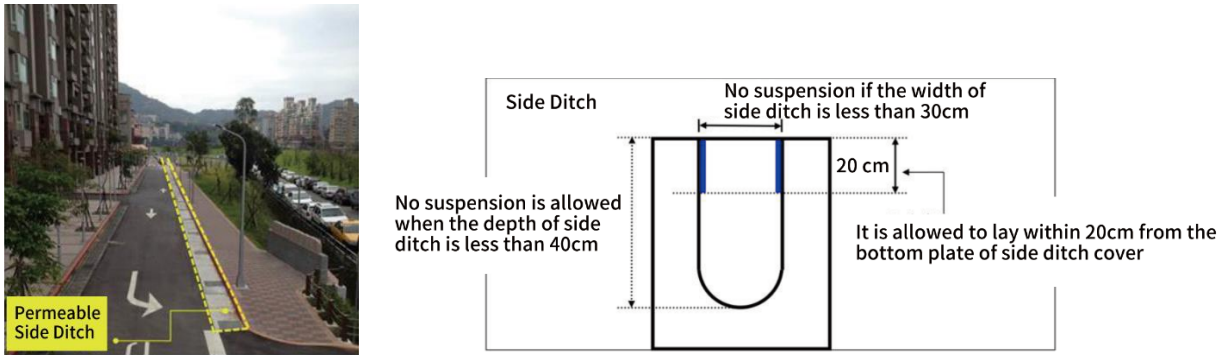


Figure 4.6.2.4.2 Diagram of Side Ditch 2 (only for reference)

4.6.2.5 Pipeline Construction and Compliance with Regulations

The process of smart pole related projects can be roughly divided into several stages:

(a) Construction assessment

After winning the bid, it will take 2-3 months to prepare documents, certification of structural experts and other relevant data before construction.

(b) Application for road permit

After the completion of the construction evaluation, the contractor needs to apply for the road permit, and the whole project can be completed within the period of applying for the road permit.

(c) Excavation

At this stage, the documents and road passes have come into force, and construction can start. At the beginning, the road surface will be excavated to the depth of pipeline burial and a little extra spare space will be provided. If the common pipeline leased by the government is used, the construction area can also be shortened. The Contractor will sort out the gravels and sundries after excavation to facilitate the subsequent setting out and actual site measurement.

(d) Lofting

The Contractor will prearrange the pipeline and survey the location on site to ensure that the pipeline is placed in a reasonable space and can be connected to the destination. After the correction is confirmed to be correct, the county and municipal government will conduct re inspection, and the construction can be started only after the re inspection is confirmed to be correct. If the setting out is inconsistent with the design drawing, the Contractor will be required to make correction and re inspection.

(e) Construction

The main purpose of the construction is to erect the PVC pipeline in the excavated trench. The backfilling shall be started after confirming that the buried depth of the pipeline complies with the government's specifications. Taking Taipei City as an example, Article 8 of the "Taipei City Road Excavation Administration and Self Government Regulations" [66] stipulates that the vertical depth between the top surface of the road underground and the road surface:

(1) Not less than 50cm on the sidewalk

(2) The road width shall not be less than 70cm below 8m

(3) The pavement width shall not be less than 120cm when it is more than 8m

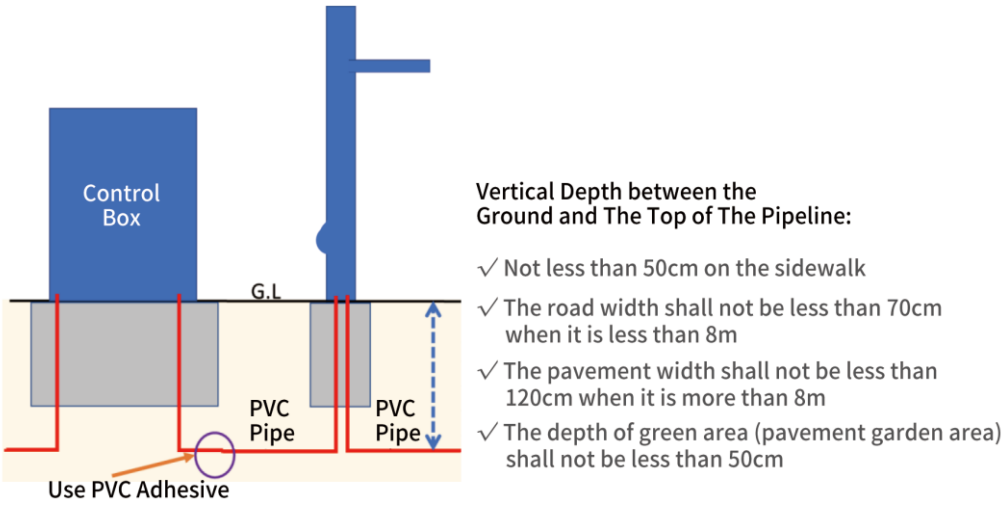


Figure 4.6.2.5-1 Diagram of Pipeline Construction

In addition, the depth of the green belt (pavement garden area) shall not be less than 50cm, and PVC adhesive can be used between PVC pipes to make them more compact, to avoid fracture at the joint after completion. The diameter of PVC pipes will be adjusted according to the current use situation. If there are many internal pipelines, larger PVC pipes will be considered.

(f) Pipe trench backfilling

Backfilling after pipeline laying is the last and very important stage. The backfill materials are divided into ground and underground. The quality of backfill material and construction method will directly affect the road safety in the future. If the construction is improper, it may cause cracks on the pavement, which will not damage the compressive

strength of the materials under the ground and the overall structure but will only cause aesthetic damage and affect the city appearance. Please refer to Figure 4.6.2.5-2 (left). In serious cases, the backfill material under the ground is damaged, causing structural damage, overall collapse and endangering driving safety. Please refer to Figure 4.6.2.5-2 (right) below

Figure 4.6.2.5-2 (left) Ground Cracking (right) Backfill Material Structural Damage (for reference only)

The backfilling of pipe trench is divided into two levels: the backfilling of original materials under the pavement and the backfilling of fillers from the asphalt layer to the depth of pipe trench. After the pipeline is installed, the manufacturer will backfill the depth from the deepest part of the pipe trench to 20cm below the road surface. After the initial setting is tested, and it is confirmed that the backfill material is indeed coagulated and can withstand moderate pressure, the raw materials from 20cm below the pavement to the pavement will be paved for backfilling. The following construction methods will be used for backfilling from the depth of pipe trench to the asphalt backfilling of pavement:

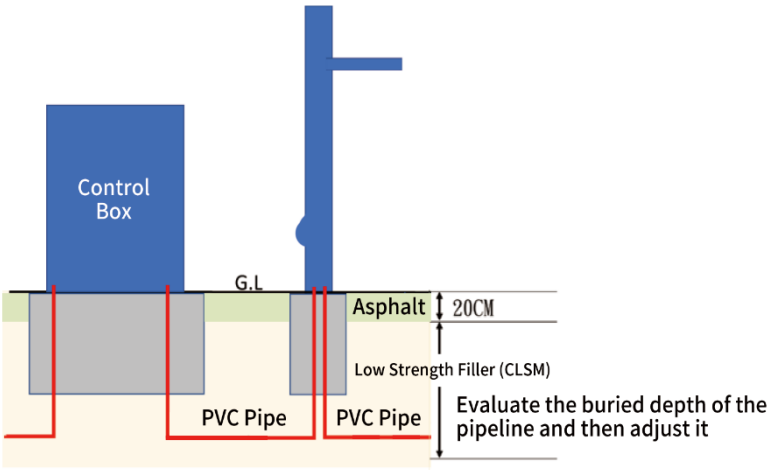


Figure 4.6.2.5-3 Pipe Trench Backfilling in Layers (Asphalt vs. Low Strength Filler)

(1) Backfilling of filling materials with the same depth of pipe trench

For pipe trenches with underground depth of more than 30 cm, liquid low strength filling material (CLSM) shall be poured from the bottom to 20 cm below the surface. CLSM is composed of cement, pozzolanic admixture, granular materials, and water in a set proportion. Pozzolanic contains silica and alumina, which will help to increase the cementation of CLSM after chemical reaction with cement. Taking Taipei City as an example, according to Chapter 03377 [67] 3.5.4 of the Engineering Construction Specifications of the Taipei Municipal Government, the initial setting state shall be reached four hours after the CLSM is poured in, and the Contractor shall deploy CLSM according to the actual situation. Early strength agent can be mixed with early strength type, blast furnace cement or concrete. The Contractor must complete the test after four hours of initial setting of CLSM, so that the road surface can be backfilled and the whole pipe trench works can be completed on the same day. There are two methods to test the strength of CLSM: one must comply with ASTM D6024-96 [68] (the American Society for Testing and Materials). Another method is to let a person of more than 60kg stand on the CLSM initially solidified in the pipe trench for more than five minutes and pass the inspection if there is no sign of collapse at the place where he stands. The second method is a testing method. It needs to record the whole process and upload it to the Taipei Road Excavation Notification APP. The process can only be completed after it is approved.


Figure 4.6.2.5-4 (left) After CLSM backfilling, ask 60kg staff to stand on it for 5 minutes to test, (right) Diagram of Backfilling CLSM to Pipe Trench (for reference only)

In addition, according to the inspection requirements of 3.5.1 in Chapter 03377 of the Taipei Municipal Government Construction Specifications, the compressive strength of CLSM should reach 40~80kgf/cm2. In the process of backfilling, CLSM backfilling can be carried out in two times: the first time, from the bottom to the middle of the pipeline, the depth of the first backfilling can be adjusted according to the excavation depth of the pipeline and the current site environment. After the initial setting, the second backfilling shall be carried out below the asphalt layer, and the pressure test shall be carried out again. It is suggested that the CLSM for the first backfilling should be mainly of high fluidity in the process of deployment, and the gap filling should increase the compactness. The CLSM for the second backfilling should increase the compressive strength and initial setting time.

There is another material for backfilling pipe trench, with sand and concrete gradation. Concrete gradation includes natural and recycled materials. Natural concrete gradation refers to the ingredients made of natural rock or gravel through crushing, screening, or mixing procedures. Recycled concrete gradations are rolled from stone waste, waste concrete, waste ceramics, etc. After backfilling, these graded granular materials do not need four hours of initial setting, such as CLSM, and can bear the load immediately. However, because they are less mobile than CLSM during backfilling, some small gaps cannot be filled. Therefore, the manufacturer recommends using CLSM for backfilling in smart pole related projects. However, the backfilling method shall be changed according to the design requirements of each county and city, and the backfilling method can be appropriately adjusted or matched according to the environmental requirements.

(2) Backfilling of original pavement materials

The backfilling of raw materials shall not be carried out until the CLSM has initially set and passed the inspection. Depending on the material of the construction pavement, asphalt (Asphalt Concrete - AC) can be backfilled or rigid reinforced concrete (RC) can be filled on the sidewalk, and the surface backfill material shall be laid at least 20cm below the surface. Chapter 02742 of the Construction Specifications of Taipei Municipal Government Engineering "After the asphalt is paved with a paver, the rolling machine will roll (initial rolling, secondary rolling, and final rolling) and compact it. According to the specifications of Annex [69] "Chapter 02742 Asphalt Concrete Pavement - Annex. pdf" of Taipei Municipal Government Engineering Construction Specifications, the degree of compaction:

- ✓ Road with a width of more than 8m: the compactness shall reach 95%
- ✓ Road with pavement width less than 8m: compactness reaches 93%

The actual test method can refer to CNS 12390 A3288 [70] test method to verify the compactness.

4.6.2.6 Smart Pole Wiring Hole Design

An outlet hole is reserved at the junction between the bottom of the pole and the PVC bundle pipe leading up, so that the pipeline and optical fiber can pass through the hole at the bottom after being led up from the PVC bundle pipe and access to the inside of the pole. Cable Gland will be added to these openings to increase the waterproof performance.

Figure 4.6.2.6-1 Diagram of Bottom Hole of Pole Body (only for reference)

After summing up the required quantity of PVC bundle pipes embedded in the pipeline in Section 4.6.2.3, the first version of the preliminary plan is suitable for the wiring opening of the

Alliance smart pole. Please refer to figure 4.6.2.6.2 below. In actual design, it is also necessary to make appropriate pipeline configuration and adjust the diameter of PVC bundle pipe for wiring opening.

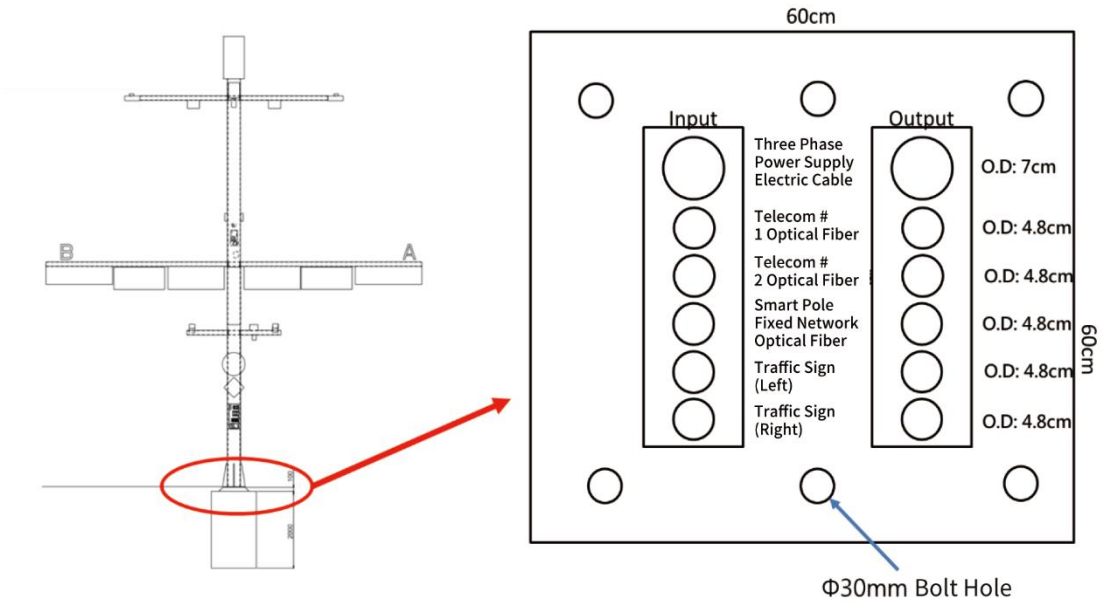


Figure 4.6.2.6.2 Diagram of Smart Pole Chassis Perforation (For Reference Only)

4.6.2.7 Hand Hole Position and Function

The handhole is used for additional wire pulling and wiring requirements. For example, the power cord of the charging pile will pull an additional cable from the control box to the required smart pole. At this time, it is necessary to embed another PVC pipeline near the smart pole from the control box, lead it through the handhole to the smart pole to facilitate the maintenance of the pipeline. Another function can also be used as a maintenance hole to facilitate the maintenance personnel to replace the pipeline and lead up. The distance between two adjacent handholes is 50 meters. The shape of the handhole can be round or rectangular, and the anti-skid design is made. Handholes on sidewalks need not be designed underground. However, if it is on the traffic trunk road and road, it is necessary to design the handhole underground. In order to prevent unnecessary traffic accidents caused by the impact of passers-by during their movement, the underground handhole needs to be covered up.

Figure 4.6.2.7 Diagram of Hand Hole (Picture is Only for Reference)

4.6.3 Construction Process

The construction of smart pole includes pre-construction, pipeline embedding, foundation base embedding, smart pole construction and inspection after completion.

(a) Pre construction:

Before construction, the contractor shall send professional technicians to the site to actually investigate the location of the smart pole and attach the equipment, and confirm the placement position of the pipeline site and the cable demand, setting out and confirming the location of the smart pole base and the excavation path of the sidewalk.

In addition, if the contracted project is to replace the old pole, it is necessary to investigate and record the original low hanging equipment base on the smart pole, contact the unit that attaches the equipment 10 days before the construction for on-site investigation and coordination. The attaching equipment on the old smart pole shall be moved to other places 3 days before the pole body replacement.

(b) Road permit application

When applying for a road permit, you must first confirm with the land ownership unit the excavation path, the pipeline arbitrage of each unit and the joint site survey. At the same time, relevant documents required by the road permit shall be filled in, and the construction plan and traffic maintenance plan shall be submitted. In addition, the application and pendant examination shall be submitted on the management system of each county and city government.

After the operation of being prepared and uploading the data, it should be noted that the line is a version of the government's road management center. After passing the examination

and issuing the road permit, it is necessary to post a notice on the site and inform the residents, drivers, and pedestrians in the area in advance to avoid civil complaints caused by the construction.

(c) Excavation and installation of smart pole foundation

Please refer to 4.6.1.1.2 Foundation Construction Process to restore the smart pole foundation and pavement first.

(d) Construction

After the construction of the foundation base is completed, please refer to 4.6.2.5 for pipe laying and backfilling to the road repair. During construction, safety facilities and construction billboards shall be placed according to the delivery and maintenance plan to prevent road users from unnecessary accidents.

(e) Pole erection and wiring

After the pipeline operation is completed and the leading pipeline is reserved, the pole erection and wiring can be started. Before construction, signboards and safety facilities shall also be placed to protect the safety of road users.

The construction of poles and tie lines shall be carried out in daytime as far as possible, and the road use right of road users shall not be affected. In addition, the power of the streetlights of Taipower will not be supplied until 6:00 p.m., so the construction personnel can safely set up the wiring of the smart pole and pipeline from daytime to 6:00 p.m., so there is no need to worry about the fire line operation caused by the power supply of the power cable.

Figure 4.6.3-1 Diagram of Pole Erection

If the old pole is renewed, the construction unit can take down the attached equipment on the old pole first, and notify the management unit of the attached equipment to attach and repair after the installation of the new pole is completed.

(f) Self-inspection and road permit settlement

Self-inspection on site: arrange personnel to regularly inspect the completed intersection, and immediately arrange for improvement if there is any defect. Road permit closing operation: within 30 days after the expiry date of the road permit, relevant data shall be attached according to relevant regulations to handle the completion closing.

(g) Project acceptance

After the independent inspection, the government agencies need to actually conduct field survey and accept the results of smart pole erection, and be present for review seven days before partial or full completion. In case of any shortage of public security, use and cleaning in site construction, it shall be improved immediately, and time shall be arranged for another review. If it is confirmed that the safety and various tests are safe, it can be used after the review of the management unit. After the use, the Public Works Bureau shall conduct another field survey to check whether the use will cause public safety or hinder the right of use of pedestrians. The overall

acceptance process can be referred to Figure 4.6.3-2 below, taking as an example the "Standard Operation Procedure for Opening to Use after Inspection by Park Street Light Engineering Management Office of Public Works Bureau of Taipei Municipal Government before Project Acceptance". The actual construction acceptance shall be carried out in accordance with the specifications of the county and city government where the contracted project is located, and in cooperation with the competent authority for review and acceptance.

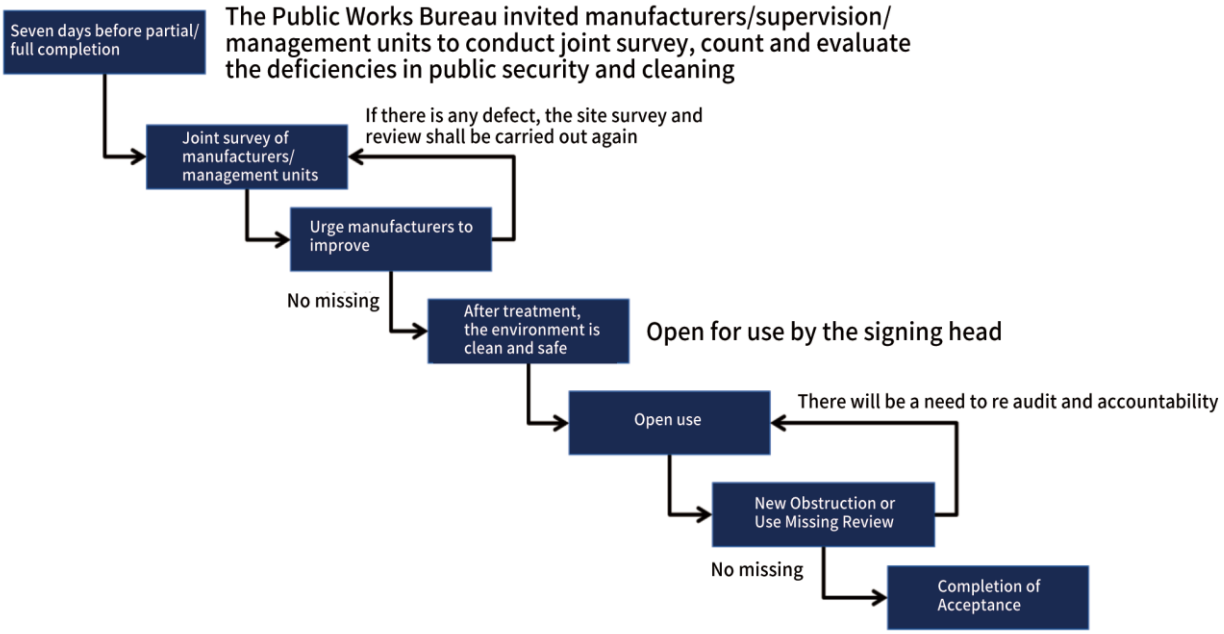


Figure 4.6.3-2 Project Acceptance Flow Chart

(h) Smart pole and pipeline positioning signs

The GML system is added to the system of the municipal government for the location and length of smart poles and pipelines, so that you can find and maintain them later.

4.7 System Management and Maintenance

According to the government's bid, as a contracting company, SI Company will purchase equipment according to the equipment specifications of various agencies, obtain the warranty and performance commitments of the equipment manufacturer, and provide education and training for the unified management of SI Company. After the construction and acceptance of the pole body and attached equipment are completed, the government authorities will sign a warranty contract with SI Company for two years or more, and SI Company will be responsible for the maintenance and operation. After the expiration of the contract, if the government agency does not renew the

contract, the maintenance and platform management will be returned to each government agency for self maintenance. The government authority can also extend the maintenance contract and let SI company continue to manage, or the government agency may open a "patrol inspection bid" so that the contractor can be responsible for the inspection of physical attached equipment and the maintenance of the management platform to a large extent.

Maintenance and operation can be divided into two parts: one is the routine inspection of the attached equipment on the actual pole body, and the other is the system operation management and maintenance of the management platform.

– Check of the attached equipment of the actual pole body

  The inspection and acceptance items jointly developed by the contractor SI Company and its equipment manufacturers shall be reviewed by the government authorities, and then the maintenance personnel shall carry out advanced calibration and inspection in the actual field one by one according to the items developed. The normal operation of the equipment attached on the physical pole body is usually inspected once a quarter, but the inspection cycle will be adjusted according to different competent authorities and projects.

– System operation management and maintenance of management platform

  There are relevant documents for system operation management and maintenance proposed in WG4 specification for reference. At present, the actual practice is still that the contractor SI Company will uniformly build the project interface management and the platform management behind each application equipment.

5. Product Power Safety System

5.1 Power Supply Design

5.1.1 Control Box and Smart Pole Power System Input

(a) The three phase three wire ungrounded system is used for the supply of the Taipower transformer box to the control box and the smart pole system, and the line voltage input to the control box is 220Vac. The grounding system shall meet the grounding requirements specified in this specification.

(b) The line voltage supplied by the control box to the smart pole is 220Vac; The grounding system shall meet the grounding requirements specified in this specification.

(c) For each control box, L1, L2 and L3 phase lines shall be staggered in sequence by the Taiwan Power Distribution Box. The control box supplies power to several smart poles matched with it to keep three-phase load balanced. Refer to Figure 5.1.1-1 for the smart pole power input circuit.

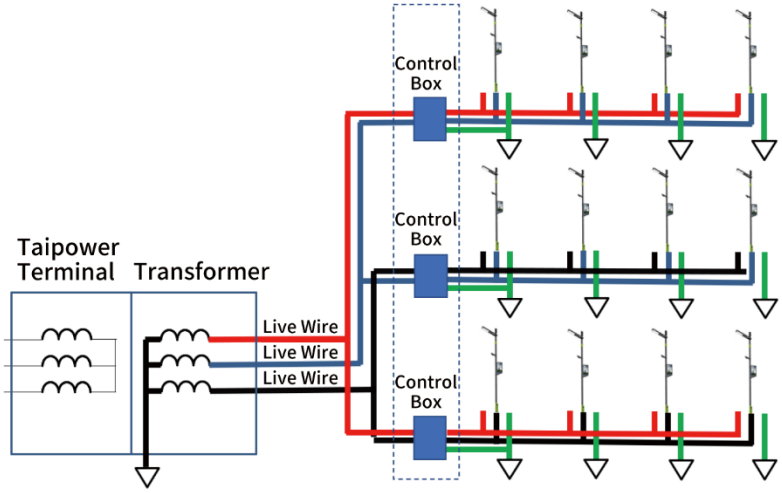


Figure 5.1.1-1 Smart Pole Power Input Circuit

(d) The power supply design shall comprehensively consider the maximum value of the electrical load of all equipment. In addition to the sum of the maximum values of the electrical load of all equipment such as 5G smart poles and control boxes, sufficient margin shall be reserved. It is recommended that 25% power margin be reserved for each smart pole for the use of the expanded attached equipment.

(e) The supply voltage of the smart pole at the end of the system shall not be lower than 90% of the rated voltage.

(f) According to Article 3 of the Administrative Rules for Electric Field Office and Professional Electrical Technicians of the Executive Yuan, the power supply voltage below 600 V is low-voltage power. The input voltage of 5G smart pole is 220Vac, which is low-voltage electrical equipment, and the third grounding in Table 5.1.1-1 applies.

(g) The power supply and distribution design of 5G smart pole shall comply with the relevant requirements of CNS 15233 LED road lighting lights [24] and CNS 14335-2-3 lights for road and street lighting [71].

Table 5.1.1-1 Type of Pole Grounding Insulation Resistance

Category	Grounding resistance	Diameter of grounding wire	Applicable positions
Special grounding	Less than 10 Ω	(1) Transformer capacity below 500kVA: insulated wire above 22mm2 (2) Transformer with a capacity of more than 500kVA: more than 38mm2 insulated wire	The low-voltage power supply system of the user transformer in the three-phase four wire multiple grounding system power supply area is grounded, or the high-voltage electrical equipment is grounded
First type of grounding	Less than 20 Ω	Insulated wire larger than 5.5mm2	Grounding of high-voltage electrical equipment supplied by non grounding system;
Second type of grounding	Less than 50 Ω	(1) Transformer capacity below 20kVA: insulated wire larger than 8mm2 (2) Transformer with capacity more than 20kVA: larger than 22mm2 insulated wire	Three phase three wire ungrounded system Power supply area Low voltage power supply system grounding of user transformer
Third type of grounding(applicable to smart pole)	(1) Voltage to ground below 150 V: below 100 Ω (2) Voltage to ground 151V to 300V: below 50 Ω (3) Voltage to ground above 301 V: below 10 Ω	(1) P.T. and C.T. secondary grounding wire above 5.5mm2 insulated wire (2) See Table 5.2 for the grounding wire of the internal line system separately grounded or grounded together with the equipment (3) See Table 5.3 for the grounding wire of the electrical equipment separately grounded or jointly grounded with the internal line system	(1) Grounding of low-voltage electrical equipment (2) Internal line system grounding (3) Secondary side grounding of P.T. and C.T (4) Support the metal grounding of low-voltage electrical equipment

(h) Grounding design

The control box body and the metal shell of the smart pole body shall be grounded independently from the base. The third grounding requirement in Table 5.1.1-1 shall be met. If the control box has no grounding design, it shall be grounded together with the adjacent smart poles in the same circuit.

(1) The PE line at the equipment end cannot be disconnected, nor can it enter the leakage switch.

(2) Material and connection requirements for protective neutral PE line: the section of protective neutral line shall not be smaller than that of working neutral line, and yellow/green two-colour line is mandatory.

(3) The protective neutral wire connected to electrical equipment shall be insulated stranded wire with a sectional area of not less than 2.5mm2.

(4) The control box and smart pole shall be grounded at the base respectively. If the actual site cannot be re grounded independently, they shall be grounded together with the nearest control box or smart pole. The grounding insulation resistance must meet the requirements of Article 25 of the Rules for Electrical Equipment and Devices for Industrial Users of the Ministry of Economy of the Executive Yuan. The grounding resistance should be less than 50 Ω. Before power transmission, the grounding test report (must be signed by the motor technician) must be attached. The grounding resistance can refer to Table 5.1.1.

(5) TN-S system or TT system should be adopted as the grounding form of electrical system. TN-S system is adopted when PE ground wire is used for the line from the power supply of the transformer box to the smart pole system, as shown in Figure 5.1.1-2; TT system is adopted when there is no PE ground wire for the power supply from the transformer box to the smart pole system, as shown in Figure 5.1.1-3.

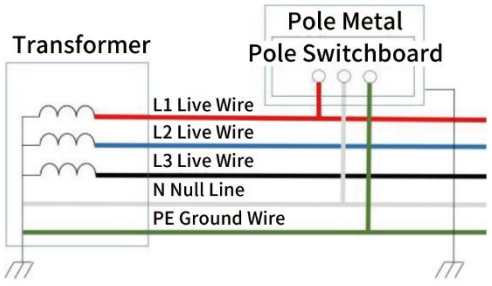


Figure 5.1.1-2 Diagram of TN-S Grounding System

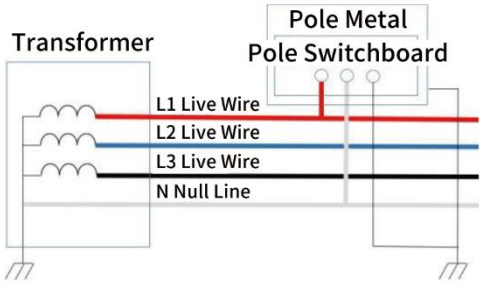


Figure 5.1.1-3 Diagram of TT Grounding System

(6) When TT grounding system is adopted, the ground wire of the attached equipment shall not be directly connected with the metal shell of the control box or smart pole, but shall be combined with the ground wire of the grounding bar to the grounding copper bar of the distribution panel.

(7) The size of grounding pole shall be 5/8 "x90cm or above.

(8) The connection between the protective neutral line and the electrical equipment shall be reliable, such as crimping terminals, and shall not be hinged.

(9) The terminals of electrical equipment shall be galvanized or coated with anti-corrosion grease to protect the zero line connection terminal block in the distribution box. No joints are allowed in other places.

5.1.2 Power Protection Device

(a) All equipment shall be equipped with independent power switch (NFB without fuse breaker) conforming to CNS 2931 [72] and leakage current protection device (RCD leakage current protector) conforming to CNS 5422 [73]. Or use leakage current operated circuit breaker (ELCB) with overcurrent protection, and set surge protection device (SPD) as required.

(1) The principle of residual current circuit breaker is that the device is in shunt

(2) Pure electromagnetic current operated residual current circuit breaker shall be used

(3) High sensitivity high-speed residual current circuit breaker shall be used (refer to Table 5.1.2-1)

(4) The rated current capacity shall not be less than the load current of the circuit

Table 5.1.2-1 High Sensitivity High-Speed Residual Current Circuit Breaker

Category		Rated sensitivity current (mA)	Action time
High sensitivity shape	High speed form	3、15、30	Within 0.1 s of rated sensitivity current
	Delayed form		Rated sensitivity current 0.1s to 2s
Medium sensitivity shape	高速形 High speed form	50、100、200、300、500、1000	Within 0.1 s of rated sensitivity current
	延時形 Delayed form		Rated sensitivity current 0.1s to 2s

(b) All equipment shall be distributed by multiple channels from the box, and crimping terminals shall be selected in consideration of waterproof requirements.

5.1.3 Equipment Power Supply System

(a) Each equipment with 220Vac working power supply is powered by 220Vac independently tapped from the control box or smart pole distribution panel. It is recommended that those devices with DC power supply and power consumption higher than 60W use independent PSU for power supply. It is recommended that equipment with DC power supply and power consumption lower than 60W can be powered by PoE through PoE splitter or PoE adapter. Equipment that can be powered by PoE is powered by PoE.

(b) The selection standard of power supply line wire shall refer to Section 5.2.1 of this standard, and the corresponding values of pipe trough wiring ampere capacity are shown in the Table 5.1.3-1 and Table 5.1.3-2.

Table 5.1.3-1 Ampere Capacity of Wiring in Wire Duct (Conductor Insulation Temperature 90 ℃)

Copper conductor			Number of wires in the same conduit						
Line type	Nominal sectional area (square mm)	Number/diameter (mm)	less than 3	4	5-6	7-15	16-40	41-60	61 and more
			Ampere capacity (Ampere)						
Single line		1.6	15	15	14	12	11	10	8
		2	20	20	17	15	13	12	11
		2.6	30	27	24	21	19	17	15
Stranded	3.5	7/0.8	20	20	17	15	13	12	11
	5.5	7/1.0	30	28	25	22	19	17	14
	8	7/1.2	40	35	30	27	24	22	19

Copper conductor			Number of wires in the same conduit						
Line type	Nominal sectional area (square mm)	Number/diameter (mm)	less than 3	4	5-6	7-15	16-40	41-60	61 and more
			Ampere capacity (Ampere)						
	14	7/1.6	55	50	45	40	35	30	25
	22	7/2.0	70	65	60	50	45	40	35
	30	7/2.3	90	80	70	60	55	50	45
	38	7/2.6	100	90	80	70	65	55	50
Note: 1. This table is applicable to metal pipe wiring, cable, flexible pipe wiring and metal trunking wiring. 2. The number of conductors in this table does not include neutral wire, ground wire, control wire and signal wire. But single-phase three wire or three-phase four If the discharge tube light is supplied by wire type circuit, the third harmonic current in the neutral line shall still be included. 3. For conductor amperage exceeding 38 mm2, please refer to the rules for electrical equipment and devices of users									

Table 5.1.3-2 Ampere capacity meter of PVC pipe wiring conductor (conductor insulation temperature is 60 ℃, and the ambient temperature is below 35 ℃)

Copper conductor			Number of wires in the same conduit						
Line type	Nominal sectional area (square mm)	Number/diameter (mm)	Less than 3	4	5-6	7-9			
			Ampere capacity (Ampere)						
Single line		1.6	13	12	10	9			
		2.0	18	16	14	12			
		2.6	24	22	19	16			
Stranded	3.5	7/0.8	19	16	14	12			
	5.5	7/1.0	25	23	20	17			
	8	7/1.2	33	30	25	20			
	14	7/1.6	50	40	35	30			
	22	7/2.0	60	55	50	40			
Note: 1. This table is applicable to PVC pipe wiring, HDPE pipe wiring and non-metallic flexible conduit wiring. 2. If PVC pipes are used for wiring, please refer to Table 16 to Table 7 of the Rules for User's Electrical Equipment and Devices for the amperage capacity of conductors exceeding 22 mm2.									

(c) It is recommended to use NEMA standard connector conforming to American national standard ANSI C136.41 [74] for power input terminal of intelligent lighting fixtures.

(d) Each new shunt does not contain load, and the insulation resistance of each line to ground shall not be less than 10M Ω.

5.1.4 Specification and Configuration of Main Pole Power Supply Box

(a) The power supply box contains system power supply, interlocking power transformer, equipment control circuit power switch, fuse holder, 3-hole power socket, power noise suppressor, fuse free circuit breaker, leakage current protector, etc.

(b) The height of the watt hour meter shall not be less than 150 cm according to the rules of the administrative institute on electric equipment and devices for users. It is recommended that the power supply box should be 150 cm above the ground. The power supply box should be waterproof. The protection circuit breaker and multi circuit ammeter in the power supply box do not require another waterproof grade.

(c) 35mm DIN standard rail structure is recommended for all equipment in the power supply box.

(d) Refer to Fig. 5.1.4-1 and Fig. 5.1.4-2 for configuration and wiring plan of power supply box.

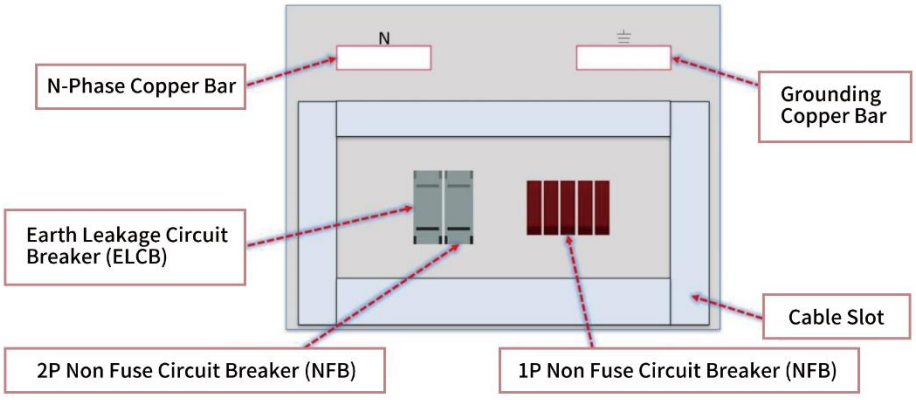


Figure 5.1.4-1 Distribution Panel Configuration and Routing Plan

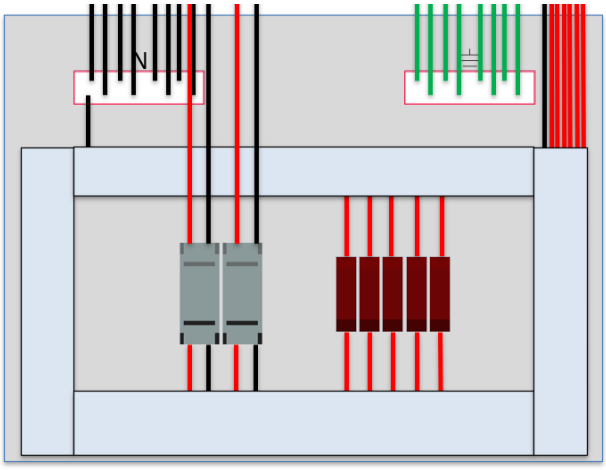


Figure 5.1.4-2 Distribution Panel Routing Plan

5.1.5 Specification and Configuration of Circuit Control Box Distributor

(a) The top layer of the loop control box is used by the electric meter, and other equipment cannot be placed.

(b) The circuit control box is equipped with a distributor to supply the equipment in the control box. Refer to Table 5.2.2-1 for the list of equipment.

(c) The distribution panel is equipped with protective circuit breaker, 220Vac socket for maintenance, AC multi circuit ammeter and other equipment.

(d) The power supply facilities shall reserve the base for the installation of electricity meters for the power supply system.

(e) Must conform to [Structural Diagram of Metal/Non combustible Non metal Meter Junction Box]

(f) Refer to Figure 5.1.5-1 for the protective elements and routing planning of the distribution panel of the control box.

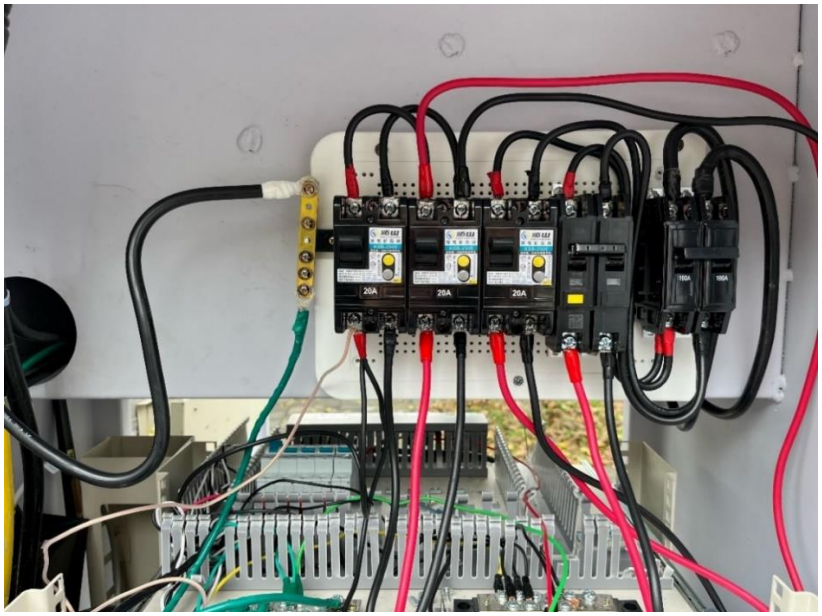


Figure. 5.1.5-1 Reference Diagram for Protective Elements and Wiring of Distribution Panel of Control Box

5.1.6 Configuration of Uninterruptible Power Supply System

The 5G smart pole can choose whether to build an uninterruptible power system (UPS) according to the construction field and needs. The reference specifications of the uninterruptible system are as follows

(a) The volume of the host and battery of the uninterruptible system was investigated, and it was suggested that the uninterruptible system should be set in the floor control box.

(b) It is recommended to use industrial grade uninterruptible power supply system, and the operating ambient temperature shall not be lower than 50 ℃.

(c) Online or online interactive uninterruptible power system is adopted.

(d) According to the energy density and operating environment temperature, it is recommended to select lithium iron phosphate battery with discharge operating temperature not lower than 50 degrees.

(e) The output power and time of the uninterruptible system are limited by the battery capacity. The importance of each attached equipment shall be considered to determine whether to supply power through the uninterruptible system.

(f) According to 5.1.5 (e), the flexibility of use and the complexity of wiring construction are investigated. If the UPS uninterruptible system is configured, it is recommended that all equipment of the floor control box and the smart mast be powered through the UPS circuit. When the output of the power grid of Taipower is interrupted, the control platform switches the equipment with low importance to the low power consumption or shutdown mode according to the user's needs.

5.2 Equipment Power Planning

5.2.1 Main Pole Equipment Power Supply Planning

(a) The 5G smart pole attached equipment includes the following items. The input voltage and maximum power of each equipment are shown in Table 5.2.1-1. If there is an expansion demand for other application equipment, the design should still be modified based on the operating voltage, power consumption and other factors of each equipment.

Table 5.2.1-1 Input Voltage and Maximum Power of 5G Smart Pole Equipment

	Input voltage	Maximum power
Telecommunication network	220Vac	150W
FWA equipment	220Vac	30W
Internet of Vehicles 5G C-V2X	PoE	26W
Wireless communication equipment DAS	220Vac	60W
Wireless communication equipment LPWAN	PoE	12W
Intelligent lighting	220Vac	150W
Video monitoring	PoE	48W
Environment monitoring	220Vac	5W
Public broadcast	PoE	36W
Traffic sign	220Vac	250W
Road digital sign	220Vac	400W
Gateway	220Vac	20W
Lidar	PoE	12W
Radar	PoE	23W
Interactive digital signage - information publishing signage	220Vac	210W
Interactive digital signage - screen interactive device	220Vac	120W
Emergency call	PoE	12W

(b) With reference to Table 5.2.1-1, the input power of each equipment is 220Vac and PoE, and the PoE PD (Powered Device) load equipment can be divided into 802.3af, 802.3at and 802.3bt according to the consumed power. The PSE of the network management switch shall select the switch with enough PoE output ports and the total power of PoE output shall be higher than the total power consumed by the PD load equipment.

(c) Different colours or marks shall be used for each attached equipment line to facilitate differentiation.

(d) Both ends of power lines in all distribution boxes must be marked with wire numbers.

(e) The distribution board is set in the distribution box to install protective circuit breakers, multi circuit meters and other equipment. The 1P non fuse circuit breaker

of the distribution board can cut off the power supply of each equipment independently. To avoid confusion between construction and maintenance personnel, it is necessary to clearly mark the non-fusible circuit breaker switch and the corresponding equipment name in a conspicuous and unshaded place.

(f) The material specification of the conductor pipe of the underground buried wire shall conform to the PVC pipe of the national standard CNS1302-K3006 [75], and it is not mandatory to use PVC pipe for the power wiring in the smart pole main pole.

(g) The selection principle of AC power wire is as follows: the wiring from the Taipower transformer box to the control box, and the wiring from the control box to the smart pole switchboard. The XLPE-PVC material is used for buried pipelines. The selection of wire diameter withstand current shall reserve at least 25% margin according to the maximum possible operating current.

(h) The power lines in the smart pole switchboard and the power lines supplied from the switchboard to the attached equipment end need to be made of PVC. The selection of wire diameter withstand current shall reserve at least 25% margin according to the maximum possible operating current.

(i) The Ethernet cable with PoE power supply function shall be Cat5e or above, and the conductor impedance of the conductor shall be no more than 10 Ω per 100 meters.

(j) According to the requirements of the input end of each equipment, the waterproof joint or lock is used for connection, and the specification of the connector is not mandatory. Refer to the tree diagram of power supply network, Figure. 5.2.1-1 Connection mode.

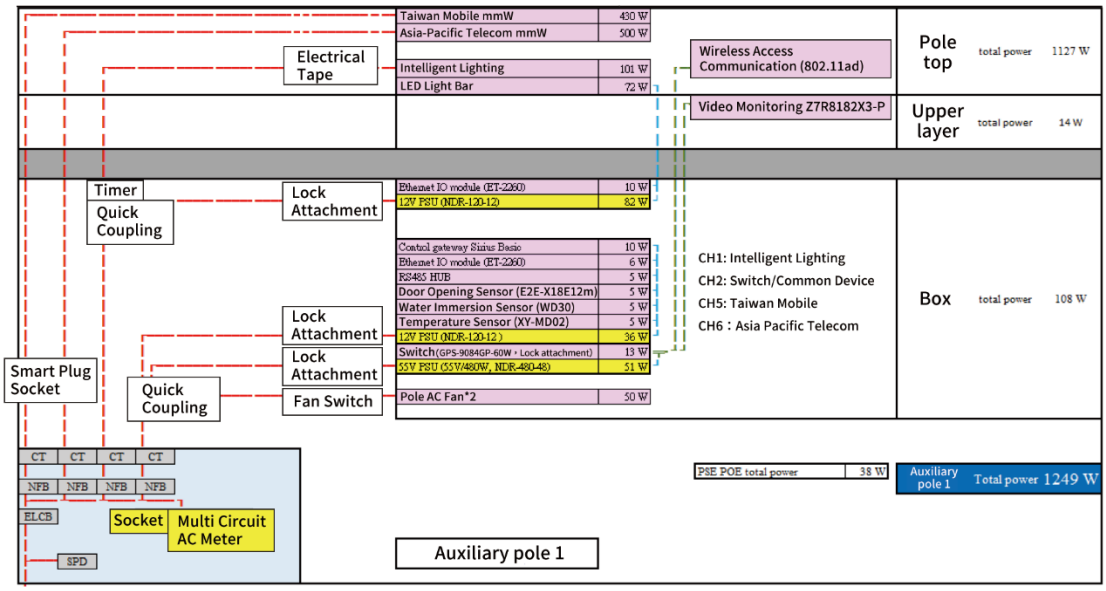


Figure 5.2.1-1 Tree View of Power Supply Network

5.2.2 Control Box Power Supply Planning

In order to cooperate with the construction of 5G smart pole, there should be a floor type control box around the smart pole to power the equipment in Table 5.2.2-1. The power supply mode of equipment is mainly 220Vac and PoE. Refer to 5.2.1 (b)~5.2.1 (i) for specification details.

Table 5.2.2-1 List of Control Box Equipment

Application	Function instruction	Size
Optical fiber transmission system equipment	ONU equipment	300mm x 480mm x 44mm
Optical fiber transmission system equipment	CWDM/DWDM equipment	300mm x 480mm x 44mm
Communication equipment of smart pole subsystem	Edge computing	254mm x 244mm x 209mm
Video monitoring	Video monitoring host	188.2mm × 295mm × 279.6mm
Gateway & Optical Network Unit	Managed Ethernet switch (Layer 3)	116.4mm x 170mm x 180mm
Wireless network controller	Managing WIFI APs on smart poles	438mm x 302.7mm x 44mm
Uninterruptible system	UPS host and backup battery	Host 432mm x 254mm x 88.6mm Battery 230.5mm x 139.9mm x 208.8mm (Total 4)

Application	Function instruction	Size
Switchboard	Ground control box power supply and cost distribution panel	260mm * 650mm
Taipower electricity meter	Taipower electricity meter	238.5mm * 187.5mm * 187mm

5.2.3 Charging Method for Attached Equipment of Smart Pole

As shown in Table 5.1.2-1, multiple circuit AC meters can be used for independent billing of various equipment. If multiple DC devices share PSUs and need to be charged independently, the DC meter shall be used to independently calculate the power consumption ratio for their devices, and the AC meter cost at the front end of the PSU shall be shared in proportion.

PoE (Power Over Ethernet) devices need to use network switches that can monitor the output power of each PoE port in real time. The management platform captures the instant power consumption of PoE devices at regular intervals (for example, 1 to 10 minutes) and accumulates it into monthly power consumption. The AC power consumption is measured at the front end of the network switch. The power charge is shared by each PoE port device according to the power consumption ratio. It is recommended to use standard 35mm DIN rail design for AC/DC multi circuit ammeter, with RJ45 or RS485 communication interface, which can independently record the power consumption of each circuit.

In the pole system, such as gateway and other hardware used for the integration of the attached system, the electricity cost is shared equally by all attached equipment. The block diagram of power supply equipment and ammeter circuit is shown in Figure 5.2.1-1. The full AC charging method is shown in Figure 5.2.3-1, the AC/DC hybrid charging method is shown in Figure 5.2.3-2, and the AC/PoE hybrid charging method is shown in Figure 5.2.3-3.

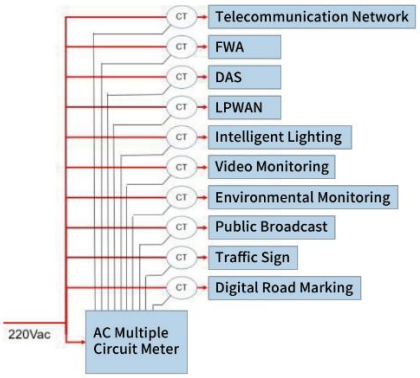


Figure 5.2.3-1 Billing Diagram of Pure AC Equipment

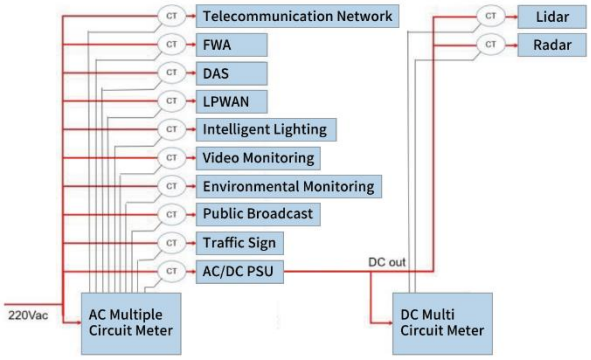


Figure 5.2.3-2 Diagram of AC/DC Mixed Charging

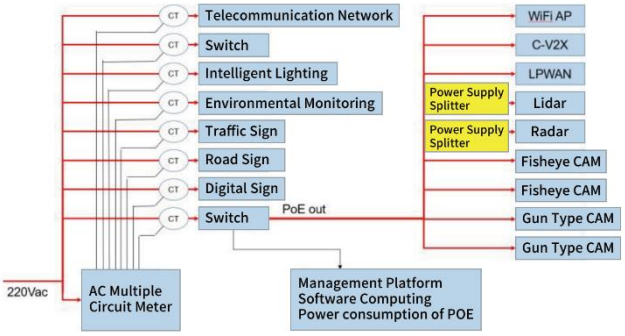


Figure 5.2.3-3 Diagram of AC/PoE Mixed Billing

5.2.4 Charging Method of Electric Charge for Control Box Equipment

The electric meter is set in the control box of Taiwan Electric Power Co., Ltd. One control box supplies power to multiple smart poles according to the design and user needs. An AC multi circuit ammeter is set in the control box to record the power consumption of each AC equipment. If there is a PoE power supply demand, please refer to Section 5.2.1 (b) to select the network switch for power supply and Section 5.2.3 to calculate the power consumption.

The schematic diagram of billing method is shown in 5.2.4-1. PoE equipment will share the PSE switch electricity charge in proportion; The AC equipment in the control box and smart pole obtains the power consumption through the AC multi loop ammeter, and all AC equipment shall share the electricity cost of the Taiwan watt hour meter in proportion.

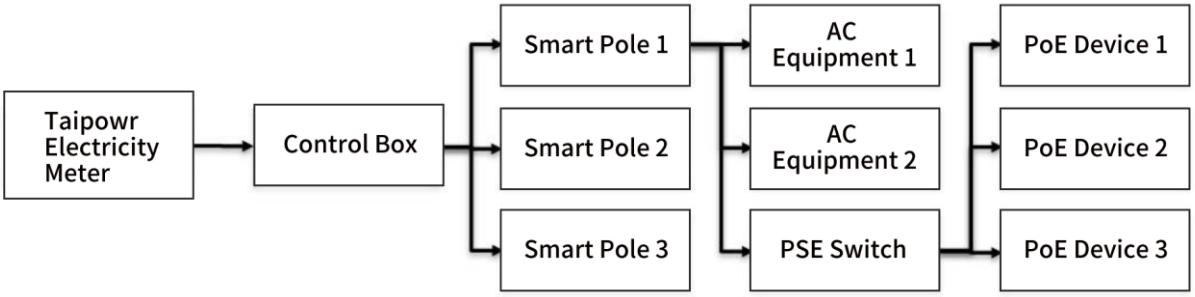


Figure 5.2.4-1 Diagram of electricity cost sharing proportion

5.3 Safety Requirements

The 5G smart pole body and all additional equipment must pass the following test specifications.

5.3.1 Electromagnetic Compatibility Requirements

(a) Shall pass: CNS 14676-3 radiation, RF and electromagnetic immunity test.

(b) Shall pass: CNS 14676-6 conducted disturbance immunity induced by RF field.

(c) Shall pass: CNS 14676-8 power frequency magnetic field immunity test.

(d) Shall pass: CNS 14676-9 impulse magnetic field immunity test.

(e) Shall pass: CNS 14676-10 damping vibration magnetic field immunity test.

(f) Shall pass: CNS 14934 Part 2-Part 5 relevant electromagnetic compatibility specifications

(g) Shall pass: IEC 61000-4-11 Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests

5.3.2 Antistatic Requirements

(a) Shall pass the antistatic requirements.

5.3.3 Safety Requirements

(a) Shall pass CNS 14676-4 electrical fast transient/cluster immunity test. Refer to Table 5.3.3-1 for test level.

Table 5.3.3-1 Test Level of Immunity to Electrical Fast Transient/Burst

Open circuit output test voltage and pulse repetition frequency				
Level	Power port, grounding port(PE)		Signal and control port	
	Voltage peak kV	Repetition frequency kHz	Voltage peak kV	Repetition frequency kHz
1	0.5	5 or 100	0.25	5 or 100
2	1	5 or 100	0.5	5 or 100
3	2	5 or 100	1	5 or 100
4	4	5 or 100	2	5 or 100
X	Specific value	Specific value	Specific value	Specific value
Note: "X" can be any digit. Higher than, equal to, lower than or between other levels, which must be specified in the specification of special equipment.				

(b) It is required to pass CNS 14676-5 Surge Immunity Test. Refer to Table 5.3.3-2 for the test level. It is recommended to use 4kV level test for 5G smart pole. If there are special requirements, the test voltage level can be defined separately.

Table 5.3.3-2 Test Level of Surge Immunity

Level	Open circuit test voltage kV	
	Line to line	Line to ground
1	—	0.5
2	0.5	1
3	1	2
4	2	4
X	Specific value	Specific value
"X" can be any bit level, higher than, lower than or between other bit levels. This level shall be specified in the special equipment specification.		

5.3.4 Other Safety Requirements for LED Lighting Fixtures and Additional Equipment

The information communication equipment shall be designed in accordance with CNS 15598-1 Audio Visual, Information and Communication Technology Equipment - Part 1: Safety Requirements and the international standard IEC 62368-1.

(a) LED intelligent lighting pole must conform to CNS 15233 specification for light-emitting diode road lighting fixtures.

(b) The individual requirements for lights shall comply with the individual requirements of CNS 14335-2-3 lights for road and street lighting.

(c) The LED street light power supply shall be designed according to the RF disturbance limitation and measurement methods of CNS 61347-1, CNS 61347-2-13 light source control device, CNS 14115 electrical lighting and similar equipment.

(d) The information communication equipment shall be designed according to CNS 15598-1 Audio Visual, Information and Communication Technology Equipment - Part 1: Safety Requirements.

5.4 Design Reference for Loop Control Box and Poles of 5G Smart Pole POC Scheme

The distribution panel of the circuit control box in the POC scheme is set in an independent and fixed space on the back of the electric meter. Each pole box is designed as a 19 inch standard cabinet. The distribution panel is set on the top of the box and is designed as a slide rail. The plane configuration of distribution panel is shown in Fig. 5.4-1. The number and specification of circuit breakers are selected according to the requirements of system equipment.

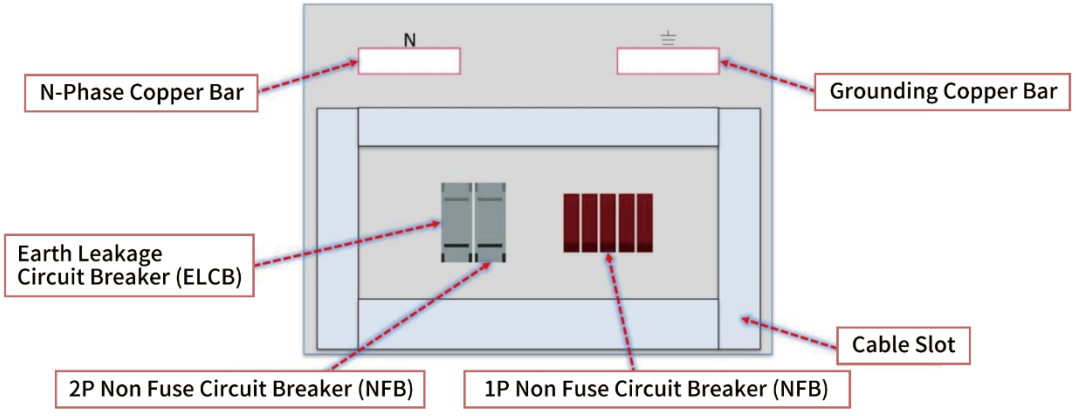


Figure 5.4-1 Layout Plan of POC Distribution Panel

5.4.1 Type 2 Power Supply Network Diagram/Distribution Panel Configuration Diagram

The maximum power consumption of main pole is about 8055 W.

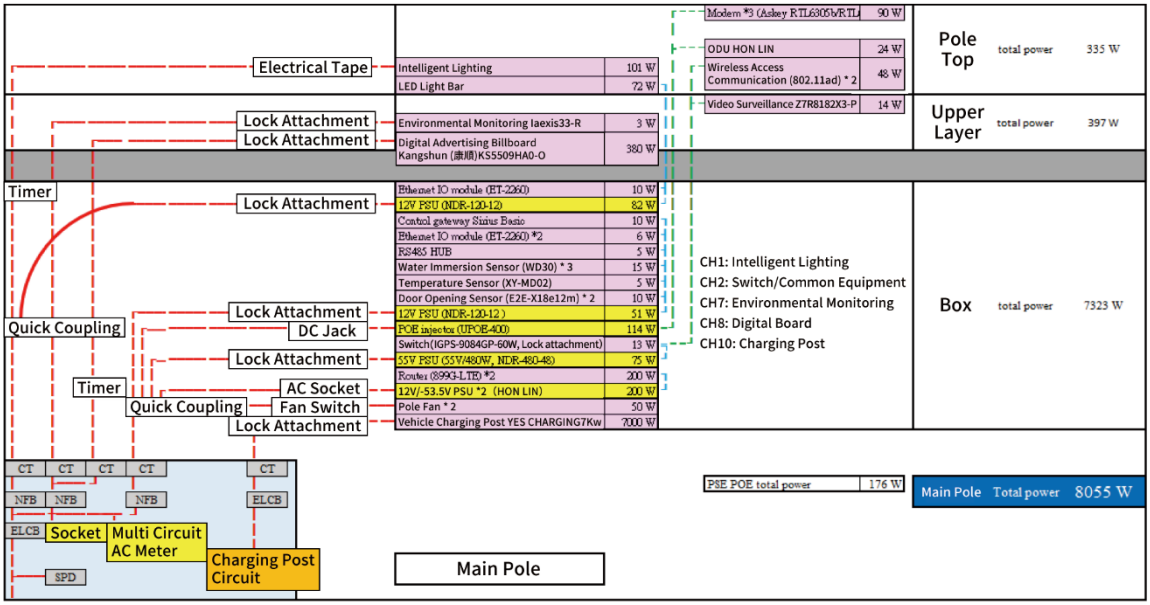


Figure 5.4.1-1 Power supply network diagram of main pole

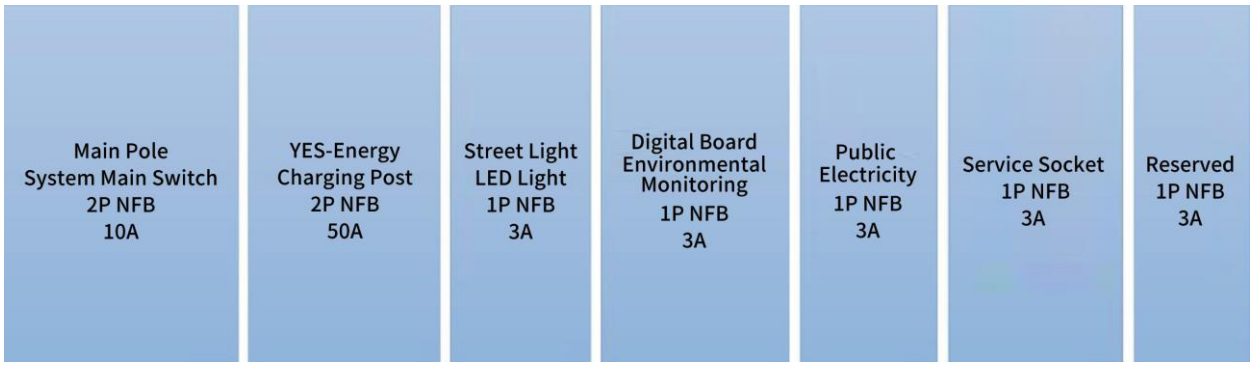


Figure 5.4.1-2 Main Pole Distribution Panel Configuration

5.4.2 Auxiliary Pole 1 Power Supply Network Diagram/Distribution Panel Configuration Diagram

The maximum power consumption of auxiliary pole 1 is about 1249 W.

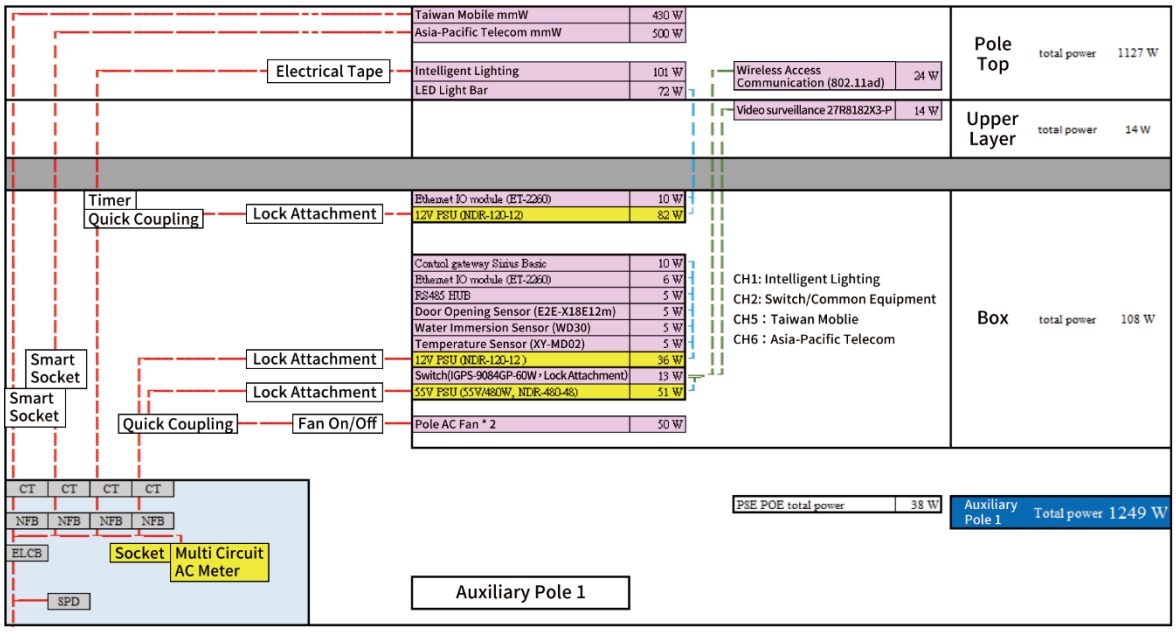


Figure 5.4.2-1 Circuit diagram of auxiliary pole 1 power grid

Figure 5.4.2-2 Distribution panel configuration diagram of auxiliary pole 1

5.4.3 Auxiliary Pole 2 Power Supply Network Diagram/Distribution Panel Configuration Diagram

The maximum power consumption of auxiliary pole 2 and main pole is about 7832 W.

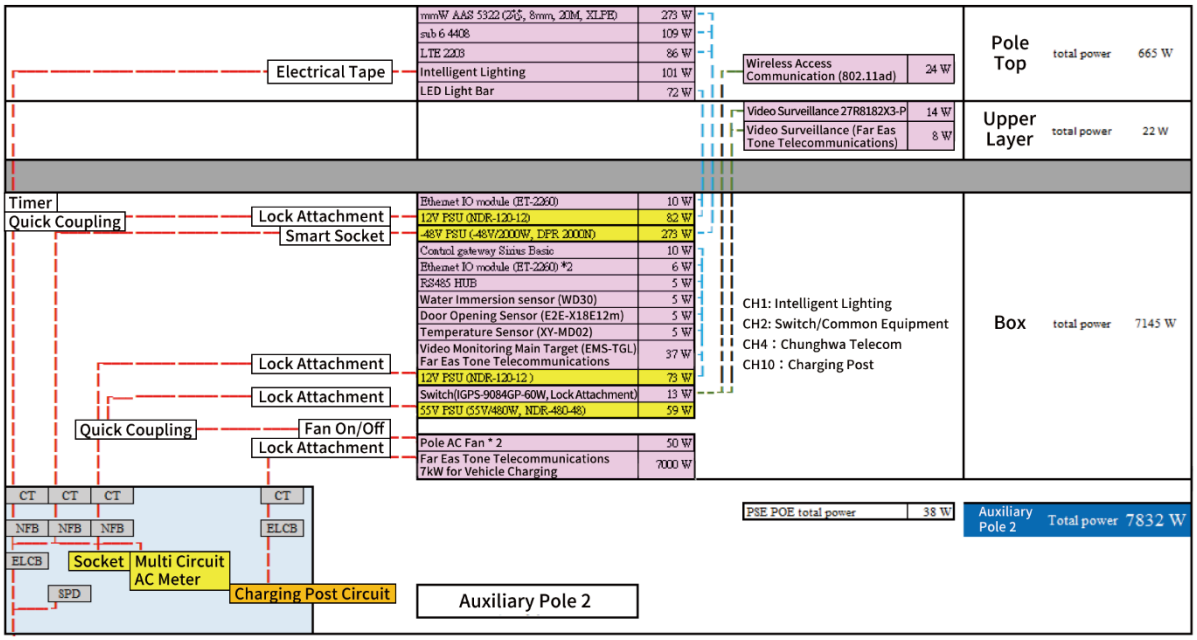


Figure. 5.4.3-1 Power supply network diagram of auxiliary pole 2

Figure 5.4.3-2 Distribution panel configuration diagram of auxiliary pole 2

5.4.4 Circuit Control Cox Power Supply Network Diagram / Distribution Panel Configuration Diagram / Distribution Panel Equipment List

The maximum power consumption of the loop control box is about 979 W (excluding UPS and battery charging power consumption).

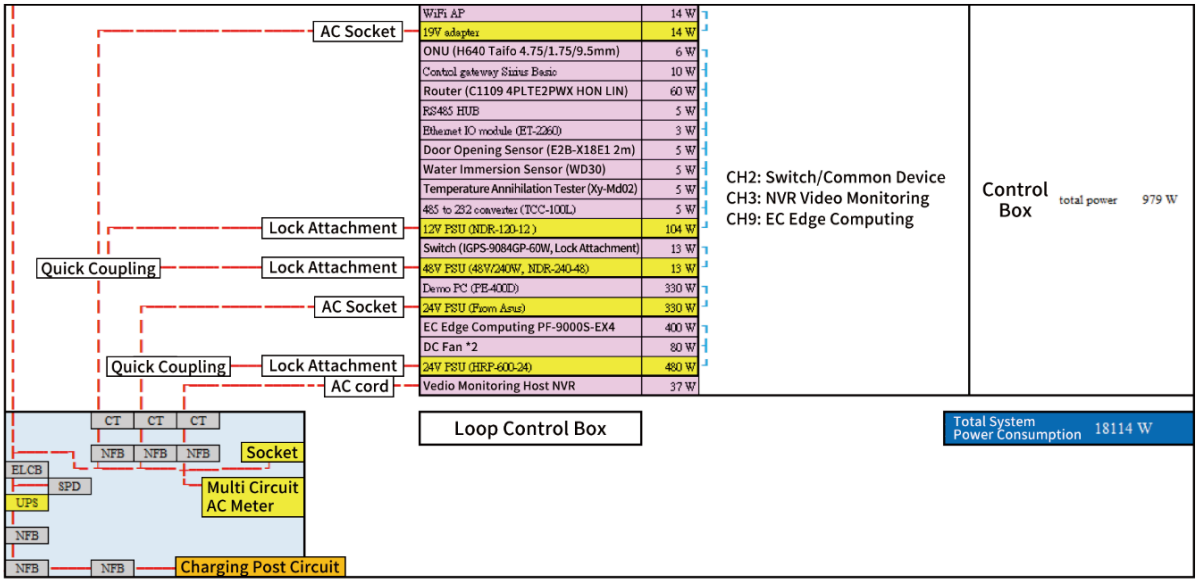


Figure 5.4.4-1 Power Supply Network Diagram of Loop Control Box

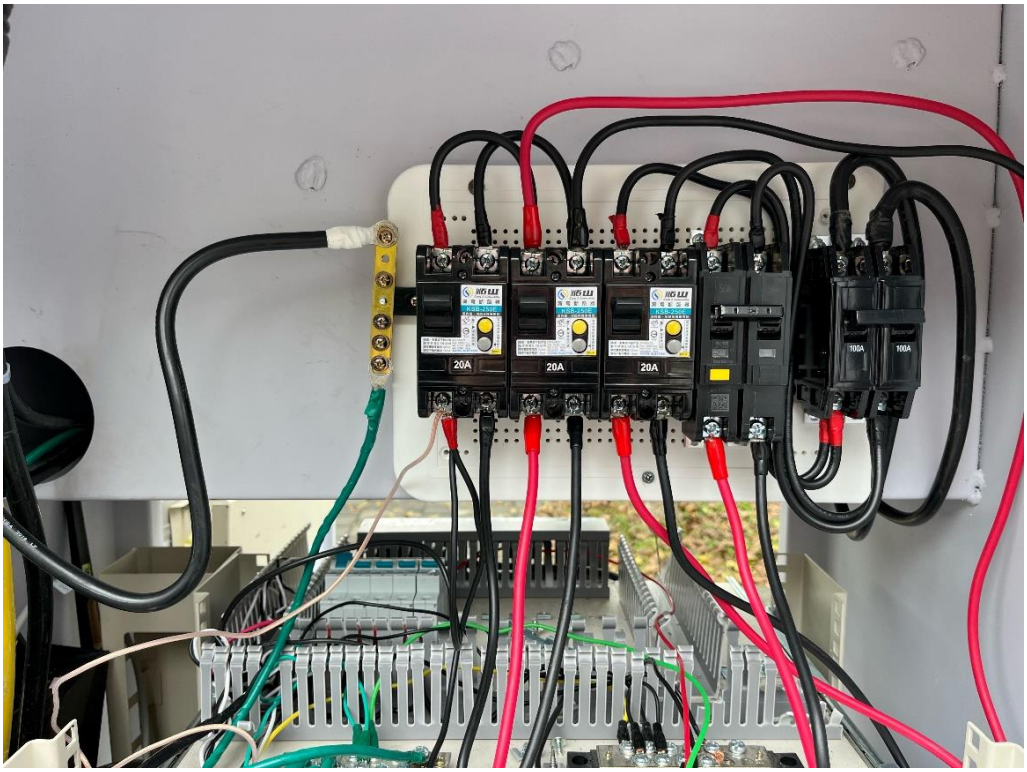


Figure 5.4.4-2 Distribution Panel Configuration of Circuit Control Box

6. 5G and Wireless Communication Module (Managed by WG3)

6.1 5G Wireless Communication Equipment

6.1.1 Planning Range of Wireless Communication Equipment Supported by Smart Poles

(a) This pole is planned to include 5G Sub-6 equipment, 5G mmWave equipment, 5GC core network server, MEC edge computing, Fixed Wireless Access (FWA), LPWAN (NBIOT&LORA. Etc), 5G Repeater & DAS, 5G C-V2X.

6.1.2 5G Architecture Support

(a) The 5G framework applied by the smart pole follows the R15 version (including) released by the 3GPP standard setting organization, and the subsequent 3GPP updated version is the specification.

(b) According to the requirements of application development and 3GPP specifications, 5G networks and equipment can adopt either non standalone architecture (NSA) or standalone architecture (SA).

6.1.3 5G BTS Software Interface Standard

(a) The 5G base station software interface standard applied by the smart phone must comply with the R15 version (including) released by the 3GPP standard setting organization, and the subsequent 3GPP updated version is the specification.

(b) The following chart (based on the O-RAN Alliance) shows the 5G/4G mobile communication software interface standard. The integrated All in one base station or CU-DU-RU separated base station scheme can be used.

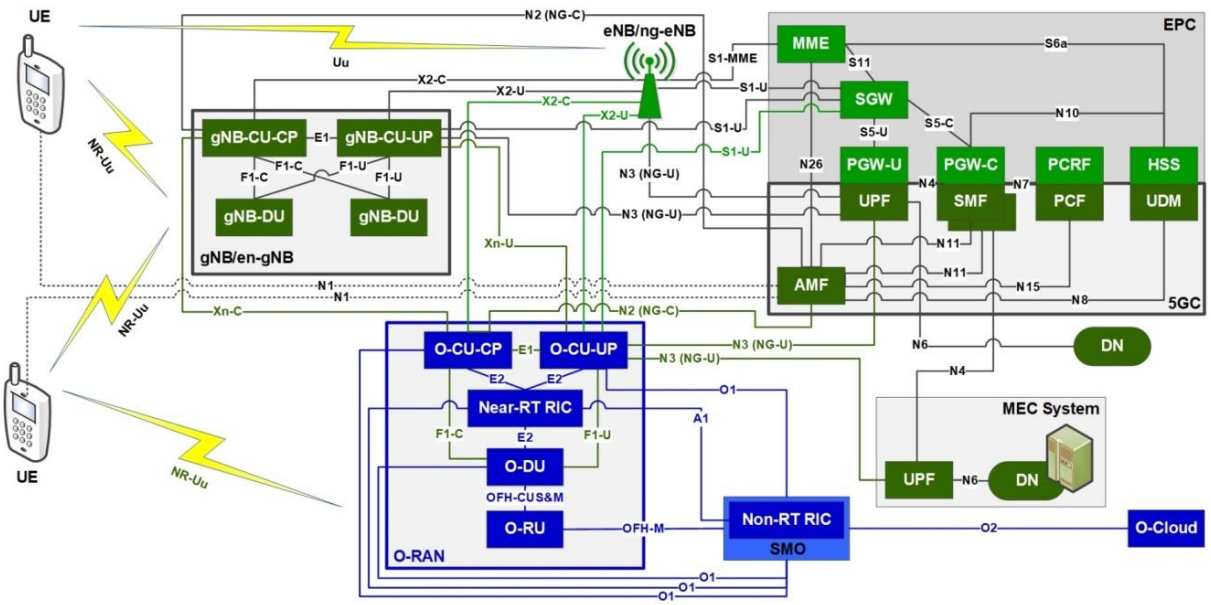


Figure 6.1.3-1 Base Station Software Interface Standard (Referenced from O-RAN Alliance) [76]

(c) The standard definition of All-in-one BTS software interface must comply with the following interface standards: refer to Table 6.1.3-1 for Backhaul interface (connecting NGC & All in one BTS)

Table 6.1.3-1 All in one BTS Software Interface Standards

All in one BTS Software Interface Standards			
Front end	Back end	Interface	Description
All-in-one base station	5GC or EPC	NG/S1	According to Backhaul standard defined by 3GPP.

(d) The interface standard definition of CU-DU-RU separated base station software must conform to the following interface standards: including Backhaul interface (connecting NGC&All in one small base station), please refer to Table 6-2

(1) F1 interface (connecting CU&DU)

(2) Fx interface (connecting CU&DU)

(3) X1 interface (connecting gNB & eNB)

(4) Xn interface (connecting gNB & eNB)

(5) The standard definition of CU-DU-RU separated base station software interface must comply with the following interface standards: refer to Table 6.1.3-2 for Backhaul interface (connecting NGC & All in one small base station)

Table 6.1.3-2 CU-DU-RU Separate Scheme Base Station Software Interface Standard

CU-DU-RU Separate Scheme Base Station Software Interface Standard			
Front end	Back end	Interface	Description
DU or DU/RU	CU	F1	According to the standard defined by 3GPP, Option 2 Split is mainly used.
RU	DU	eCPRI	According to the standards defined by O-RAN, Option 7-2x Split is mainly used.

(6) The standard definition of communication interface between base stations of CU-DU-RU separated base station must conform to the definition in Table 6.1.3-3

Table 6.1.3-3 CU-DU-RU Separated Scheme Base station software interface standard

CU-DU-RU Separate Scheme Base Station Software Interface Standard			
Base station	Base station	Interface	Description
gNB or en-gNB	eNB	X2	According to X2 standard defined by 3GPP.
gNB	gNB or ng-eNB	Xn	According to Xn standard defined by 3GPP.

6.2 5G Communication Equipment Specification Requirements

6.2.1 5G SUB-6 Communication Equipment Specification Requirements

(a) The equipment must conform to the R15 version (included) released by the organization that supports 3GPP standard formulation, and the subsequent 3GPP updated version is the specification.

(b) The equipment must comply with the Technical Specifications for Mobile Broadband Base Station Verification [77] defined by the National Communication Commission (NCC). The project shall obtain the certificate of conformity after passing the verification according to the verification procedure.

(c) Sub-6 communication ontology equipment can use the required equipment for 5G smart pole application planning and follow the minimum requirement specifications listed in the following table.

(d) The 5G Sub-6 device can set 4G and 5G base station concurrent applications for NSA (Non Standalone networking) or SA (Standalone networking) single 5G base station for related applications.

(e) The electromagnetic compatibility test requirements of the 5G micro base station Small Cell refer to the test conditions and test requirements of the electromagnetic compatibility requirements in Part 6 of the 5G smart phone technical specifications, and conduct strict tests according to the environment set by the smart phone.

Table 6.2.1-1 Sub-6 Specification of RF Equipment

Communication RF equipment architecture	All in One or O-RAN Sub-6 RF equipment can be used
SU-MIMO	DL: >=2 layers, UL: >=2 layers
Modulation	DL: QPSK/16QAM/64QAM/256QAM, UL: QPSK/16QAM/64QAM/256QAM
Interface	10GbE RJ45 x 1, Others
Duplex mode	TDD
Frequency band	n78, n79
Bandwidth	100MHz Maximum
Max. transmit power	>20dBm per Chain
Dimensions	Specification for pole attached in body type Pole top equipment: the maximum equipment length<400mm, width<300mm and weight<15Kg Upper layer equipment: the maximum equipment length<400mm, width<300mm and weight<15Kg Lower layer equipment: the maximum equipment length<400mm, width<300mm and weight<15Kg Installed outside the pole body Recommended specifications Pole top equipment: volume<=15L and weight<15Kg Upper equipment: volume<=15L and weight<15Kg

	Lower layer equipment: stored separately in external chassis
Synchronization	GPS/SyncE/IEEE1588 PTP (At least one of three synchronization technologies)
Power supply	12V/19V/48V all applicable DC adaptor (85~264VAC input)
Environments	Operating Temperature -10°C to 60°C At least IP65 for placement outside the pole

6.2.2 5G mmWAVE Communication Equipment Specification Requirements

(a) The equipment must conform to the R15 version (included) released by the 3GPP standard setting organization, and the subsequent 3GPP updated version is the specification.

(b) The equipment must comply with the technical specifications for mobile broadband base station verification defined by the National Communications Commission (NCC). The equipment shall pass the verification project according to the verification procedure and obtain the verification certificate.

(c) The mmWave communication ontology equipment can use the required equipment and follow the minimum specifications listed in the following table for 5G smart pole application planning.

(d) This 5G mmWave device can set 4G and 5G base station concurrent applications for NSA (Non Standalone networking) or SA (Standalone networking) single 5G base station for related applications.

(e) The electromagnetic compatibility test requirements of the 5G micro base station Small Cell refer to the test conditions and requirements mentioned in Part 6 Electromagnetic Compatibility Requirements of the 5G Smart Pole Technical Specifications, and conduct strict tests according to the environment set by the smart pole.

Table 6.2.2-1 Specification of 5G mmWave Millimeter Wave RF Equipment

Communication RF equipment architecture	All in One or O-RAN mmWave RF devices can be used
SU-MIMO	DL: >=2 layers, UL: >=1 layers
Modulation	DL: QPSK/16QAM/64QAM/256QAM UL: QPSK/16QAM/64QAM/256QAM
Interface	At least 1 set 10Gbps RJ45
Duplex mode	TDD
Frequency band	n257
Bandwidth	At least 100MHz
EIRP	The limit value of fixed wireless access terminal equipment is 55 dBm.
Antenna	>=128T128R
Dimensions	Installed inside the pole Recommended specifications Pole top equipment: the maximum equipment length<400mm, width<300mm and weight<15Kg Upper layer equipment: the maximum equipment length<400mm, width<300mm and weight<15Kg Installed outside the pole body Recommended specifications Pole top equipment: volume<=15L and weight<15Kg Upper equipment: volume<=15L and weight<15Kg Lower layer equipment: stored separately in external chassis
Synchronization	GPS/SyncE/IEEE1588 PTP(At least one of three synchronization technologies)
Power supply	12V/19V/48V all applicable DC adaptor (85~277VAC input)
Environments	Operating Temperature -10°C to 60°C At least IP65 for placement outside the pole
Power consumption	< 150W

6.2.3 5G Core Network Server Equipment Specification Requirements

(a) In the 5G NR system, the core network is called NGC (Next Generation Core)

(b) The equipment must conform to the R15 version (included) released by the 3GPP standard setting organization, and the subsequent 3GPP updated version is the specification.

(c) The ontology equipment can be planned for 5G smart pole application, and the required equipment can be used according to the specifications listed in the following table.

Table 6.2.3-1 5G Core Network Equipment Specifications

5G Core network	
Processor	X86 (Xeon Processor) or ARM-Based (unlimited)
Memory	More than 2GB (inclusive)
Interface	At least one group (including) of RJ-45 10/100/1000BASE-T Ethernet ports At least 2 groups (including) of 10G SFP+Ethernet ports At least 1 set of VGA ports
Interface (Optional)	At least one group (including) of serial ports (COM) At least one group (including) of USB interfaces
Synchronization Interfaces	GPS, IEEE 1588 v2 specification, and cascading (1pps + TOD) (At least one of three synchronization technologies)
Power supply	(85~277V AC input)
Environments	Operating Temperature -10°C to 60°C
Power consumption	< 1600W
Dimension	2U 19 inch chassis or 1U 19 inch chassis

6.2.4 5G Mobile Edge Computing Server Equipment Specification Requirements

(a) The equipment must conform to the R15 version (included) released by the 3GPP standard setting organization, and the subsequent 3GPP updated version is the specification.

(b) The ontology equipment can be planned for 5G smart pole application, and the required equipment can be used according to the specifications listed in the following table.

Table 6.2.4-1 Equipment Specification of 5G Mobile Edge Computing (MEC) Server

5G Mobile Edge Computing (MEC) server	
Processor	X86 (Xeon Processor) or ARM-Based (unlimited)
Memory	More than 2GB (inclusive)
Interface	At least one group (including) of RJ-45 10/100/1000BASE-T Ethernet ports At least 2 groups (including) of 10G SFP+Ethernet ports At least 1 set of VGA ports
Interface (Optional)	At least 1 group (including) of Serial port (COM) At least 1 set of USB
Synchronization Interfaces:	GPS, IEEE 1588 v2 specification, and cascading (1pps + TOD) (At least one of three synchronization technologies)
Power supply	(85~277V AC input)
Environments	Operating Temperature -10°C to 60°C
Power consumption	< 1600W
Dimension	2U 19 inch chassis or 1U 19 inch chassis

6.2.5 5G Distributed Antenna System Equipment Communication Equipment Specification Requirements

(a) The ontology equipment can be planned for 5G smart pole application, and the required equipment can be used according to the specifications listed in the following table.

(b) The equipment must be compatible with 5G small cell.

(c) The equipment must comply with the technical specifications for mobile broadband base station verification defined by the National Communications Commission (NCC), and obtain the verification certificate after passing the verification items according to the verification procedures.

(d) DAS equipment includes the following front-end units (HEU) and remote access units (RAU)

Table 6.2.5-1 5G Front End Unit (HEU) Equipment Specifications

Head End Unit (HEU)	
Support frequency	n78 or n79
RF Connector style	SMA or N-Type
RF Input power	0dBm ~ 24dBm (per Carrier)
Power overload protection	Support RF input exceed over range
Input / Output interface	Optical fiber or network route (Cat6/Cat6a/Cat7)
Network management interface	10/100 Base-T, RJ45 connector
DC Power input mode	DC voltage source converted through 100-240V Or PoE mode power supply and conform to the following compatibility specifications of IEEE A.802.3at type2(30W) B.802.3bt type3(60W)
Power consumption	Note
Environmental requirements	Operating Temperature -10°C to 60°C Lower layer equipment: stored separately in external chassis
Size and Weight	<5KG
Attachment mode	Standard 1 U rack attach interface
Note: The required wattage varies from 30W to 500W according to the actual application demand (telecom co structure level)	

Table 6.2.5-2 5G Remote Access Unit (RAU) Equipment Specification

Remote Access Unit (RAU)	
Support frequency	n78 or n79
RF Connector style	SMA or N-Type
Downlink RF Output power	<=24dBm per port
Input / Output interface	Optical Fiber or Network Route (Cat6/Cat6a/Cat7)
Power control interface	10/100 Base-T, RJ45 connector
DC Power input mode	DC voltage source converted through 100-240V Or PoE mode power supply and conform to the following compatibility specifications of IEEE A.802.3at type2(30W) B.802.3bt type3(60W)
Power consumption	Note
Environmental requirements	Operating Temperature -10°C to 60°C At least IP65 for placement outside the pole
Size and Weight	Pole top equipment: the maximum equipment length<400mm, width<300mm and weight<15Kg Upper layer equipment: the maximum equipment length<400mm, width<300mm and weight<15Kg
Attachment mode	Wall attach or Pole Attach
Note: The required wattage varies from 30W to 60W according to the actual application demand (telecom co structure level)	

6.2.6 5G C-V2X Communication Equipment Specification Requirements

(a) The ontology equipment can be planned for 5G Smart Pole application, and the required equipment can be used according to the specifications listed in the following table.

(b) The equipment must conform to the R15 version (included) released by the 3GPP standard setting organization, and the subsequent 3GPP updated version is the specification.

(c) The equipment must comply with the technical specifications for new radio broadband terminal equipment for mobile broadband services defined by the National Communications Commission (NCC), and the project shall obtain the qualification certificate after passing the examination according to the examination procedure.

(d) This equipment application includes RSU road side unit and vehicle on board unit, which must meet the compatibility test.

Table 6.2.6-1 Specifications for RSU Roadside Unit C-V2X

RSU Roadside Unit C-V2X Specification	
Technology	Supportable LTE C-V2X / 5G C-V2X
RF Output power	Power level of terminal equipment: 2: 26dB milliwatt (dBm). The power level of terminal equipment is 3: 23dBm. *Applicable frequency band and allowable error of power level shall comply with NCC
DC Power input mode	DC voltage source converted through 110-220V Or PoE mode power supply and conform to the following compatibility specifications of IEEE A.802.3at type2(30W)
Input/Output interface	10/100/1000Mbps 802.3at PoE+ x 1
Antenna unit	Support 5G/LTE antenna unit, C-V2X antenna, GPS or GNSS antenna
Power consumption	26W
Weight and Size	Specification for pole attached in body type Upper layer equipment: the maximum equipment length<400mm, width<300mm and weight<15Kg Specification for mounting on external pole body Upper equipment: volume<=15L and weight<15Kg
Support frequency	LTE: Band 1/3/7/8,…etc 5G: n78/n79 擇一 (alternative)
Environmental requirements	Operating Temperature -10°C to 60°C At least IP65 for placement outside the pole

6.3 Router Equipment Specification Requirements

(a) The equipment must meet the compatibility test with 5G base station equipment.

(b) The ontology equipment can be planned for 5G smart pole application, and the required equipment can be used according to the specifications listed in the following table.

Table 6.3-1 Router Specifications

Router Specifications	
Interface	At leat 1 set GE/ 10GE SFP+ Port At leat 1 set GE/2.5GE*SFP Ports At leat 1 set 10/100/1000Mbps Base-T Ethernet
Interface (Optional)	At leat 1 set RJ45 Console Port At leat 1 set USB
Synchronization Interfaces:	RF GPS IEEE 1588 V2 SyncE (At least one of three synchronization technologies)
Power supply	12V/19V/48V all applicable DC adaptor (85~277)VAC input)
Environments	Operating Temperature -10°C to 60°C
Power consumption	< 100W
Dimension	2U 19 inch chassis or 1U 19 inch chassis

6.4 Specification Requirements for Fixed Wireless Access Communication Equipment

(a) The ontology equipment can be planned for 5G smart pole application, and the required equipment can be used according to the specifications listed in the table below.

(b) The equipment must conform to the R15 version (included) released by the 3GPP standard setting organization, and the subsequent 3GPP updated version is the specification.

(c) The equipment must comply with the technical specifications for new radio broadband terminal equipment for mobile broadband services defined by the National Communications Commission (NCC), and obtain the certificate of conformity after passing the examination items according to the examination procedures.

6.4.1 5G Outdoor User Terminal Equipment

The body equipment is suitable for the environment with good signal coverage of the 5G base station. In the 5G smart pole application, this equipment can be connected to the 5G base station, which can be used in the situation where the bandwidth usage is relatively small.

Table 6.4.1-1 5G Outdoor CPE (FR1/FR2)

5G Outdoor CPE(FR1/FR2)	
5G communication specification	Comply with 3GPP R15 (included) later updated version
Support frequency	Can support n78/n79/n257
RF connector style	SMA or N-Type
RF Output power	The maximum conducted output power of FR1 does not exceed Power level of terminal equipment: 2: 26dB milliwatt (dBm). The power level of terminal equipment is 3: 23dBm. *Applicable frequency band and allowable error of power level shall comply with NCC FR2 Effective Isotropic Radiated Power (EIRP for short) limit value shall comply with NCC specification: The limit value of vehicle or mobile terminal equipment is 43 dBm. The limit value of fixed wireless access terminal equipment is 55 dBm.
WiFi technology	Support any 802.11 a/b/g/n/ac/ax technology
Input/Output interface	RJ45 network route (Cat6/Cat6a/Cat7)
DC Power input mode	DC voltage source converted through 100-240V Or PoE mode power supply and conform to the following compatibility specifications of IEEE a.802.3at type2 (30W)
Power consumption	<30W
Environmental requirements	Operating Temperature -10°C to 60°C At least IP65 for placement outside the pole
Size and Weight	Upper layer equipment: the maximum equipment length<400mm, width<300mm and weight<15Kg Middle floor equipment: the maximum equipment length<400mm, width<300mm and weight<15Kg
Attachment mode	Wall attach or Pole Attach

6.4.2 Point to Point and One to Multipoint Wireless Network Transmission Device

(a) The equipment is applicable to the condition that it is not easy to lay limited optical fibers. It can be used to replace the front haul system of wired optical fibers.

(b) When it is used with a 5G mini NodeB, it is recommended to use an all-in-one architecture.

(c) When it is used with a 5G mini NodeB, it is recommended to use an all-in-one architecture.

Table 6.4.2-1 Specifications for Point to Point and Point to Multipoint Wireless Network Transmission Equipment

Point to Point and Point to Multipoint Wireless Network Transmission Equipment	
Communication standard	802.11ad
Support frequency	57.24GHz -63.72GHz TDD 分時雙工 57.24GHz -63.72GHz TDD time sharing duplex
Transport configuration	Support point-to-point transmission or one to multipoint transmission
Antenna technology	Phase array beamforming antenna supporting 128 antenna elements
Input/output interface	RJ45 network route (Cat6/Cat6a/Cat7)
DC Power input mode	DC voltage source converted through 100-240V Or PoE mode power supply and conform to the following compatibility specifications of IEEE A.802.3at type2(30W) B.802.3bt type3(60W)
Power consumption	<30W
Environment requirements	Operating Temperature -10°C to 60°C At least IP65 for placement outside the pole
EIRP Equivalent omnidirectional radiation power	The limit value of fixed wireless access terminal equipment is 55 dBm
Size and Weight	Pole top equipment: the maximum equipment <300mm, width<150mm, weight< 5Kg Upper layer equipment: the maximum equipment <300mm, width<150mm, weight< 5Kg
Attachment mode	Pole Attach

6.5 Specification Requirements for Wireless Hotspot WI-FI Access Point Communication Equipment

(a) The ontology equipment can be planned for 5G smart pole application, and the required equipment can be used according to the specifications listed in the table below.

(b) The equipment must comply with IEEE 802.11x specification.

(c) The equipment must comply with the technical specifications for low power RF motors defined by the National Communications Commission (NCC), and obtain the qualification certificate after passing the examination items according to the examination procedures.

Table 6.5-1 WiFi Outdoor Access Point Equipment

WiFi Outdoor Access Point	
WiFi Technical standards	Support any 802.11a/b/g/n/ac/ax/WLAN Mesh technology
Support frequency	Can support 2.4 GHz & 5 GHz
RF Connector style	SMA or N-Type
RF Output power	Operating at 2400 MHz~2483.5 MHz The maximum EIRP output power shall not exceed 30dBm (1W) (included). Operating in the 5 GHz frequency band is as follows: 5.15 GHz ～ 5.25 GHz, 5.25 GHz ～ 5.35 GHz, 5.470 GHz ～ 5.725 GHz and 5.725 GHz ～ 5.85 GHz. The maximum EIRP output power shall not exceed 30dBm (1W) (included).
Input/Output interface	RJ45 network route (Cat6/Cat6a/Cat7)
DC Power input mode	DC voltage source converted through 100-240V Or PoE mode power supply and conform to the following compatibility specifications of IEEE a.802.3at type1 (15.4W) b.802.3at type2 (30W)
Power consumption	<30W
Environment requirements	Operating Temperature -10ºC~60ºC At least IP65 for placement outside the pole
Size and Weight	Pole top equipment: the maximum equipment length<200mm, width<200mm and weight<2Kg Upper layer equipment: the maximum equipment length<200mm, width<200mm and weight<2Kg
Attachment mode	Wall attach or Pole Attach

6.6 Specification Requirements for Gigabit Passive Optical Fiber Network Communication Equipment

(a) This equipment can be deployed with the required equipment according to the 5G smart pole application planning and the specifications listed in the following table.

6.6.1 Optical Cable Line Terminal Equipment

(a) The equipment must comply with the inspection items defined by the Bureau of Standards and Inspection of the Ministry of Economic Affairs, and must pass the electromagnetic compatibility (EMC) and electrical safety specification tests. Only after the items are approved according to the inspection procedures can the inspection certificate be obtained.

Table 6.6.1-1

GPON (Gigabit-Capable Passive Optical Networks)- OLT: Optical Line Terminal (Optical cable line terminal equipment)	
Technical standards	The technology needs to meet the international standard ITU-T G.984/G.988 protocol
Technical agreement	Support IEEE 802.1D spanning tree protocol Support IEEE 802.1s rapid spanning tree protocol Support IEEE 802.1w multiple spanning tree Support LACP to comply with IEEE 802.3ad
Hardware interface support	The following specifications need to be met 4 *PON port 4*10G/2.5G/1G port (SFP+/SFP,fiber) 4* GE 1/2.5G port (SFP,fiber) 4* FE/GE port (RJ45,copper) 1*Console port, USB type-A 1*management port, RJ45 1*alarm port, 1*swappable fan module
Other software function support	QOS OAM Multicast Security
Power input mode	Support AC 100V to 240V DC dual input (support power backup mechanism)
Power consumption	<100W
Environment requirements	Operating Temperature -10ºC~60ºC

Size and Weight	1U (19 inch ") This equipment is recommended to be placed in the control box or machine room equipment Reference dimension: length<440mm, width<250mm and weight<5Kg

6.6.2 Optical Network Unit/Optical Network Terminal Communication Equipment Specification

(a) The equipment must comply with the inspection items defined by the Standards Inspection Bureau of the Ministry of Economic Affairs, and must pass the electromagnetic compatibility (EMC) and electrical safety specification tests. Only after the items are approved according to the inspection procedures can they obtain the inspection certificate.

(b) The equipment must comply with the Technical Specifications for Optical Fiber Network Telecommunication Terminal Equipment (ONTE01) defined by the National Communication Commission (NCC). The project can only obtain the certificate of conformity after passing the examination according to the examination procedure.

Table 6.6.2-1

GPON（Gigabit-Capable Passive Optical Networks）- ONU/ONT Equipment	
GPON technical standard	Support ITU-T G.984. x technology Support the maximum distance of 20KM
Hardware interface support	Must support WAN: 1 port Giga optical interface (SC/APC) LAN: 1 port (inclusive and more)* 10/100/1000 Mbps RJ45-port Item can be chosen ➢ WLAN Support 802.11 a/b/g/n/ac (2.4GHz/5GHz any one)
Other software function support	QOS OAM Multicast VLAN

Power input mode	DC voltage source converted through 110-220V 12V-48V all applicable
Power consumption	<20W
Environment requirements	Operating Temperature -10ºC~60ºC
Size and Weight	This equipment is recommended to be placed in the control box or machine room equipment Reference dimension: length<250mm, width<180mm and weight<2Kg

6.7 5G Smart Pole Communication System Architecture

The 5G smart pole communication system can be divided into two major subsystems: 5G communication equipment subsystem and smart pole subsystem.

(a) 5G communication subsystem:

The 5G communication equipment subsystem includes Small Cell (All in one), DAS and O-RAN architecture. It can cooperate with domestic telecom companies to attach communication equipment to serve the general needs of public communication.

(b) Smart pole subsystem:

Including the system and equipment attached on the pole, focusing on the application of the equipment attached on the pole, and charging each unit in proportion. Except for public WiFi sharing, most of the functions will not be open to the public. The wireless application device includes CPE/802.11ad transmission point-to-point wireless device/WiFi Mesh related devices for application.

- It is suggested that WiFi Mesh can be used in suburban environment with smart pole application planning. Because the interference caused by large-scale deployment of 2.4GHz&5GHz frequency bands in the metropolitan area is not easy to control, it is not recommended to use it in the metropolitan area.
- LPWAN is widely used in the current smart pole system, but it is not recommended in promoting the practice of 5G smart pole architecture

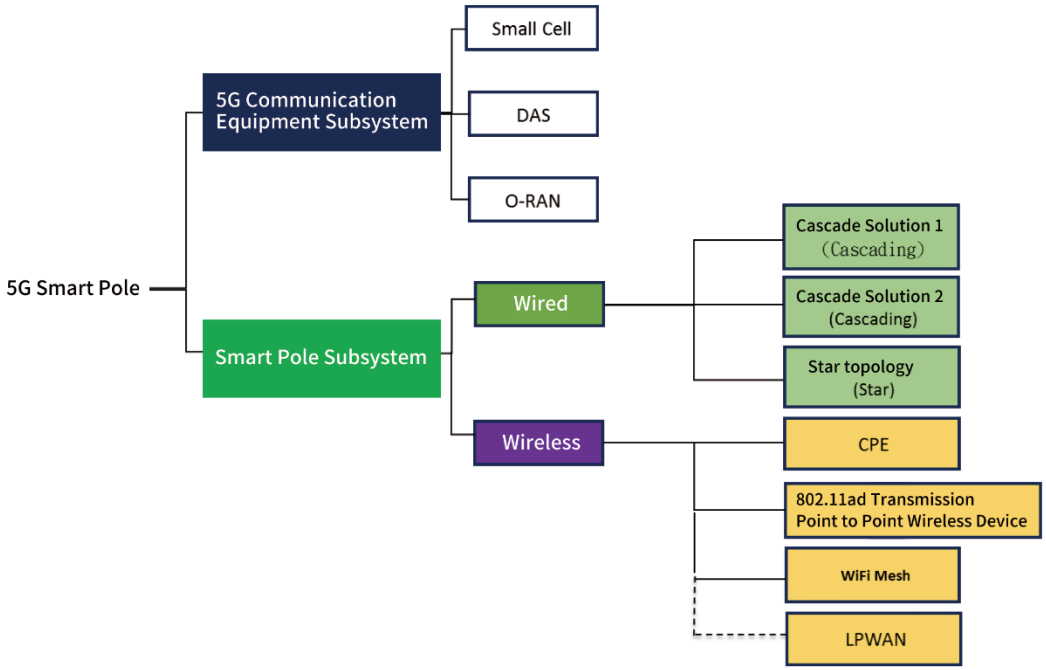


Figure 6.7-1 Category of 5G smart pole communication system

6.7.1 Recommended Application Architecture of 5G Smart Pole Communication Equipment Subsystem

The block diagram of 5G communication subsystem is divided into three architecture types according to the current planned system application as follows.

Refer to 6.7.2, 6.7.3 and 6.7.4

6.7.2 Architecture (I) Integrated Mini BTS for SUB-6 Band

As shown in the figure below, the integrated design of small cells in the sub-6 band can be used to deploy 5G small base stations on smart light poles and plan according to the field coverage requirements, and manage the corresponding small base stations of different telecom operators through DWDM (Dense Wavelength Division Multiplexer) fine wavelength multiplex transmission or CWDM (Coarse Wavelength Division Multiplexer) coarse wavelength multiplex transmission back to the 5G core network.

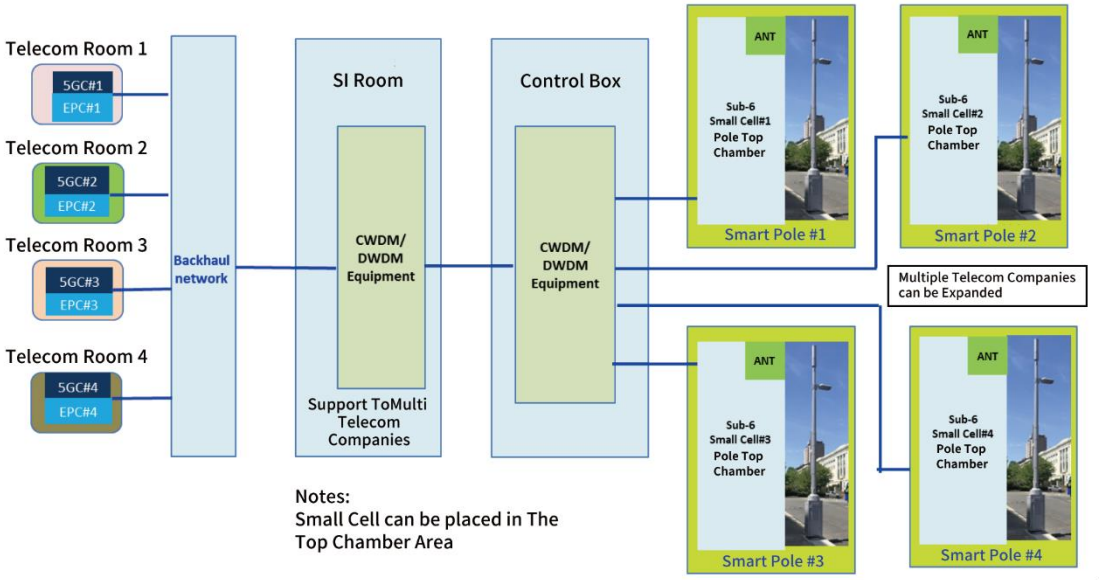


Figure 6.7.2-1 (All-In-One Small Cell) Applied to sub-6 Band

6.7.3 Architecture (II) Open Network Architecture Wireless BTS Applied to SUB-6 Band

As shown in the figure below, the RU can be transmitted back to the central unit (CU) and distribution unit (DU) through the sub-6 frequency band. The 5G small cell can be deployed on the smart light pole using the O-RAN standard interface and planned according to the coverage requirements of the site. In addition, DWDM (Dense Wavelength Division Multiplexer) fine wavelength multiplex transmission or CWDM (Coarse Wavelength Division Multiplexer) coarse Wavelength multiplex transmission is transmitted back to the 5G core network to manage the small base stations of telecom operators.

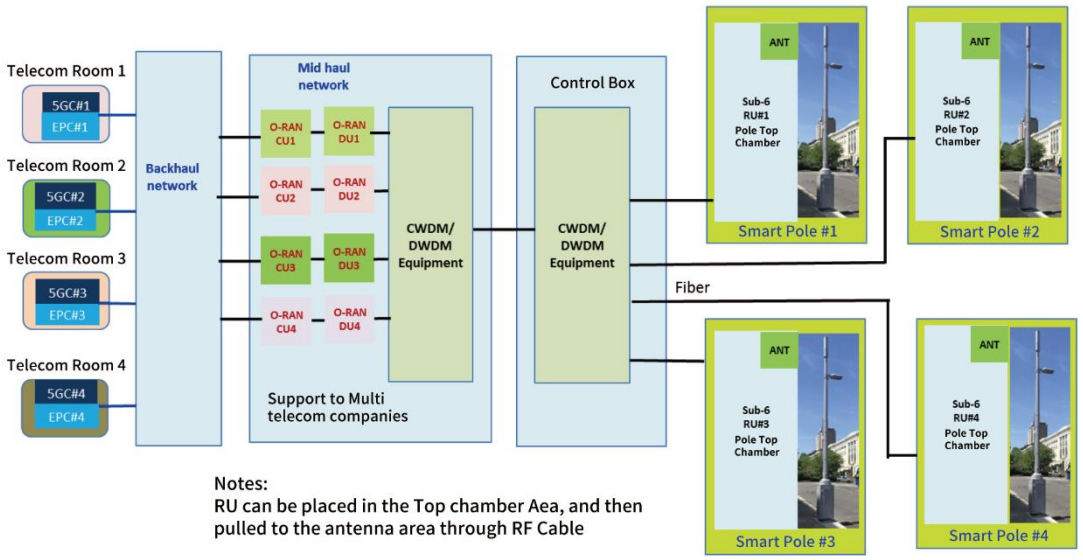


Figure 6.7.3-1 O-RAN Radio Unit Applied to Sub-6 Band

6.7.4 Architecture (III) Small Cell Integrated Design Applied to MMWAVE Band

Install the 5G small cell on the smart light pole. According to the field coverage requirements, manage the corresponding small cells of different telecom companies through the technology of fiber optic transmission back to the 5G core network.

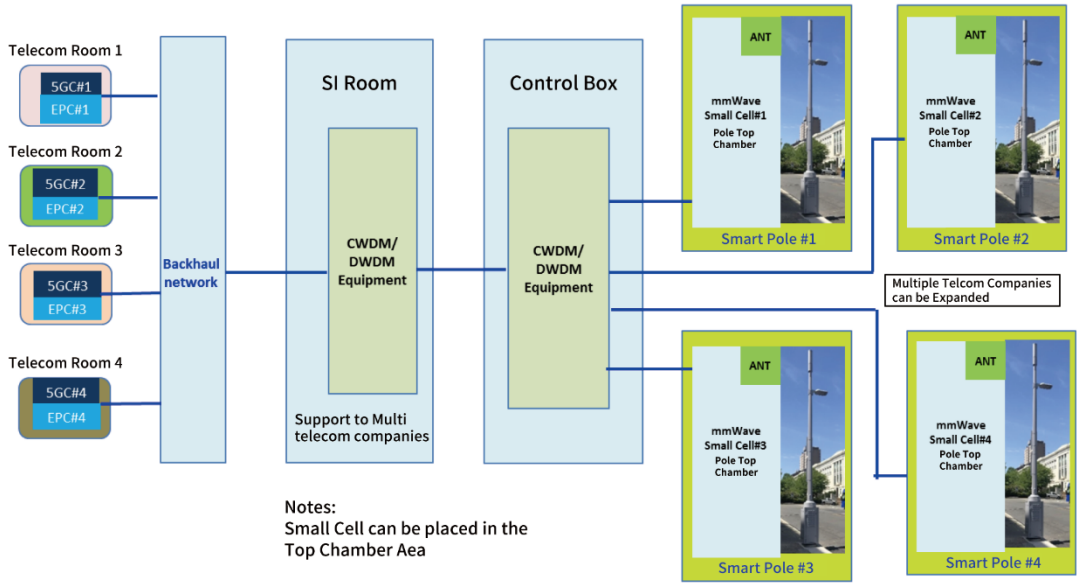


Figure 6.7.4 All-In-One Small Cell Applied to mmWave Band

6.7.5 Architecture (IV) Open Network Architecture Wireless Base Station Applied to mmWAVE Band

As shown in the figure below, the RU can be transmitted back to the central unit (CU) and distribution unit (DU) using the mmWave frequency band. The O-RAN standard interface is used to deploy the 5G small cell on the smart light pole. According to the field coverage requirements, DWDM (Dense Wavelength Division Multiplexer) fine wavelength multiplexer or CWDM (Coarse Wavelength Division Multiplexer) coarse wavelength multiplexer are used to transmit back to the 5G core network to manage the small cells of the corresponding telecom operators.

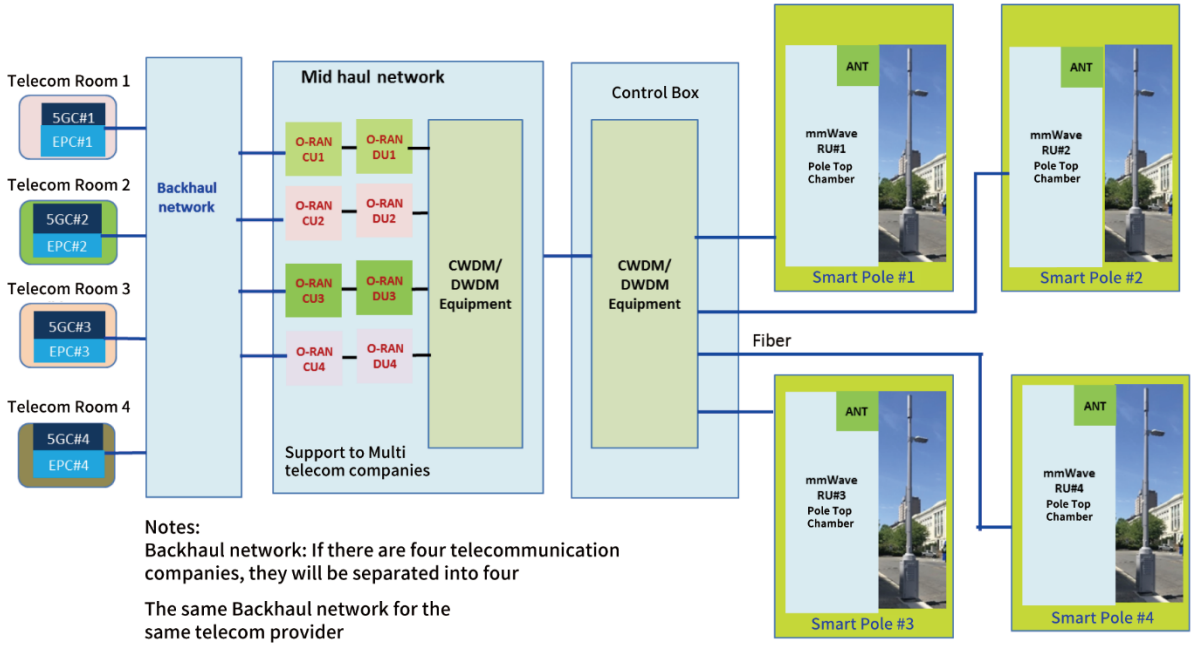


Figure 6.7.5 O-RAN Radio Unit Applied to mmWave Band

6.7.6 Architecture (V) Common Architecture Application Architecture of Active Distributed 6.7.6 Antenna for SUB-6 Band (A)

As shown in the figure below, it is possible to integrate the base station equipment of multiple telecom operators, and use Active DAS to integrate the radio frequency signals of small base stations applied to the sub-6 band O-RAN and Non O-RAN/All in one architecture, which are fed back to the head unit of the Active DAS, and then convert the signals into optical fiber signals and forward them to the radio access

Unit (RAU). Place the RAU equipment and antenna equipment in the top compartment of the 5G smart pole, and install the 5G DAS RAU equipment on the smart pole according to the field coverage requirements.

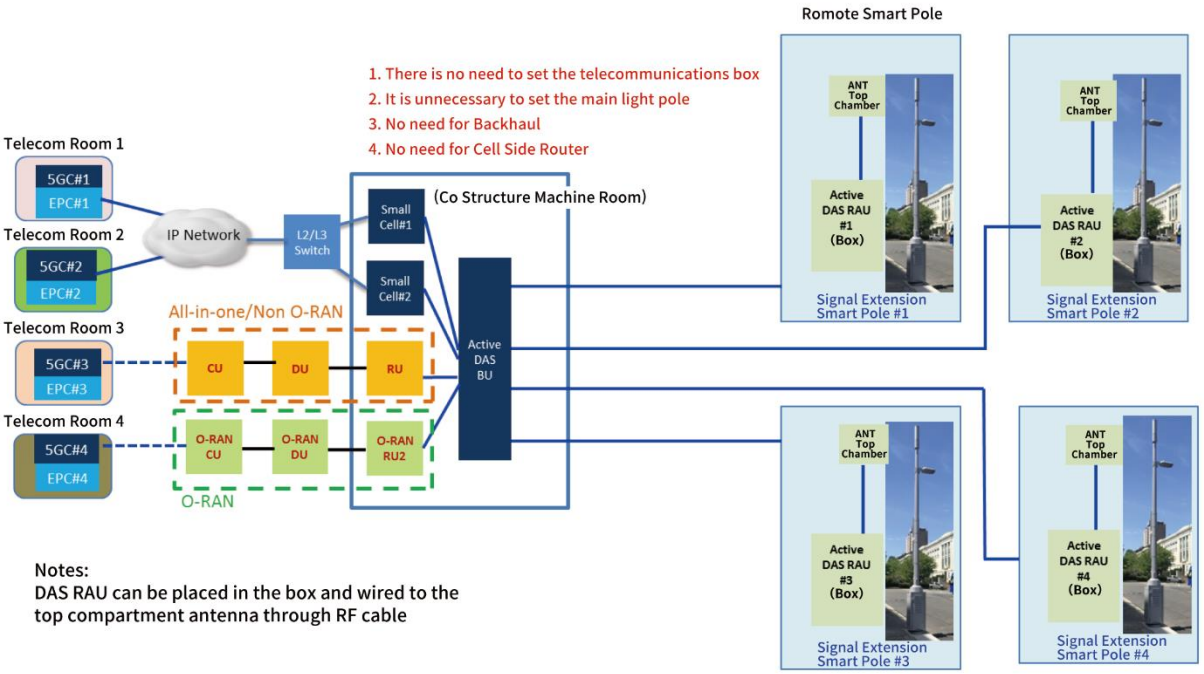


Figure 6.7.6-1 Active DAS Co structured Application Architecture Applied to Sub-6 Band (A)

6.7.7 Architecture (VI) Active Distributed Antenna Common Structure Application Architecture for sub-6 Band (B)

As shown in the figure below, the base station equipment used by multiple telecom companies can be integrated. The active distributed antenna system Active DAS can be used to integrate applications in the small base stations of the O-RAN and Non O-RAN architectures in the sub-6 band. Its RF signal is fed back to the head unit of the active distributed antenna system, and the signal is converted into optical fiber signal and transmitted to the wireless access Unit (RAU). The RAU equipment is placed in the control box and the antenna equipment is placed in the top compartment of the 5G smart pole. The 5G DAS RAU equipment is placed on the smart light pole according to the field coverage requirements.

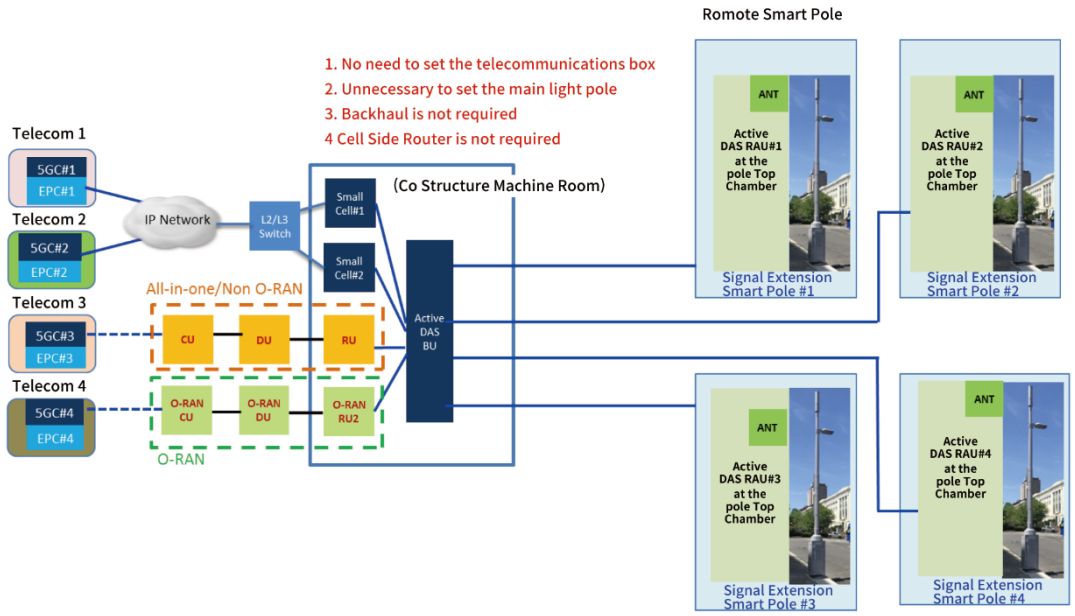


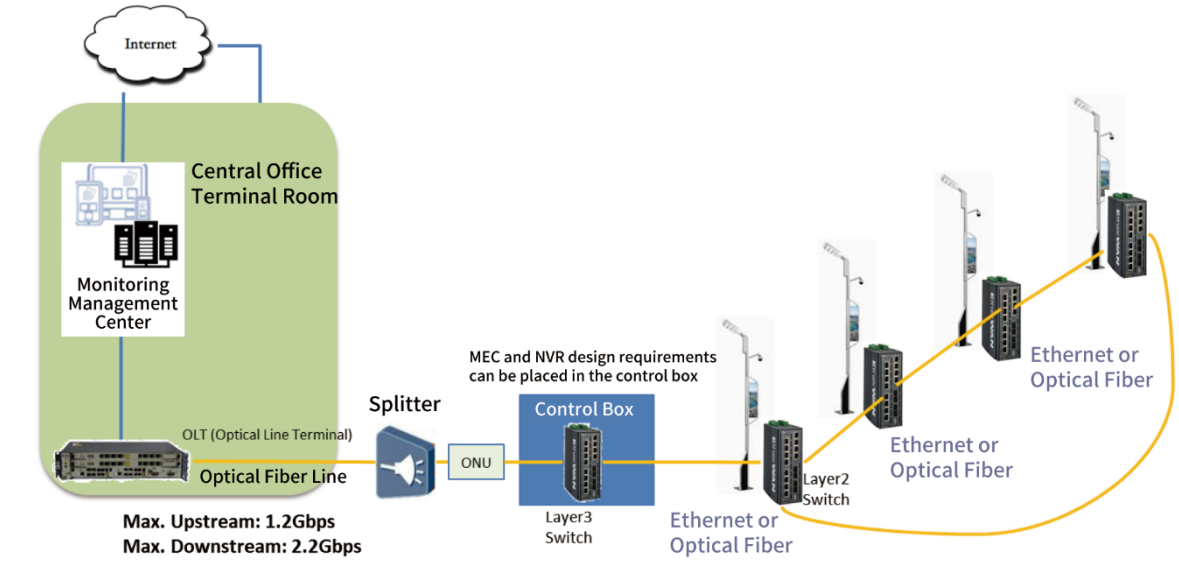
Figure 6.7.7-1 Active DAS Co structured Application Architecture Applied to Sub-6 Band (B)

6.8 Recommended Application Architecture of smart Pole Subsystem

The system architecture of the smart pole is connected by GPON technology. The optical fiber enters the ONU (Optical Network Unit) from the OLT (Optical Line Terminal) of the office computer room through the splitter. The actual application layer Data Rate supports a maximum downlink transmission of 2.2Gbps and a maximum uplink transmission of 1.2Gbps. The optical fiber transferred from ONU corresponds to different scenarios applicable to smart poles, develops different connection methods according to different topology methods, and actually estimates the traffic consumption of each device.

6.8.1 Cascading Architecture – Plan 1

Because it is necessary to place MEC (Multi Access Edge Computing) and NVR or other devices in the control box adjacent to the smart pole according to the use situation of the smart pole design, the reference system architecture is shown in the following figure:



OLT (Optical Line Terminal)
ONU (Optical Network Unit)
MEC (Multi-Access Edge Computing)
NVR (Network Video Recorder)

Figure 6.8.1-1 Cable Cascade Architecture Solution 1 –System Layout

The Ethernet/optical fiber transferred from the ONU (Optical Network Network) is first connected to the switch of layer 3, and then connected to the layer 2 switch on the smart stick in cascading connection mode. Because the design requirements of each county, city and manufacturer are different, the network video recorder (NVR) of multiple access edge computing (MEC - Multi Access Edge Computing) and image monitoring equipment can be connected to the downstream port of the layer 3 switch in the control box. It can also be cut in the way of VLAN with the image monitoring system attached to the next smart pole. In the case of limited traffic, use the characteristics of layer3 switch to arrange the order, and give priority to the attached devices with the highest priority. In addition, edge computing is placed closer to the device on the smart stick, and the delay time is expected to decrease again.

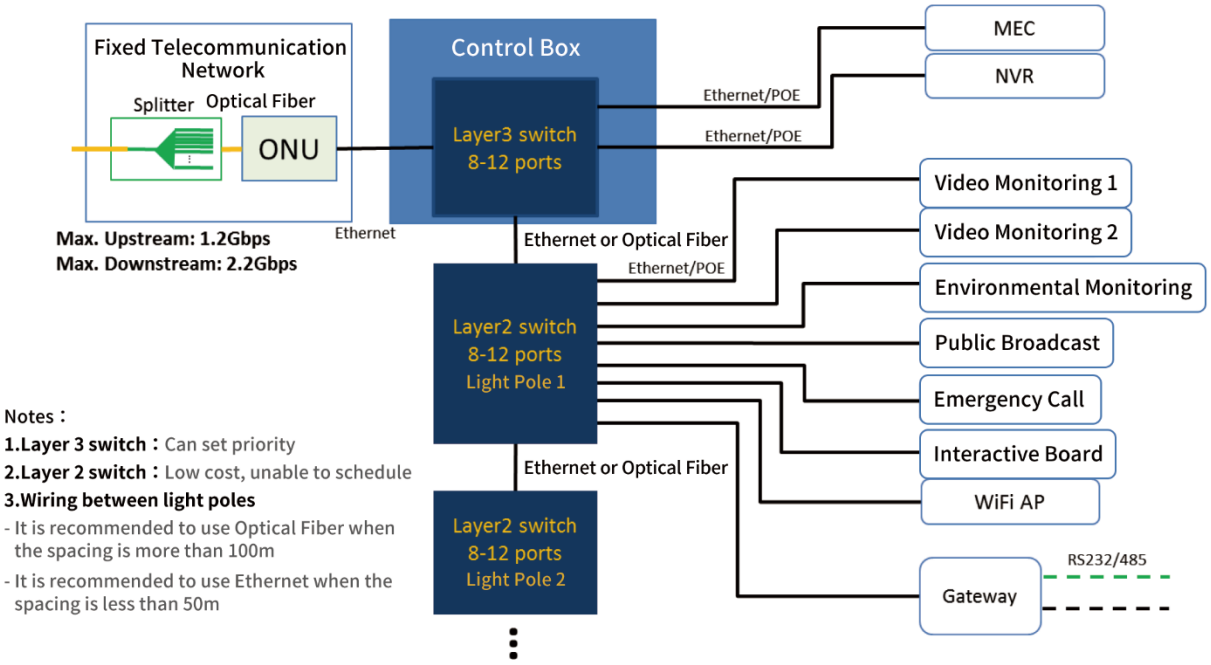


Figure 6.8.1-2 Cable Cascade Architecture Solution 1 – System Architecture

The above figure shows the system architecture preliminarily planned by referring to the use situation of Type 2 smart poles with many use situations. Each smart stick attaches a layer 2 switch, and each layer 2 switch downstream connects to the mount device used in the type 2 scenario. When the interfaces of some attached devices, such as smart lights and traffic signs, are not Ethernet, they can be converted through the gateway or other converters. However, the branch flow of the attached equipment needs to be calculated in detail to prevent overspending.

Situations:

The following wired system architecture can be used in the use situation where optical fibers and cables can be rearranged, such as new towns, re zoned districts, etc.

6.8.2 Cascading Architecture – Plan 2

The design architecture and layout of different counties and cities and manufacturers will be slightly different. The purpose of the specification is to cover multiple design areas rather than single manufacturer and single system architecture. Therefore, another system architecture is provided for reference:

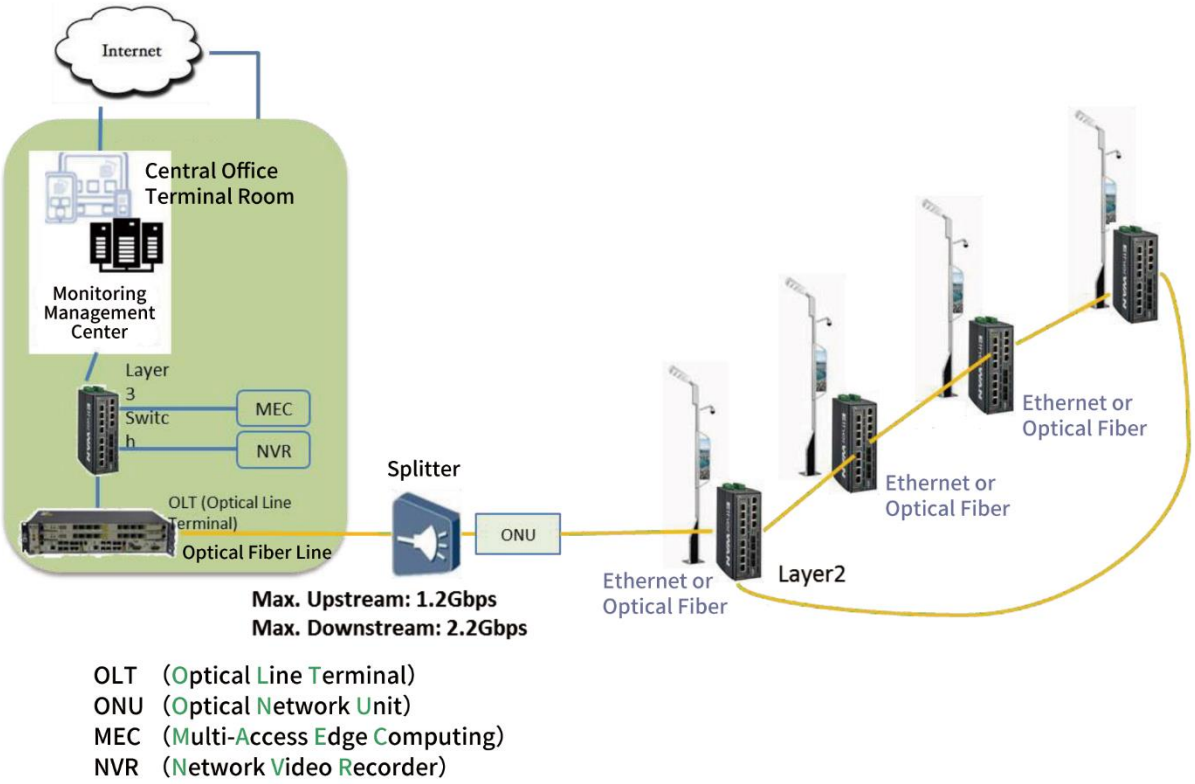


Figure 6.8.2-1 Cable Cascade Architecture Solution 2 – System Layout

Move the Layer 3 Switch and its connected multiple access edge computing (MEC), NVR and other devices to the office machine room. According to this layout, the control box is located outdoors near the smart pole. Although the equipment is covered, the heat dissipation and uncertain environmental factors are investigated, so these equipment are moved to the office end machine room for connection. With the reduction of environmental temperature control and uncertainty factors in the computer room, the system failure rate will also be reduced.

Since the Layer 3 switch has been moved to the office machine room, the optical fiber or Ethernet transferred from the ONU (Optical Network Unit - Optical Network Unit) can be directly connected to the layer 2 switch in the smart stick. Like Solution 1, each attached device needs to estimate the flow to prevent overloading.

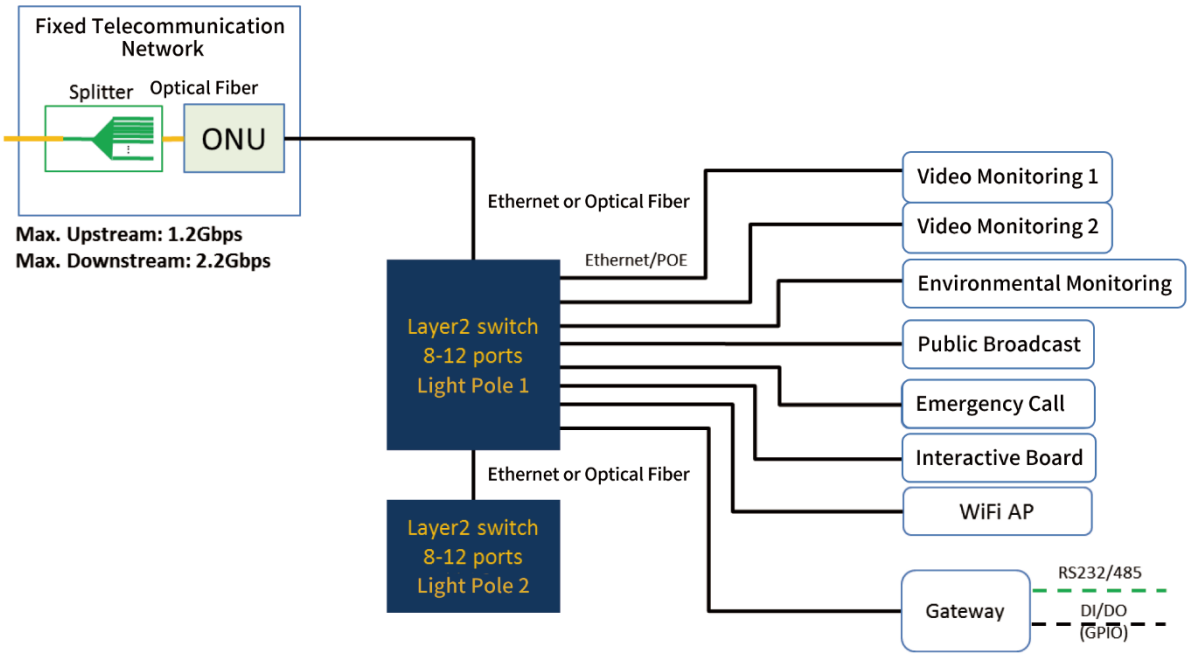


Figure 6.8.2-2 Cable Cascade Architecture Solution 2 – System Architecture

Similar to the system architecture of Solution 1, there is almost no change in the smart stick body, only the layer 3 switch is moved to the office machine room, so it is not covered by this system architecture.

6.8.3 Star Architecture

Considering the different usage scenarios, for example, when the functions of type 4 and type 5 are less, it is not necessary to add Ethernet ports to connect to the mount device. Therefore, the switch can be omitted in the system architecture, and the Ethernet ports transferred from ONU can be directly used to connect to the mount device. Since there are fewer attached devices in this architecture, the traffic distribution is more abundant, but the topology of the connection is different from the above cascade. The star type of topology is adopted. All ONUs are directly connected by optical fibers separated from the splitter. Each ONU is configured in a smart pole, showing a star connection.

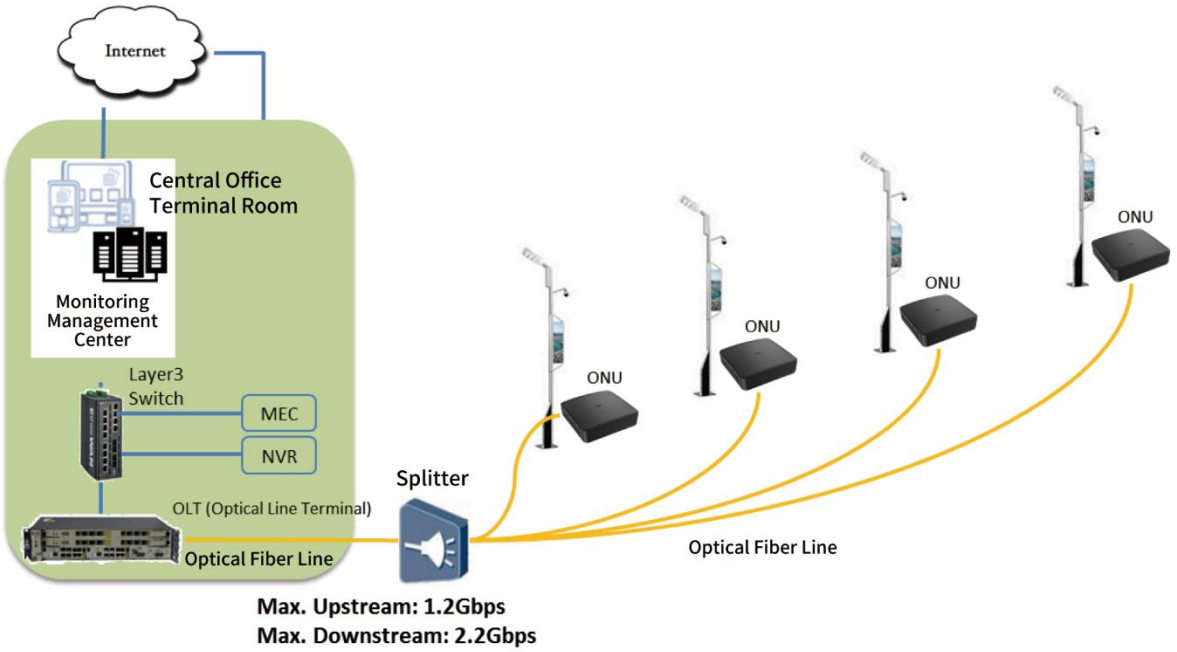


Figure 6.8.3-1 Cable star architecture- system layout

This architecture is relatively simple. If there are few smart poles attached, you can refer to this architecture layout.

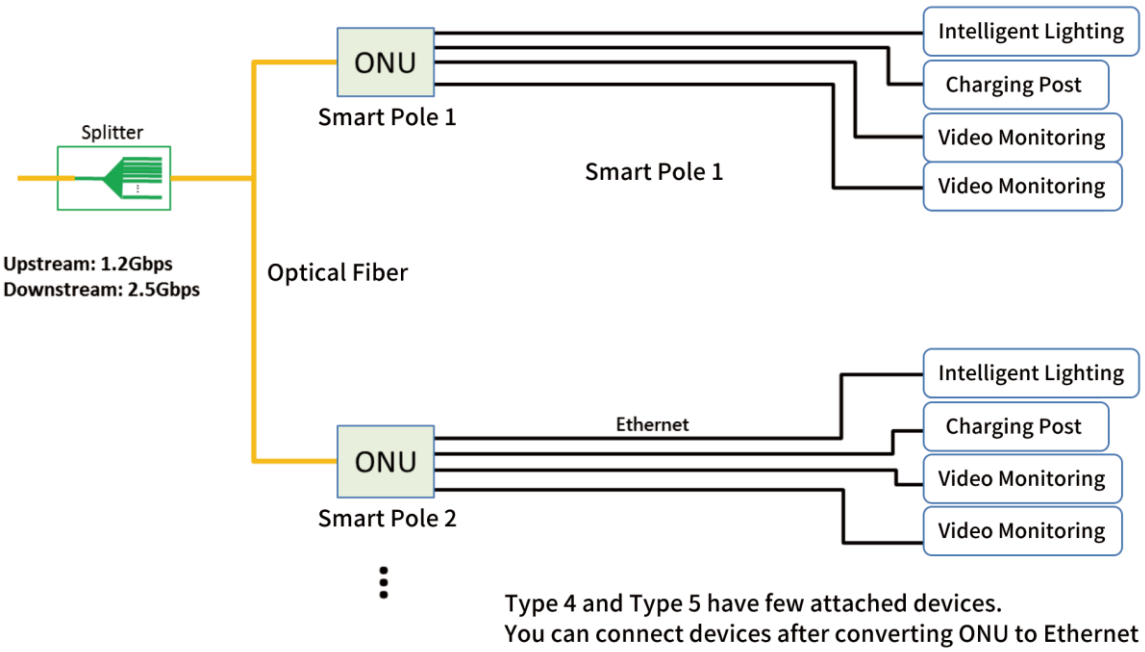


Figure 6.8.3-2 Cable star architecture system architecture

Situation:

This framework is applicable to smart pole erection with simple functions and less attached equipment. The optical fiber line layout is star shaped, and the line layout is flexible, so it is suitable for the construction or layout of a single smart pole in the suburbs or rural areas.

6.8.4 Wireless System Architecture: Customer Front-end Device

Connect to CPE (customer front-end device) through 4G/5G, and connect to the switch in the control box or smart stick after converting to Ethernet. At the same time, more Ethernet, RS485/232, DI/DO (GPIO) and other signals are transferred out, and the surrounding sensing devices such as interactive digital billboards, Wi Fi devices, environmental detection devices, emergency buttons, charging piles, street light signs, public push broadcasts and so on are connected. The 4G/5G transmission path is used to return the information to the base station. The monitoring management platform is online with the base station, and the nuclear network is connected to the network, so that users can connect to the monitoring management platform from the external network for operation. Refer to Figure 6.8.4-1 Wireless Transmission CPE System Layout.

If the equipment attached to the smart stick does not require large transmission volume and continuous transmission, you can refer to this architecture layout. CPE is not recommended because its layout is limited by the flow of the base station.

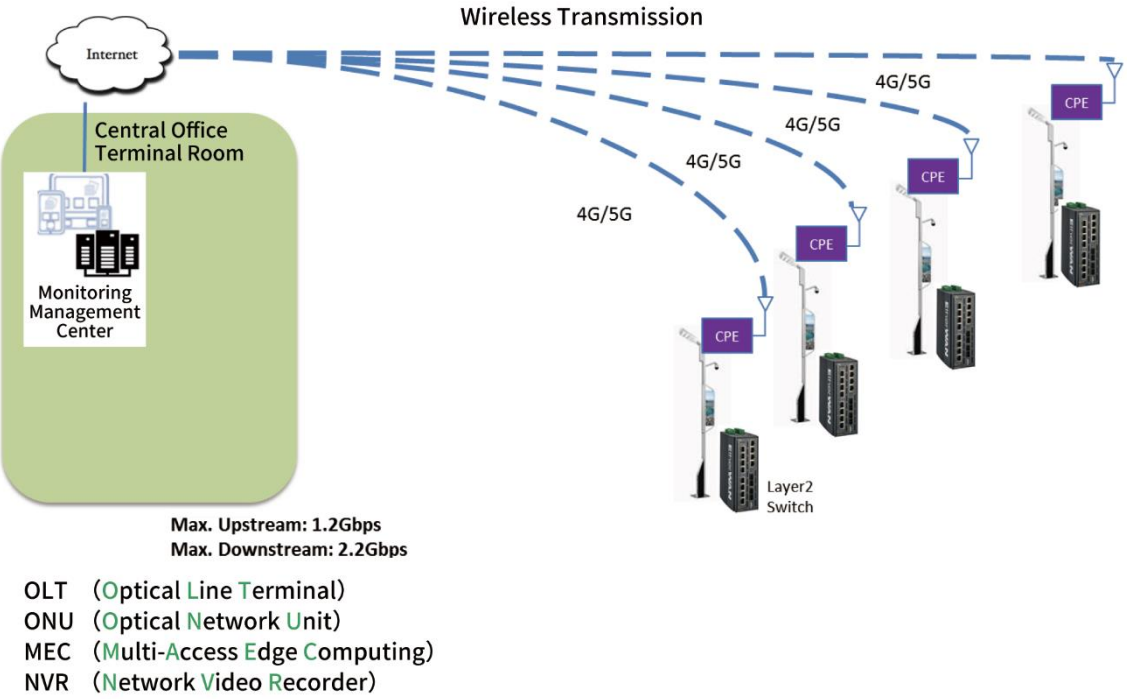


Figure 6.8.4-1 Wireless Transmission CPE Architecture System Layout

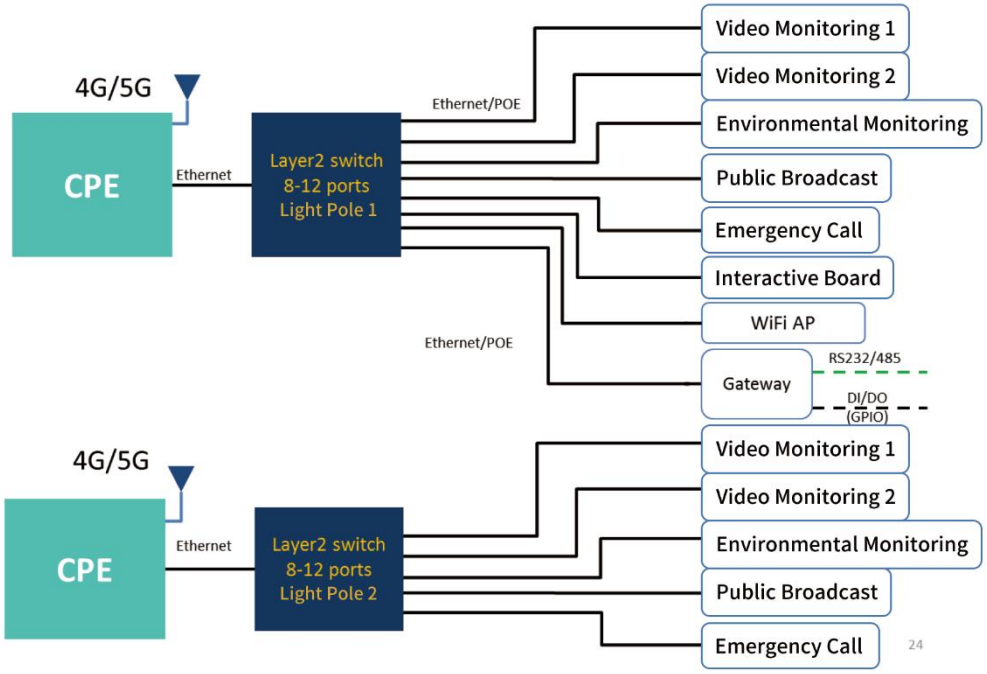


Figure 6.8.4-2 Wireless Transmission CPE Architecture System Layout

Situation:

It is applicable to the layout of smart poles in old urban areas, places of historic interest and other areas where it is inconvenient to pull optical fibers. The signals transferred from the smart poles

are used for equipment communication on the smart poles, not for general public telecommunications services. It is still recommended to use optical fiber and wired connection methods to ensure stability and popularity.

6.8.5 Wireless System Architecture: 802.11AD Point-to-point Wireless Transmission Device

This device realizes point-to-point wireless transmission through 60GHz frequency band, which can replace the deployment of wired optical fiber or Ethernet cable. During the construction, it is necessary to avoid the impact on the transmission quality caused by the shielding of wireless signals between the wireless transmission paths of two 802.11ad devices.

Please refer to the system layout in Fig. 6.8.5-1 and the system architecture in Fig. 6.8.5-2. First, an 802.11ad device is used to exchange data with the wired system through the Ethernet interface, and then the next wireless device is transmitted through the 802.11ad wireless signal. Two 802.11ad devices on the same smart pole can be connected via Ethernet interface for wireless transmission of the next smart pole. At the same time, it exchanges and transmits data with the attached device on the smart stick through the Ethernet interface.

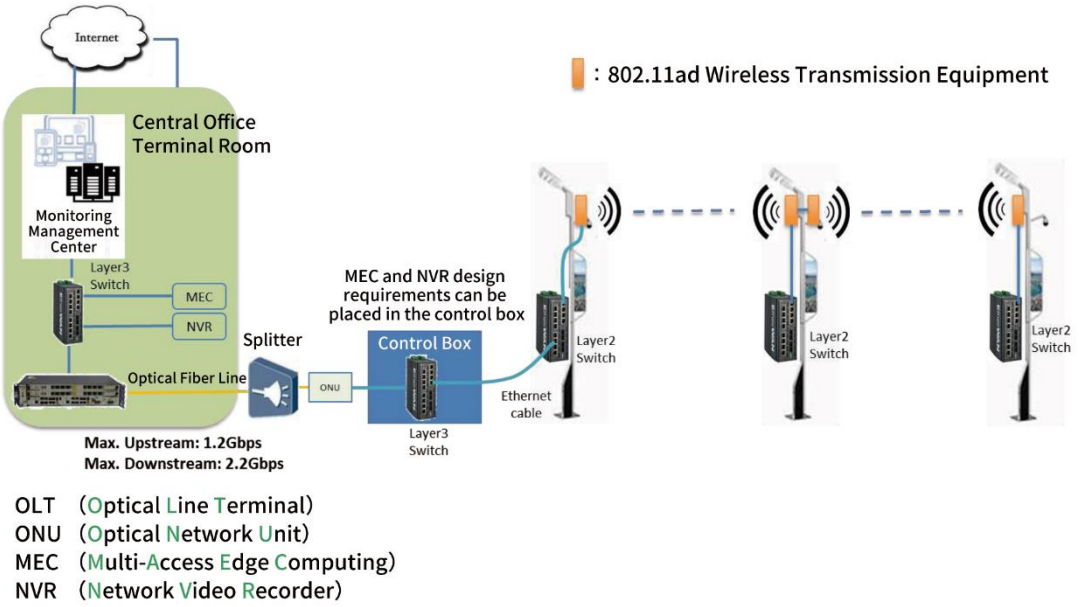


Figure 6.8.5-1 802.11ad Point-to-Point Wireless Transmission Architecture System Layout

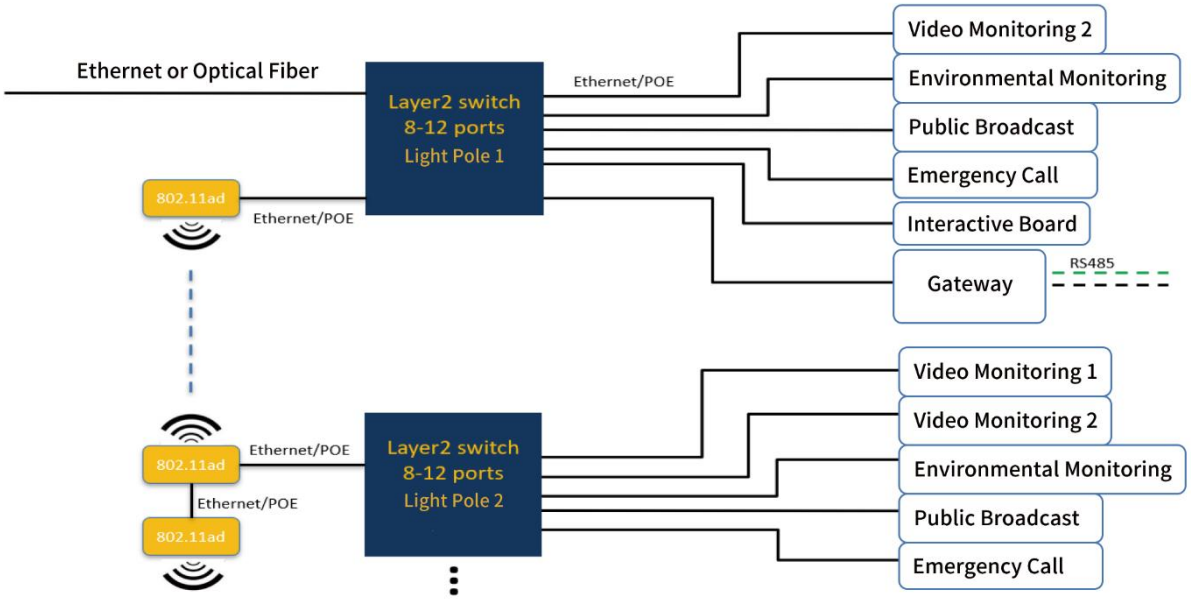


Figure 6.8.5-2 802.11ad Point-to-Point Wireless Transmission Architecture System Layout

Situation:

It is applicable to the layout of smart poles where it is inconvenient to dig the road between poles to lay optical fiber or Ethernet cable, and there should be no shelter between the wireless paths of equipment to block the wireless signal and affect the wireless transmission quality. The transmitted signals are used for communication of devices on smart poles, not for general public telecommunication services

6.8.6 Wireless System Architecture: Low-power WAN

The system architecture of LPWAN takes NB-IOT as an example. The NB-IOT Gateway can be placed on one of the smart poles or in a position close to the smart pole, such as a control box. Each smart pole is equipped with a NB-IOT controller, which connects the Gateway with each NB-IOT controller through a star topology. Refer to Figure 6.8.5-1 LPWAN Gateway System Layout.

After receiving the signal from the NB-IOT base station, the controller on the smart pole will convert to DALI (NEMA connector), RS485 and other interfaces to realize intelligent lighting system, status collection and other functions. When attaching the device to report the collected data content, it will first convert the signal from DALI, RS485 and other signals back to NB-IOT, and then return the information to the base station to the monitoring management platform in a

wireless way. At the same time, connect the core network to the network, so that users can connect to the monitoring management platform from the external network for operation. Refer to Figure 6.8.5-2 LPWAN online system architecture.

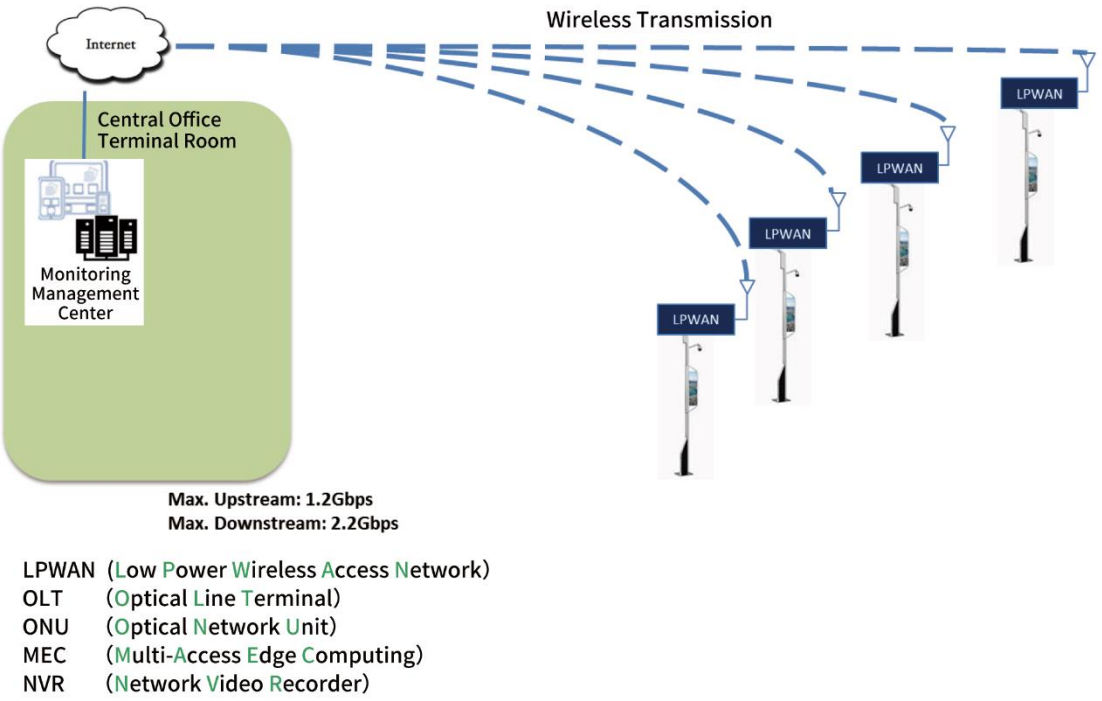


Figure 6.8.6-2 LPWAN Connection System Architecture

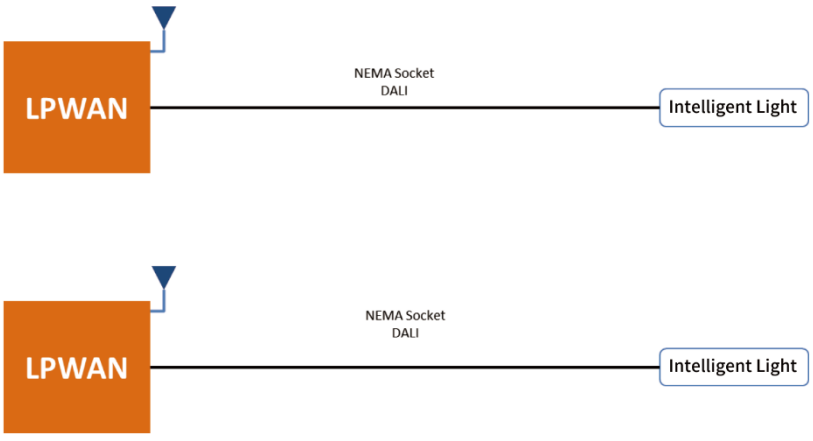


Figure 6.8.6-2 LPWAN Connection System Architecture

Situation:

It is applicable to areas where it is not convenient to pull optical fiber, such as remote mountain areas, and the data transmission rate of intelligent lighting and status reporting functions is low, so LPWAN can be used.

Relevant Gateway can refer to the following specification examples:

Table 6.8.6-1 Example of NB-IoT Gateway Specifications

Category	Spec.
Communication interface	Ethernet (RJ45): 1+ ports NB-IoT RS485, NEMA: 2+ ports
SIM Card (On mini Gateway)	Standard/ micro/ Nano/eSIM
Operation temperature	-20°C ~75°C
Protection grade	IP65
Maximum output power (mini gateway)	14 dBm
Antenna wire specification (mini gateway)	Antenna Efficiency>50%

7. Information Interoperability and Management System (Managed by WG4)

This standard specifies the general requirements for system design, system engineering, system operation management and maintenance of the 5G smart pole system, as well as the composition of design documents.

7.1 System Design

7.1.1 System Composition

The system can be divided into several subsystems, including the Internet of Things subsystem, the pole management subsystem, the user management subsystem, the log subsystem, the operation and maintenance management subsystem, the lighting management subsystem, the environment monitoring subsystem, the multimedia push broadcast subsystem, the energy management subsystem, etc. This chapter defines the core system as the IoT subsystem, the pole management subsystem, the user management subsystem, and the log subsystem.

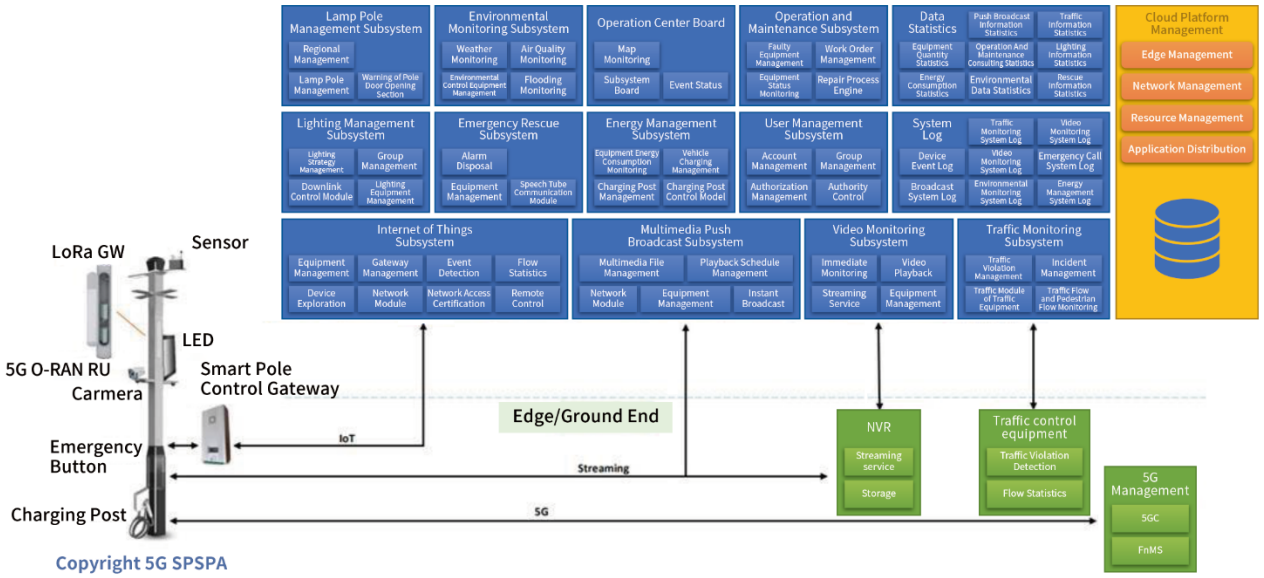


Figure 7.1.1-1 Suggestions on System Architecture of Smart Light Sensing Platform

7.1.2 Multi-functional Smart Poles Management Platform

7.1.2.1 General Requirements

Should meet the following requirements:

(a) It shall support cloud deployment and local deployment.

(b) Distributed architecture design shall be adopted, with flexible expansion and smooth capacity expansion capability.

(c) It shall be able to provide a unified standard API data interface for various application services for third-party platforms to call.

(d) The hierarchical structure design should be adopted. The upper level platform should be able to obtain the business data and management data of the lower level platform through the unified standard API interface.

(e) Modular design should be adopted, and new functions support online upgrading, rollback, and capacity expansion.

(f) The operating system should be Linux or open source system.

7.1.3 Management of Platform Functions

7.1.3.1 Internet of Things Subsystem

The management platform should have following functions:

7.1.3.1.1 Monitoring and Alarm Function

(a) It shall conduct real-time online monitoring on the key data information of the multi-functional smart stick and the status of each attached device, including system status, operation mode, control mode, operation power consumption, environmental conditions, fault alarm, etc.

(b) It shall monitor the alarm information immediately, receive the alarm and fault notification reported by each equipment, and provide the fault alarm level classification function. The fault information shall include the fault information of various monitoring objects and the software and hardware fault information of the monitoring systems at all levels.

(c) It shall have the function of event recording, saving and managing, recording all events (including the opening and closing of various alarms, intercom calls, emergency lighting and other equipment) and saving the related video and audio information of events, so that the administrator can search by events.

(d) The fault alarm information shall be able to notify the relevant responsible person by voice phone, APP push, SMS, email, etc. The control background shall have sound and light alarm function. The administrator can define different fault levels and configure the combined alarm reminder mode (for example, for important alarms, voice phone+ SMS+ mobile APP push+ audible and visual alarm can be used).

(e) The emergency plan can be set, and the intelligent linkage control between the event and the equipment can be automatically implemented through the plan when the event occurs (for example, the one button call equipment can link the camera to record video information, and the linked broadcast equipment can notify the surrounding personnel to rescue in time).

7.1.3.1.2 Control Gateway Management

(a) A filtering search area should be provided to provide control gateway profile filtering and control gateway ID. It only supports searching for strings that fully match: control gateway sorting, adding a control gateway, viewing the details of the control gateway, viewing the location (the location of the control gateway on the map), modifying the control gateway, deleting the control gateway, anchoring the control gateway, clustering the control gateways (the control gateways in close geographical locations are presented in clusters), and zooming the map.

(b) Functions shall include: control gateway identification code, control gateway information (control gateway name, control gateway configuration file, network information, software and hardware version, status and last receiving time), control gateway location, last received radio frequency, device node ID and time. Query the historical data of the control gateway Calendar and time extraction (after clicking "date field", the calendar will appear for the user to select the query date; after clicking "time field", the menu will appear for the user to select the time; after clicking "today" You can quickly filter the data of the day. When visualizing the chart mode, you can extract the date range of single day, multiple days and months. If there is no historical data in the single day option, you cannot select the date. When switching to packet log, only single day historical data is extracted).

(c) There should be historical statistics and charts showing the uplink and downlink data packets of this control gateway. Through the date and time selector, the operator can switch between month, multi day and single day options, and display packet statistics of different time types according to the time range, including the total number of packets received, the number and ratio of good packets displayed, and the number of packets forwarded to the server.

(d) The historical packets of this control gateway should be displayed, and the paging list of single day packet data can be extracted through the date time selector.

(e) Users should be provided with advanced operations on the control gateway, including control gateway backup, version restore, firmware update, restart of the control gateway, and remote RSSH operations on the control gateway.

(f) Control gateway configuration file management should be provided. Different configuration file information can be provided according to different control gateway types. The functions include page display, adding, editing, and deleting.

(g) The data routing function should be provided, which can set and manage the data routing of device packet transmission for different devices and transmit packets to one or more back-end application servers. Functions such as adding, editing, and deleting routing rules are equipped.

(h) It is advisable to provide functions such as adding, editing, and deleting routing rules. The user query function can only query user data below the group to which it belongs. This function is unavailable if there is no user.

7.1.3.1.3 Equipment Management

(a) It is advisable to provide functions such as searching, adding, editing, deleting and other functions, and be able to present two display modes, including geographical location map and table list.

(b) It is advisable to provide functions such as filtering search area, displaying the latest data, adding devices, batch adding devices, device information dialog box, map zooming, device clustering (devices with similar geographical locations are presented in clusters), device anchor, device sorting, viewing information, viewing location, device modification, device deletion, batch deleting device, page number display, etc.

(c) It shall have device identification code, device settings, device information (device related information, including terminal name, connection type, terminal configuration file, network source, program routing, enabling status, new and updated time, updater, and the latest received original packet content and receiving time), display switching (switching packet log, radio frequency, paging function of network management) Calendar and time extraction (the calendar allows the user to select the date and time fields for query, which allows the operator to quickly filter the data of the current day. When switching to packet log, the date range of month and week can be selected), download packet log, device location, and display area.

(d) It is advisable to display the network traffic uplink and downlink data packet query, and provide the administrator with a downlink command setting device.

(e) Device configuration file management should be provided, and device configuration files can be added, modified, deleted, sorted, and viewed.

(f) The devices and equipment associated with the pole body should be managed.

7.1.3.2 Pole Management Subsystem

The management platform can centrally manage and control all multi-functional smart poles and attached devices. It can be compatible with the communication and transmission protocols of the adopted systems and equipment and can realize data exchange with other management platforms.

(a) It should have the management function of organization resources, at least the function of adding, deleting, and modifying organizations. It can add or delete any nodes and equipment and modify the settings and attributes of editing nodes and equipment. Support the test of equipment from different manufacturers for business functions, performance requirements and safety specifications.

(b) It shall have the functions of data acquisition, parameter setting and operation control for the deployment of the pole body and each mounted equipment.

(c) It shall support linkage strategy configuration to realize linkage of front-end sensing devices (such as one button alarm linkage camera, lighting, broadcast, display screen, manhole cover rollover, trash can rollover and overflow linkage camera).

(d) It shall have multiple control modes for various application equipment, such as single control, group control, group control, map area control or condition control.

(e) The access and compatibility of existing systems should be considered, and data exchange, data aggregation or unified presentation with other management platforms and application subsystems should be supported to maximize the protection of existing resources.

(f) It should have the functions of monitoring, querying and positioning the operating state of the pole body and attached equipment, including monitoring the tilt state of the pole.

(g) It should support the unified distribution function of the mounting position of the pole body. It is designed according to the standard mounting positions deployed by different poles, providing unified management and allocation functions for other equipment mounting and optical fiber resources in the future.

(h) It can support full life cycle management and IT support, including asset management, fault demarcation, work order management, assembly and maintenance services, predictive maintenance, online customer service. in production (testable), deployment (inventory), use (installable, installed, deactivated, under repair), and retirement (scrapped, recycled) states.

(i) The management platform design of mobile terminal can be added to facilitate maintenance and supervision by maintenance personnel.

7.1.3.3 User Management Subsystem

The user management subsystem includes account management, authority control and others.

Account management

(a) The system shall take user groups as user groups for management, the user authorities in each group are same.

(b) There are different display interfaces and operation rules according to the user's login permission.

(c) It shall have a unified authentication and authorization management mechanism to conduct dual authentication of identity code and password for visitors.

(d) The permission configuration can be divided into users and roles. Different users can set their roles. The user's priority can be defined, and the user's permission can be authorized, transferred, and canceled online.

Access control

(a) This subsystem shall be able to uniformly control logs, data, etc.: API management shall be provided. All application APIs in the management system can be added, modified, deleted, enabled or disabled. It can also set the default state. When a user group is added, the default state will be used as the permission standard.

(b) There should be rule management to manage the permission rules of user groups. The administrator can disable the API function of some user groups.

(c) Different management permissions and interfaces should be provided according to different role attributes of users. In role permission configuration, functions can be authorized, such as control module permissions, system log viewing permissions, and device broadcast permissions.

7.1.3.4 Log Subsystem

This subsystem shall be able to uniformly control logs, data, etc.:

(a) It shall have complete operation log saving and log management functions to completely record the settings, modifications, data deletion, etc. of the platform management server, various servers and front-end equipment. The log shall not be modified or deleted and shall be kept for at least six months.

(b) It should have unified automatic and manual timing functions to improve the accuracy of equipment management and data acquisition time of each module.

(c) The log should provide at least three categories, including event facilities (system, application, terminal device, control gateway, route, and event level), emergency events (alarm, danger, error, warning, attention, information, and error elimination), groups, and time filtering functions.

7.1.3.5 User Management Subsystem

Operation and maintenance management subsystem includes work order APP, work order system and others.

Work APP

(a) There should be a map function, and you can click the bar icon on the base map to view the bar information (status, installation time, power consumption, address, and city).

(b) It shall have the dashboard function to provide statistical information, such as total energy consumption (kWh), total energy cost, and total data flow in the last seven days and one month. Provide equipment information, including the total number of areas, the number of poles, the number of online normal, the number of offline, the number of under maintenance, and the number of exceptions. Provide the top 10 areas with the largest number of poles. Top 5 poles in terms of electric energy consumption (kWh) in the last seven days, and top 5 poles in terms of data flow in the last seven days.

(c) It shall have the function of bar list and be able to search according to the operator, bar identification code, bar model, status, administrative region, city/postal area number.

(d) The intpoleuction of the pole shall be provided, including the pole model, pole name, WAN IP, installation date, administrative area, voltage/wattage, postal area number, city, address, instant image, environmental information (temperature and humidity, wind speed, PM2.5), and status (water immersion alarm, hatch opening).

(e) A list of pole devices shall be provided, which can be searched according to device type, device name, city/postal area number and status.

(f) A list of pending/new work orders shall be available, and each work order shall contain information such as event name, bar identification code, postal area number, address, latest update time, work order identification code, work order status, event type, executor, agent, supervisor, etc. In addition, it provides the function of assigning a work order to the executor. The reason shall be filled if there is no assignment.

(g) It shall provide work order history, work order details, list of work orders being processed, list of closed work orders, and provide function of reporting work orders.

7.1.4 Platform Performance Requirements

Shall meet the following requirements:

(a) It can support more than 1000 equipment access capabilities and can be expanded to 1 million level access capabilities according to actual needs.

(b) The number of concurrent users should be greater than 1000.

(c) The response delay shall be determined according to the requirements of each application business, and the page response time shall be less than 5s.

(d) The design requirements with strong availability shall be realized to meet 99.9% availability. If some servers or virtual machines of the system fail, the system can still run normally.

7.2 Control Gateway

The control gateway is the data format for connecting the smart pole and peripheral devices with the cloud management platform: the data upload format. The gateway shall be industrial dust-proof, moisture-proof, remote management and easy installation. The control gateway shall have the power, network and other interfaces to provide the operation and networking capabilities of smart poles and peripheral equipment, and the gateway shall be able to provide the transmission protocols required by both the equipment and the control platform. It can automatically or remotely control the lights on and off, monitor the power status and abnormal warning of peripheral equipment, and monitor the temperature in the pole body, environmental meteorology, pollution and other related data with relevant sensors.

7.2.1 Basic Function

7.2.1.1 Lamp Control

The control gateway shall be able to provide the functions of controlling the switch light and adjusting the light source of the streetlight. The control mode shall be divided into automatic control and remote control.

(a) Automatic control: the control gateway itself has the function of automatically controlling the switch light of the road (street) light, such as timing control (setting the switch light schedule), sunrise and sunset schedule (calculating the local actual sunrise and sunset time through longitude and latitude) or illumination control (external light sensor).

(b) Remote control: The control gateway shall provide a control interface for the remote platform to control the street lights in real time, such as REST API. The content fields of the control interface are as follows:

(1) Control Gateway ID

(2) Luminaire equipment No.

(3) Control switch

(4) Brightness ratio

(5) Command downloading time

7.2.1.2 Pole Body Related Equipment Monitoring

The control gateway shall be able to provide the monitoring function of relevant peripheral equipment on the smart pole, and its basic monitoring functions are as follows:

(a) The feedback on the power utilization of each equipment is as follows:

(1) Control Gateway ID

(2) Current power status (on or off)

(3) Current of equipment

(4) Current equipment voltage

(5) Data upload time

(b) Power abnormality warning, which means that the voltage or current exceeds the normal operating range, and the feedback content is as follows:

(1) Control Gateway ID

(2) Current working current

(3) Maximum operating current

(4) Current working voltage

(5) Minimum operating voltage

(6) Maximum operating voltage

(7) Data upload time

7.2.1.3 Pole Body Related Equipment Access

The control gateway shall be able to provide a variety of power and communication interfaces and protocols for the operation and data reception of the peripheral equipment related to the smart stick itself. The control gateway shall basically relate to temperature and humidity sensors, water immersion sensors, air quality monitors and other equipment. If the equipment does not have the function of automatically reporting data, the control gateway shall regularly poll the equipment data and report to upload. For example, the control gateway shall have the function of Modbus Master to poll and upload the current data of Modbus device/slave.

The returned data contents are as follows:

(a) Control Gateway ID

(b) Sensor ID

(c) Temperature (temperature and humidity sensor)

(d) Humidity (temperature and humidity sensor)

(e) Volatile organic compound concentration (air quality monitor)

(f) PM2.5 concentration (air quality monitor)

(g) Water immersion status (yes/no) (water immersion sensor)

The control gateway shall provide the function of querying the current status of the communication interface. The query feedback are as follows:

(a) Control Gateway ID

(b) Communication interface identification code

(c) Communication interface status (online or disconnected)

(d) Query feedback time

The control gateway shall upload the flow statistics of the communication interface regularly. The feedback data contents are as follows:

(a) Control Gateway ID

(a) Communication interface identification code

(b) Upstream flow

(c) Downlink flow

(d) Query feedback time

If the lighting equipment is connected, the smart gateway shall provide the lighting status query interface. The query returned contents are as follows:

(a) Control Gateway ID

(b) Luminaire equipment No

(c) Current status (on or off)

(d) Brightness when on

(e) Query feedback time

7.2.1.4 Remote Management

The control gateway shall provide API instruction set for remote management platform query, setting, control, firmware update and other operation and maintenance management functions.

(a) The query command should feedback the following data:
   (1) Control Gateway ID
   (2) IP setting mode (dynamic/static)
   (3) IP address/subnet mask/default gateway address/primary DNS address/secondary DNS address
   (4) Firmware version
   (5) System start up time
   (6) Data upload time

(b) The setting instruction are as follows:
   (1) Control Gateway ID
   (2) IP setting mode (dynamic/static)
   (3) IP address/subnet mask/default gateway address/primary DNS address/secondary DNS address

(c) The control instructions are as follows:
   (1) Control Gateway ID
   (2) Control command (firmware update/restart/restore factory default)
   (3) Command downloading time

7.2.1.5 Safety Protection

The control gateway shall be capable of detecting and warning the intrusion of the smart pole cover opening, the inclination of the pole body or the flooding.

The alarm message is as follows:

(a) Control Gateway ID
(b) Alarm type (box open/pole tilt/immersion/abnormal temperature/humidity)
(c) Sensor ID
(d) Sensor data
(e) Alarm time

7.2.1.6 Data Transmission

The control gateway shall have the function of data exchange and network gateway, which enables the pole equipment and cloud management platform to communicate with each other and collect data and remote control.

(a) IP network gateway: It has the general IP gateway function. The WAN terminal can access the private network or the public network through the fixed IP, DHCP or PPPoE set in the Ethernet or optical network, and has the functions of network address translation (NAT), intranet penetration (Port Forwarding), data encryption.
(b) Internet of Things bridge: provides the common protocols for general industrial and near end low-power Internet of Things devices as the channel for peripheral devices to access and receive data, such as RS485/Modbus, Zigbee or BLE.
(c) Data exchange: A common language used between the controller and the cloud management platform needs to be defined as the basis for communication and data exchange between peripheral devices, control gateways and cloud management platforms. JSON/XML structured data commonly used in the industry can be used to represent network information, control gateway information and commands, peripheral device information and commands and others. The data contents are as follows:

(1) Light control command content (downlink)

Key/Tag	Value	Unit	Notes
gw_id	string	N/A	Control Gateway ID code
device_id	string	N/A	Luminaire device No.

switch	bool	N/A	Light switch. 1: On; 0: Off
level	int	percent	The value of the regulator, expressed as a percentage.
time	string	N/A	Message UTC time. Example: 2020-07-0T05:50:00Z

(2) Monitoring content of pole equipment (upstream)

– Equipment power status

Key/Tag	Value	Unit	Notes
gw_id	string	N/A	Control Gateway ID code
power_id	int	N/A	Power circuit ID code
power_status	bool	N/A	Power circuit status. 1: On; 0: Off
now_current	int	Ampere	Current working current
now_voltage	int	Voltage	Current working voltage
time	string	N/A	Message UTC time. Example: 2020-07-0T05:50:00Z

– Equipment power abnormal warning

Key/Tag	Value	Unit	Notes
gw_id	string	N/A	Control Gateway ID code
power_id	int	N/A	Power circuit ID code
now_current	int	Ampere	Current working current
max_current	int	Ampere	Maximum working current
now_voltage	int	Voltage	Current working voltage
max_voltage	int	Voltage	Maximum working voltage
min_voltage	int	Voltage	Minimum working voltage
time	string	N/A	Message UTC time. Example: 2020-07-0T05:50:00Z

(3) Pole device data content (upstream)

– Data content of temperature and humidity sensor, water immersion sensor and air quality monitor

Key/Tag	Value	Unit	Notes
gw_id	string	N/A	Control Gateway ID code
device_id	string	N/A	Sensor device ID code
temperature	int	N/A	Temperature
temp_unit	int	N/A	Temperature units. 1-Kjeldahl (K); 2 - Celsius (° C); 3 - Fahrenheit (° F)
humidity	int	percent	Humidity
tvoc	int	ppm	Volatile organic compound concentration
pm25	int	ppm	PM2.5 concentration
soak	bool	N/A	Water immersion state
shock	int	mm/s	Vibration
time	string	N/A	Message UTC time. Example: 2020-07-0T05:50:00Z

– Current status query of communication interface

Key/Tag	Value	Unit	Notes
gw_id	string	N/A	Control Gateway ID code
iface_id	int	N/A	Communication interface ID code
link_status	bool	N/A	Communication interface status. 1: Connection; 0: Disconnection
time	string	N/A	Message UTC time. Example: 2020-07-0T05:50:00Z

– Communication interface data flow statistics

Key/Tag	Value	Unit	Notes
gw_id	string	N/A	Control Gateway ID code
iface_id	int	N/A	Communication interface ID code
in_octets	uint	bytes	Upstream data flow
out_octets	uint	bytes	Downlink data flow
time	string	N/A	Message UTC time. Example: 2020-07-0T05:50:00Z

– Light status query feedback

Key/Tag	Value	Unit	Notes
gw_id	string	N/A	Control Gateway ID code
device_id	string	N/A	Luminaire device No.
status	bool	N/A	Current status. 1: On; 0: Off
level	int	percent	When the luminaire is turned on, the value of the regulator, expressed as a percentage.
time	string	N/A	Message UTC time. Example: 2020-07-0T05:50:00Z

(4) Remote management command content

– Query instruction reply content (upstream)

Key/Tag	Value	Unit	Notes
gw_id	string	N/A	Control Gateway ID code
conn_type	int	N/A	IP address type; 1 – dynamic； 2 – static
ip	string	N/A	IP address
mask	string	N/A	Subnet Mask
gateway	string	N/A	Preset gateway IP address
1st_dns	string	N/A	Primary DNS IP address
2nd_dns	string	N/A	Secondary DNS IP address
fw_version	string	N/A	Firmware version No.
uptime	string	N/A	Start-up time UTC time format - "2020-07-20T05:50:00Z"
time	string	N/A	Message UTC time. Example: 2020-07- 0T05:50:00Z

– Set instruction content (downlink)

Key/Tag	Value	Unit	Notes
gw_id	string	N/A	Control Gateway ID code
conn_type	int	N/A	IP address type; 1 – dynamic； 2 – static
ip	string	N/A	IP address
mask	string	N/A	Subnet Mask
gateway	string	N/A	Preset gateway IP address
1st_dns	string	N/A	Primary DNS IP address
2nd_dns	string	N/A	Secondary DNS IP address
time	string	N/A	Message UTC time. Example: 2020-07-0T05:50:00Z

Note: conn_ When the type is 2, there is ip/mask/gateway/1st_ dns/2nd_ Dns and other field information.

– Set instruction content (downlink)

Key/Tag	Value	Unit	Notes
gw_id	string	N/A	Control Gateway ID code
cmd	int	N/A	1 - Firmware renewal; 2 - Restart; 3 - Restore preset values
exec_time	string	N/A	UTC time of instruction execution. Example: 2020-07-20T05:50:00Z
time	string	N/A	Message UTC time. Example: 2020-07-0T05:50:00Z

(5) Security protection alarm message content (upstream)

Key/Tag	Value	Unit	Notes
gw_id	string	N/A	Control Gateway ID code
alarm_type	int	N/A	1 - Vibration; 2-tilt; 3 - Immersion; 4 - Abnormal temperature; 5 - Abnormal humidity

device_id	string	N/A	Sensor device ID code
device_value	string	N/A	Perceptron data in case of exception, including unit.
time	string	N/A	Alarm UTC time. Example: 2020-07-20T05:50:00Z

7.2.2 Fundamental Interfaces

7.2.2.1 Status Display

The control gateway shall provide basic LED lights or screens to display the operation status of the control gateway, such as power on and abnormality.

7.2.2.2 Power Interface

The control gateway shall provide array AC (110VAC) and DC (12/24VDC) output interfaces for the operation of various peripheral equipment.

7.2.2.3 Ethernet

The control gateway shall provide the function of multi-port 1G POE switch, which can not only support the operation of POE power supply equipment, but also provide network access channels for using related equipment, such as IP Camera and advertising push screen.

7.2.2.4 Optical Fiber Network

The control gateway shall provide an optical fiber port as one of the backbone networks of the smart pole.

7.2.2.5 RS485

The control gateway can provide a set of RS485/RS232 connection interfaces, which are commonly used data transmission interfaces for industrial IoT sensors, and can connect several peripheral devices or sensors in series.

7.3 Communication Protocol

In order to unify the protocol standards of communication and data transmission between hardware equipment and software platform, and ensure consistent communication interface and data outline. This chapter establishes design specifications for pole equipment, subsystems and

edge service communication on the smart pole platform.

7.3.1 Pole equipment Communication

The pole equipment is a hardware device installed on the smart light pole, which will periodically report the sensing data and its own status to the management platform (such as temperature and humidity sensor, water level gauge, LED display screen, IP Camera, air quality monitor). In order to achieve the purpose of plug and play, the data transmission mode and content of pole equipment and management platform need to have a unified standard. According to the communication direction between the device and the platform, it can be divided into uplink data and downlink instructions, and then subdivided into communication mode and data outline.

7.3.1.1 Uplink Data

Equipment status and perception data, such as power, operation status, temperature and humidity, and others.

(a) Communication mode: the uplink data communication mode from the pole equipment to the management platform. According to the number of communication nodes, two-layer communication architecture and three-layer communication architecture can be distinguished.
   (1) Double layer communication architecture: the pole equipment and the management platform communicate directly according to the addressing and routing mode of the network (IP) layer. For example, through WiFi network, Ethernet network, LTE network and 5G network, it belongs to a two-layer communication architecture, and the communication mode can follow the media network communication protocol.
   (2) Three-layer communication architecture: the pole equipment transmits data to the management platform through the network relay equipment (gateway/control gateway). If the pole equipment and relay equipment transmit data at the data connection layer (MAC) level, such as LoRa network, Bluetooth network, etc., the pole equipment shall follow the upstream communication protocol of the media network for data encapsulation and transmission. For the communication mode from the network relay equipment to the management platform, follow the established communication protocol of the network (IP) layer.

(b) Data outline: data exchange is presented in a structured way, such as JSON/XML.

(c) Uplink data: the structured information that the device transmits data to the platform. The

example is as follows.

```
<?xml version="1.0" encoding="UTF-8"?>
<DeviceID_uplink>
 <Time>2015-07-09T16:06:38.49+02:00</Time> // Timestamp for the packet
 <DeviceID>00000000007E074F</DeviceID>
 <FCntUp>11</FCntUp> // The uplink counter for this packet
 <FCntDn>0</FCntDn> // The last downlink counter to the device
 <payload_hex>0027…bd00</payload_hex> // payload in hexa ascii format
 <PlatformID>00000065</PlatformID>
 <ControlGatewayID>08040059</ControlGatewayID>
 <Battery>187</Battery> // Battery level
</DeviceID_uplink>
```

7.3.1.2 Downlink Instruction

The control command sent to the device from the management platform.

(a) Communication mode: the downlink command communication mode from the management platform to the pole equipment. According to the number of communication nodes, two-layer communication architecture and three-layer communication architecture can be distinguished.

   (1) Double-layer communication architecture: the management platform and pole equipment give instructions to devices according to the IP layer addressing and routing methods.

   (2) Three-layer communication architecture: the communication mode from the management platform to the network relay equipment (gateway/control gateway) should follow the established communication protocol of the network (IP) layer. Network relay equipment and pole equipment, such as LoRa network and Bluetooth network, transmit data at the data connection layer (MAC) level. The pole equipment shall follow the downlink communication protocol of the media network to receive and respond to downlink commands.

(b) Data outline: data exchange is presented in a structured way, such as JSON/XML.

(c) Downlink data: The platform downlink command is sent to the device. The example is as follow.

```
curl -H "Content-type:application/x-www-form-urlencoded" -X POST
"https://domainname/lrc/rest/downlink?DeviceID=000000000F1D8
```

693&Payload=01020304050607080 90A"

7.4 Subsystem Communication

The intelligent light pole management platform consists of many subsystems. Subsystem is responsible for managing its own system resources, which are isolated from each other and operate independently. In order to enable different subsystems to access resources and coordinate work with each other, subsystems also need to communicate to each other.

7.4.1 Communication Mode

Since the purpose of communication can be divided into active resource request and passive status notification, the subsystem communication should have synchronous and asynchronous communication methods at the same time.

(a) Synchronous communication: Synchronous communication is generally used for active resource request and requires the receiver to make timely resource response. The common implementation method is Webhook (REST API).

(b) Asynchronous communication: asynchronous communication is generally used for non-timely message notification. The common method is message queue

7.4.2 Data Outline

Data exchange is presented in a structured way, such as JSON/XML.

7.4.3 Information Exchange

Standardize the general data provided by the core/subsystem for other subsystems or upper integration platform. The data are system ID, system name, system version, system status, and system update time. The following is an example of API.

POST **{host-domain}**/smartpole/api/v1/systeminfo

Input Property	Value	Description	Notes
Required Parameters in body (form-data)			
sys_id	Integer	System ID	sys_id

Example

```
{
  sys_id:1 //
}
```

Output JSON	Type	Description	Notes
data	**Array**		
sys_name	String	System name	
sys_version	String	System version	
sys_status	String	System status	
sys_updatetime	DateTime	System updateTime	

Example (success)

```
{
  "data": [
    {
      "sys_name": “照明管理子系統,”
      "sys_version": "v2.0",
      "sys_status": "在線",
      "sys_updatetime": 2020-11-05 20:29:36,
    }
  ],
}
```

Example (error)

```
{
  "error": "format illegal"
}
```

Response Code	Status	Notes
200	OK	Success
400	Bad Request	Input error
500	Internal Server Error	Operation is failed

The specifications of different cores/subsystems shall provide the minimum business data for use by other subsystems or upper integration platforms.

a) Core system

The core system mainly monitors the health status, power consumption and flow of the pole body. Such as abnormal pole temperature, pole immersion, pole impact, abnormal lamps, and control gateway status.

Field name	Chinese explanation	Date type	Format	Note
samrtpole_id	智慧杆識別碼	String	N/A	
smartpole_name	智慧杆名稱	String	N/A	
smartpole_address	智慧杆地址	String	N/A	
smartpole_latitude	智慧杆緯度(WGS84)	Value	N/A	
smartpole_longitude	智慧杆經度(WGS84)	Value	N/A	
light_id	燈具設備識別碼	String	N/A	
light_name	燈具設備名稱	String	N/A	
light_state	燈具設備狀態	Value	N/A	1:ON 0:OFF
light_brightness	燈具設備明亮度	Value	N/A	
light_consumption	燈具設備用電量	Value	N/A	
light_in_octets	燈具設備上行數據流量	Value	N/A	
light_out_octets	燈具設備下行數據流量	Value	N/A	
light_datetime	燈具設備日期時間	String	N/A	
control_gateway_id	控制閘道器編號	String	N/A	
control_gateway_name	控制閘道器名稱	String	N/A	
control_gateway_info	控制閘道器資訊(e.g., 韌體版本、型號、通信技術)	json	N/A	
control_gateway_state	控制閘道器狀態 (e.g., 在線、離線)	String	N/A	
control_gateway_in_octets	上行數據流量	Value	N/A	
control_gateway_out_octets	下行數據流量	Value	N/A	
control_gateway_electricity	控制閘道器電力統計資訊(e.g., 電流、電壓、電量、安培)	json	N/A	
control_gateway_datetime	控制閘道器日期時間	String	N/A	
temperature_sensor_id	溫度傳感器識別碼	String	N/A	
temperature_sensor_interface	溫度傳感器通信介面	String	N/A	
temperature_sensor_state	溫度傳感器狀態	Value	N/A	
temperature_sensor_data	溫度傳感器資料	Value	N/A	
temperature_sensor_consumption	溫度傳感器用電量	Value	N/A	
temperature_sensor_in_octets	溫度傳感器上行數據流量	Value	N/A	
temperature_sensor_out_octets	溫度傳感器下行數據流量	Value	N/A	
temperature_sensor_datetime	溫度傳感器日期時間	String	N/A	
water_sensor_id	水浸傳感器識別碼	String	N/A	
water_sensor_interface	水浸傳感器通信介面	String	N/A	

water_sensor_state	水浸傳感器狀態	Value	N/A	
water_sensor_data	水浸傳感器資料	Value	N/A	
water_sensor_consumption	水浸傳感器用電量	Value	N/A	
water_sensor_in_octets	水浸傳感器上行數據流量	Value	N/A	
water_sensor_out_octets	水浸傳感器下行數據流量	Value	N/A	
water_sensor_datetime	水浸傳感器日期時間	String	N/A	
vibration_sensor_id	震動傳感器識別碼	String	N/A	
vibration_sensor_interface	震動傳感器通信介面	String	N/A	
vibration_sensor_state	震動傳感器狀態	Value	N/A	
vibration_sensor_data	震動傳感器資料	Value	N/A	
vibration_sensor_consumption	震動傳感器用電量	Value	N/A	
vibration_sensor_in_octets	震動傳感器上行數據流量	Value	N/A	
vibration_sensor_out_octets	震動傳感器下行數據流量	Value	N/A	
vibration_sensor_datetime	震動傳感器日期時間	String	N/A	
door_sensor_id	開門傳感器識別碼	String	N/A	
door_sensor_interface	開門傳感器通信介面	String	N/A	
door_sensor_state	開門傳感器狀態	Value	N/A	
door_sensor_data	開門傳感器資料	Value	N/A	
door_sensor_consumption	開門傳感器用電量	Value	N/A	
door_sensor_in_octets	開門傳感器上行數據流量	Value	N/A	
door_sensor_out_octets	開門傳感器下行數據流量	Value	N/A	
door_sensor_datetime	開門傳感器日期時間	String	N/A	

b) Video monitoring and security

Field name	Chinese explanation	Date type	Type	Format	Note
control_gateway_id	控制閘道器識別碼	String	Required		
device_id	影像監控安防設備編號	String	Required		
datetime	訊息日期時間	String	Required	ISO 8601 format, example : 2020-07-20T05:50:00Z	
power_status	電源迴路狀態	Boolean	Required	1:ON;0:OFF	
camera_type	監視器型式	String	Optional		

c) Advertising Push Subsystem

Field name	Chinese explanation	Date type	Type	Format	Note
control_gateway_id	控制閘道器識別碼	String	Required		

device_id	廣告推播設備編號	String	Required		
datetime	訊息日期時間	String	Required	ISO 8601 format, example : 2020-07-20T05:50:00Z	
power_status	電源迴路狀態	Boolean	Required	1:ON;0:OFF	

d) 充電樁子系統 Charging post subsystem

Field name	Chinese explanation	Date type	Type	Format	Note
control_gateway_id	控制閘道器識別碼	String	Required		
device_id	燈具設備編號	String	Required		
datetime	訊息日期時間	String	Required	ISO 8601 format, example : 2020-07-20T05:50:00Z	
power_status	電源迴路狀態	Boolean	Required	1:ON;0:OFF	
usage_status	車輛充電狀態	String	Optional	Charging, full, not used	
charging_power	充電功率	String	Optional	KW	
charging_current	充電電流	String	Optional		
charging_voltage	充電電壓	String	Optional		
charge_stime	開始充電時間	String	Optional	[yyyyMMddHHmmss]	There is value during charging
charge_etime	車輛充電狀態	String	Optional	[yyyyMMddHHmmss]	There is value during charging

e) Emergency call system

Field name	Chinese explanation	Date type	Type	Format	Note
control_gateway_id	控制閘道器識別碼	String	Required		
device_id	緊急呼救設備編號	String	Required		
datetime	訊息日期時間	String	Required	ISO 8601 format, example： 2020-07-20T05:50:00Z	
power_status	電源迴路狀態	Boolean	Required	1:ON;0:OFF	
alarm_status	緊急呼救狀態	String	Optional	ON/OFF	
alarm_time	緊急呼救時間	String	Optional	ISO 8601 format, example： 2020-07-20T05:50:00Z	

f) Edge computing

Field name	Chinese explanation	Date type	Type	Format	Note
control_gateway_id	控制閘道器識別碼	String	Required		
device_id	邊緣運算設備編號	String	Required		
datetime	訊息日期時間	String	Required	ISO 8601 format example 、 2020-07-20T05:50:00Z	
power_status	電源迴路狀態	Boolean	Required	1:ON； 0:OFF	
system_config_hw	系統硬體規格	String	Optional		CPU, GPU, Memory, ...
system_config_sw	系統軟體規格	String	Optional		OS, version,...
system_usage	系統使用量	String	Optional		CPU, MEMORY, STORAGE...
gpio_dir_num	gpio in out 狀態	Boolean	Optional		
gpio_val_num	gpio high low狀態	Boolean	Optional		
cpuTempCelsius	cpu溫度	Value	Optional	˚C	
mbTempCelsius	主機板溫度	Value	Optional	˚C	
cpuFan1Speed	CPU風扇	Value	Optional	rpm	
chaFan1Speed	系統風扇	Value	Optional	rpm	
power3Voltage	3.3V	Value	Optional	V	
power3vsbVoltage	3.3Vsb	Value	Optional	V	
vbatVoltage	電池電壓	Value	Optional	V	

power5Voltage	5V	Value	Optional	V	
vcoreVoltage	核心電壓	Value	Optional	V	
vccmVoltage	記憶體電壓	Value	Optional	V	
DC in Voltage	DC IN 電壓	Value	Optional	V	

7.5 Interaction Between Edge Services and Cloud Services

Edge operation is to process the largest amount of data in the shortest delay time. The result of the operation is the resource of the edge service, so the communication protocol of the edge service covers the resource management, cloud communication, remote deployment, data format and other specifications.

7.5.1 Resource Management

As a part of the Linux Foundation, the Cloud Native Computing Foundation (CNCF) is promoting the collection of Cloud Native Technology (CNT), which enables organizations to build and run scalable applications in edge and cloud computing environments. It advocates the use of software containers, service grid management, microservices, immutable infrastructure and declarative application interfaces to illustrate the methods of implementing dynamic application EN programs and service management.

7.5.1.1 Software Containerization, Registration and Distribution

All software running on edge and cloud computing platforms should be containerized according to the following specifications:

(a) Specification: Open Container Initiative (OCI) image and execution environment standard
(b) Package format: Cloud native application package v1 (CNAB 1)
(c) Container execution environment: implementation reference of OCI execution environment, runc,
(d) Container execution environment interface (CRI): Kubernetes CRI or containerization (v.1.1) for OCI compatible execution environment, new Docker container execution environment

7.5.1.2 Continuous Integration/Continuous Delivery

Continuous Integration/Continuous Delivery or Deployment (CI/CD) performs automation and monitoring throughout the application lifecycle (from consolidation and testing to delivery and deployment). Argo based on GitOps is a container continuous delivery tool recommended by CNCF to Kubernetes choreographers.

7.5.1.3 Software Container Management and Programming

Software container management and programming are mainly responsible for managing the life cycle of software containers, including but not limited to: opening and deploying software containers, maintaining the availability of software containers, scaling or removing software containers in the infrastructure to evenly distribute computing pressure, transferring software containers to different nodes, allocating resources between software containers, exposing services in software containers Load balancing, monitoring the status of software containers and local devices, and setting software settings in software containers. The following are common software container management and programming platforms.

Kubernetes (also known as K8s) is a leading management and programming platform in the market, which is used for the deployment, arrangement and operation of automatic execution application containers across host clusters. Kubernetes, originally developed by Google, is the basis of the CNCF software architecture and can be used to orchestrate software running in edge and cloud computing environments.

7.5.2 Remote Deployment

In distributed edge cloud computing systems such as smart poles, hackers often use software updates as an attack method. Therefore, the system must be protected by powerful encryption functions (such as digital signature) to prove the authenticity and integrity of software objects, and the security software distribution infrastructure with security update agreements, trusted notaries and protection logins is used to deal with various online attacks. The following sections describe each component in this infrastructure.

7.5.2.1 Software Update Security Specification

The software update security specification (TUF) under the current CNCF specification is a set of encryption functions, file formats and standard operating procedures used to

automatically identify software updates and securely download them. There is also a different version of the software update security specification called Uptane, which is also widely used to implement secure wireless (OTA) software updates in the automotive industry.

The purpose of TUF is to meet the updating requirements of various software, including system software, application software and software library. It implements verifiable records that track the state of software objects by creating digital signature metadata that includes the hash value of the software, the identity of the signature key, and the expiration time of the metadata record. Using these explanatory materials, TUF can identify necessary software updates, download them and check their effectiveness without the intervention of the main system.

7.5.2.2 Software Notarization

Software notarization is the current specification used by CNCF to verify the authenticity and integrity of software objects. Notaries, like trusted third parties, authenticate software objects by attaching their digital signatures to the hashes and annotations of these objects. Consumers can download these objects and verify their authenticity and integrity by using the public key of the notary to check the additional digital signatures. Notary is a seamless operation of software verification and system update completely combined with TUF.

7.5.2.3 Software Registry File

As the third component of the software update infrastructure, the software log file is a repository or collection of repositories used to store validated software objects and make them available for download. In the CNCF context, container logins are the registry files for Kubernetes, DevOps, and container based application development. Harbor 2.0 is currently the first open source login center that conforms to the Open Container Initiative (OCI). It provides complete cloud native support for container images through a variety of architectures (including Docker, CNAB and OPA). In addition to its operation as a software repository, Harbor 2.0 also supports the use of Trivy for software vulnerability scanning, the use of TLS for secure Harbor component communication, and the use of Webhook to interact with Slack.

7.5.3 Communication Protocol Between Edge and Cloud

Edge and cloud communication usually operates with the services, transactions and

security protocols listed in the following table.

Table 7.5.3-1 Communication Protocol between Edge and Cloud

Service Paradigms	**Service Protocols**	**Transaction Protocols**	**Security Protocols**
Client-Server (Web Services)		RESTful [81] HTTP [82] / COAP [83]	TLS [88]/ DTLS [89]
Client-Server (Multimedia)	WebRTC [78], SIP [79]	WebSocket [84]	
Publish-Subscribe	DDS [80]	MQTT [85], AMQP [86], DDSI-RTPS [87]	

7.5.4 Edge and Cloud Internal Communication Protocol

Google Remote Procedure Calls (gRPC) was originally developed at Google in 2015. GRPC uses HTTP/2 for transmission and protocol buffers (or FlatBuffers) as the serialization language of cross platform objects. gRPC provides authentication, two-way stream and middleware control, blocking/non blocking binding, cancellation and timeout. gRPC is applied to microservices that connect front-end clients to back-end edge/cloud server connections.

7.5.5 Cloud Communication Data Format

The syntax and semantics of edge cloud message exchange must be specified for specific applications.

In terms of syntax, JSON is the most used data exchange format in client server and publish subscribe transactions on the Internet. It should be the default data exchange format for edge cloud communication. Usually used for edge cloud data transmission, including Protocol Buffer (also known as protobuf), Flat Buffers, Apache Thrift (used by Facebook) and Ion (created by Amazon).

In terms of semantics, the interpretation of JSON information and serialized data structures is usually application specific. Although OGC Sensor Things API, W3C Worldwide Internet of Things (WoT) and OPC MTConnect are all trying to develop a common vocabulary for the Internet of Things (IoT) and IT/OT devices, the goal of data semantic model integration has not yet been achieved.

8. Information Security System (Managed by WG5)

8.1 Security Framework of 5G Smart Pole

Figure 8.1-1 illustrates the functional building blocks of a 5G Smart Pole system. The primary functions of this system are: (1) to provide a physical structure for installing wireless communication equipment and auxiliary devices, (2) to provide communication and information processing support to the wireless communication equipment and auxiliary devices. Since the 5G Smart Poles will be installed in physically exposed environments and may be subjected to various adversarial attacks tabulated in Section 8.1.3, the provision of communication security (ComSec), information security (InfoSec) and computation security (CompuSec) becomes the most important factor to ensure safety, reliability and trustworthiness of the services offered by the 5G Smart Pole system. This section specifies a two-tier security architecture for achieving this goal. [90]

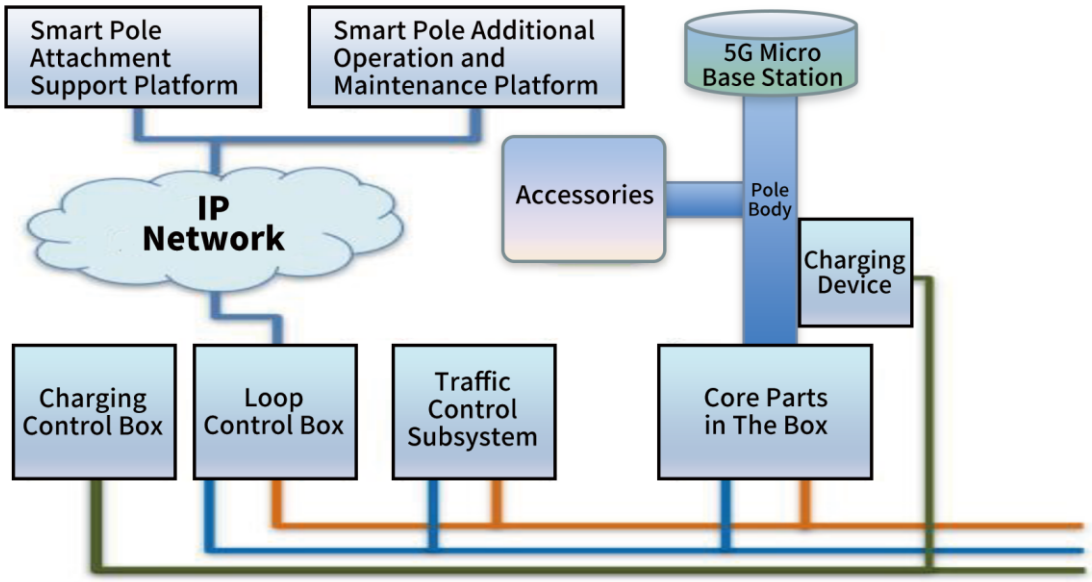


Figure 8.1-1 Schematic Diagram of 5G Smart Pole System Composition

8.1.1 Core Components

In order to provide ComSec, InfoSec and CompuSec services to the wireless communication equipment and the auxiliary devices installed on the 5G Smart Poles, a set of Core Components must be organized into a security system that can work collectively to offer the aforementioned security services. Following is a list of those components.

(a) Core Components in Equipment Chassis

(1) Ethernet Switch

(2) Pole Controller

(b) Local Subnet

(c) Controller Node

(1) Fiber Router

(2) VLAN Switch

(3) Networked Video Server

(4) Edge Server

(d) Operation/Maintenance Platform

(1) Real-Time Status Monitoring

(2) Scheduled Information Gathering

(3) Power Management

(4) Power Metering

(e) Service Support Platform

(1) Plug-n-Play Support

(2) Operation, Maintenance & Update

8.1.2 Peripheral component

The wireless communication and sensory/control services provided from the 5G Smart Poles will be delivered from the following auxiliary devices, communication, and control subsystems. These Peripheral Components are the recipients of the security services offered by the Core Components.

(a) Auxiliary Devices in Chassis

(1) LED Light Driver

(b) Auxiliary Devices

(1) LED Lights

(2) Traffic Lights

(3) Air Quality Sensors

(4) Weather Sensors

(5) Roadside Units, RSU

(6) AV Emergency Calling Device

(7) Vehicle Charging Apparatus

(c) 5G Communication Subsystem

(d) Traffic Control Subsystem

8.1.3 Threat Model

The following table lists the potential attacks on the communication security, information security and computing security of the smart pole core components.

Core components / Security aspects	Operation and maintenance platform ▪ Real time status monitoring ▪ Regular data collection ▪ Power management ▪ Collection of electricity information	Device support platform ▪ Ready to use support ▪ Operation maintenance and update	Loop control box ▪ Optical fiber router ▪ VLAN switch ▪ Network image server ▪ Edge computing server	local area network ▪ Cat 5e	Box ▪ Ethernet switch ▪ Smart Pole Controller
Communication security ▪ Confidentiality ▪ Integrity ▪ Certifiability	Eavesdropping Imposture Connection Hijacking Repeat attack	Eavesdropping Imposture Connection Hijacking Repeat attack	Eavesdropping Imposture Connection Hijacking Repeat attack	Eavesdropping Side channel attack	Eavesdropping Imposture Connection Hijacking Repeat attack
Communication security ▪ Data confidentiality ▪ Access control	Privacy violation Data damage	Software theft Program damage Model damage	Privacy violation Data damage Software theft Program damage Model damage		Privacy violation Data damage
Computing security ▪ Platform credibility ▪ System software dependability ▪ Application software credibility ▪ Information isolation	Privacy violation Data damage Result damage Software theft Program damage Model damage	Device imposture Software theft Program damage Model damage	Privacy violation Data damage Result damage Software theft Program damage Model damage		Privacy violation Data damage

Table 8.1.3-1 Threat Model of 5G Smart Pole Core Components

8.2 Cryptographic Support

Hardware-based cryptographic support must be used to implement Communication Security (ComSec) services including confidentiality, integrity and authentication. They must also be used to implement Trusted Execution Environments (TEE) for executing trusted software applications and protect their processed data.

8.2.1 Requirements of Cryptographic Functions

The Controller/Controller Node on a 5G Smart Pole must support the following three types of cryptographic functions:

(a) Symmetric (or Secret-Key) Ciphers for confidentiality protection.

(b) Asymmetric (or Public-Key) Ciphers for generating secret keys, establishing long-term security credentials and providing non-repudiation services.

(c) Cryptographic Hash Functions for providing integrity protection and authentication of communicating parties.

Specifically, the Controller Node should support the following FIPS 140-2 Annex A approved cryptographic functions at a minimum:

(a) Symmetric Key Ciphers: AES (with at least 128-bit keys)

(b) Asymmetric Key Ciphers: Z_p, Z_n^* Based: DH, RSA, DSA

(c) Cryptographic Hash Functions: SHA-224, SHA-256, SHA-384, SHA-512

(d) Random Number Generators[91]

(e) Message Authentication Codes: CCM，GCM，GMAC [92]， HMAC [93]

8.2.2 Requirements for Encryption Processor

Since it is usually deployed in a physically exposed environment, the Controller Node on a 5G Smart Pole must employ a hardware security processor such as a Trusted Platform Module (TPM), a Platform Security Processor (PSP) also known as a Crypto Processor, or a secure execution mode (such as the ARM TrustZone™ Secure Mode) on a processor core to implement cryptographically strong authentication, data encryption and key management.
Among different hardware security processors, those implement the Trusted Platform Module (TPM) Library v.2.0 specification published by the Trusted Computing Group (TCG) are RECOMMENDED. They support additional cryptographic algorithms, enhanced authorization

mechanisms and simplified management through PKCS#11. A list of available TPM 2.0 compatible products can be found on this report published in February 2020.

A True Random Number Generator (TRNG) should also be implemented in the hardware security processor installed on the Controller Node as a high entropy source of randomized key or nonce values.

8.3 Communicating Security Aspect

8.3.1 General Requirements

The following Communication Security (ComSec) services specified in the ITU-X.805 Recommendation1 SHOULD be implemented in all physical/virtual communication channels running through the Core Components of the 5G Smart Pole system since these components are often deployed in physically exposed environments.

(a) Confidentiality of connected/connectionless communication.

(b) Integrity of connected/connectionless communication, including anti-replay protection.

(c) Authentication of data source identity/communication object and access control of communication content.

In addition, in the following two communication channels, other security requirements will be added due to the communication environment:

(a) The channel between the controller node and the cloud operation and maintenance service support platform is called Node Cloud Communication Channels for short.

(b) The channel between the equipment box and various peripheral components installed on the 5G smart pole is called Node Device Communication Channels for short.

8.3.2 Security Requirements for Communication Between Nodes and Cloud

1 ITU-X.805: Security architecture for systems providing end-to-end communications, October 2003. URL: https://www.itu.int/rec/T-REC-X.805-200310-I/en.

Cryptographic strong data origin or peer authentication services shall be implemented using security credentials maintained in the Cryptographic Processors installed in the Con- troller Node [Section 8.2]. Channel access control shall be enforced according to the communication security policies established with the Cloud-based Operation/Maintenance and Service Support Platforms as a part of their service level agreements (SLA).

Cryptographic keys used in Node-Cloud Communications should be negotiated using key management protocols that support forward secrecy protection.

Since the Node-Cloud Communication Channels may go through open even wireless internet, they may need to be protected with limited traffic flow confidentiality including obscurity of packet sizes and inter-packet transmission intervals.

8.3.3 Safety Requirements for Communication between Nodes and Surrounding Components

Since the Controller Node often functions as a proxy of the Cloud-based Service Support Platform to various Peripheral Components installed on the 5G Smart Poles, the Node-Cloud Communication Channels must preserve interconnectivity and interoperability between the Peripheral Components and the Service Support Platform.

Since the choices of communication media and protocols between the Auxiliary Devices and the Controller Node through may differ among different equipment and services, their security requirements should be specified in separate cybersecurity specification for each service.

8.3.4 Recommended Practice Protocol Suites

Node-Cloud Communications are commonly conducted using the service, transaction and security protocols listed in Table 8.3.4-1. Among them, Data Distribution Service (DDS), OPC Unified Architecture (OPC UA) , MTConnect , Web Real-Time Communication (WebRTC) and Session Initiation Protocol (SIP) are protocol suites that offer service functions beyond mere client-server or publish-subscribe transaction support. They are classified as Service Protocols and are commonly used in industrial/manufacturing systems. [98]

Table 8.3.4-1 Security Communication Protocol Suite between Node and Cloud

Service Paradigms	Service Protocols	Transaction Protocols	Security Protocols
Client-Server (Manufacturing)	OPC UA [96], MTConnect [97]	RESTful HTTP / COAP	TLS [88] /DTLS [89]
Client-Server (Multimedia)	WebRTC [78], SIP [79]	WebSocket [99]	
Charging Station		OCPP	
Publish-Subscribe	DDS [80]	MQTT [100], AMQP [86], DDSI-RTPS [87]	

8.3.5 Recommended Operation: Firewall and Virtual Private network

8.3.5.1 Firewalls

The purpose of original firewall was to ensure that only required connections were allowed into the enterprise network. Firewalls are also used to limit the types of services that internal endpoint may access outside the network. These basic functions of firewalls can be performed through packet filtering, which compares the 5-tuple in packet headers including TCP/UDP, source IP address, source port number, destination IP address, and destination port number against the filtering policies to determine whether to pass or drop the packets.

However, due to the explosion of TCP-based applications, packet filtering based on the 5-tuple rules was no longer sufficient. Besides, Besides, there is also the increasing threat that hackers and attackers MAY use evasion techniques to defeat traditional firewall functions. Hence, most modern firewalls SHOULD be application aware and can detect the application traffic using DPI (Deep Packet Inspection).

Another feature of firewalls today is the ability to inspect SSL traffic. Now, a growing number of sites ranging from social media to unified communications using SSL by default. However, hackers can also use SSL to obscure attacks or use SSL to deliver malicious payloads. Thus, most next generation firewalls today also provide SSL inspection capabilities.

In addition to firewall, web application awareness, SSL decryption and inspection, some important network security functions include IDS (Intruder Detection) / IPS (Intruder

Prevention), DLP (Data Leakage Prevention), content security filtering functions (anti-spam, anti-virus, URL-filtering), and VPN access. Devices that combine more than one of the technologies are commonly referred as NGFW (Next-Generation Firewalls).

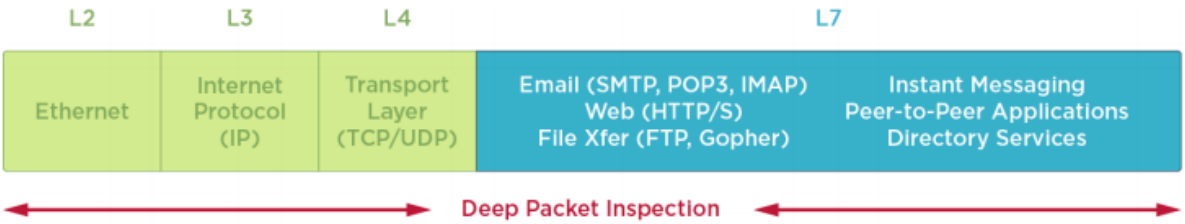


Fig. 8.3.5.1-1 Deep Packet Inspection

8.3.5.2 Virtual Private Networks, VPN

VPN (Virtual Private Network) is used to securely connect multiple sites within an enterprise, remote and roaming employees, and business partners. Two protocols are commonly used:

(a)SSL (Secure Socket Layer). This protects and encrypts traffic, while providing a web-based interface for information access.

(b)IPSEC (IP Security). This is network-level security that encapsulates and encrypts all traffic between the gateway, as shown.

As shown in Figure. 8.3.5.2-1, in IPSEC, the original packet is encapsulated in a new packet that includes an additional ESP (Encapsulated Security Payload) header. The header and additional trailers, and an optional AH (authentication header) serve to ensure that the source of the packet can be validated.

The Internet Key Exchange protocol (IKE) is a part of IPSEC which is responsible for negotiating SAs (Security Associations) which are a set of mutually agreed-upon keys and algorithms to be used by both parties trying to establish a VPN connection/tunnel. IKE is comprised of two phases. In phase one, IKE creates an authenticated, secure channel between the two IKE peers. This is done using Diffie-Hellmen key agreement protocol. In phase two, IKE negotiates the IPSEC security associations and generates the required key material for IPSEC.

IKEv2 is an improved version on IKE. Those improvements include less bandwidth consumption, support for EAP authentication, support for MOBIKE, built-in NAT traversal, and liveliness detection that enables IKE to re-establish a connection automatically when the previous connection breaks down. Related RFCs for VPN are provided as shown.

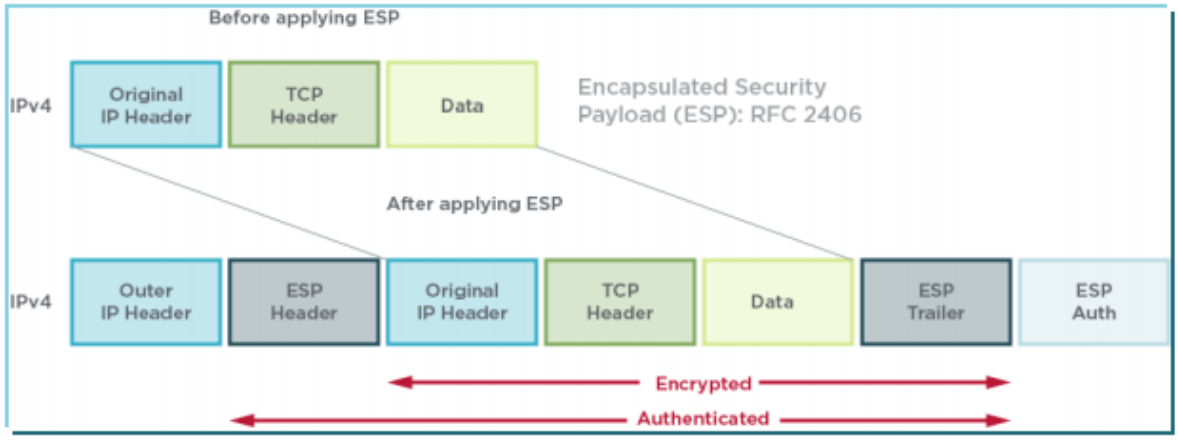


Fig. 8.3.5.2-1 IPSec Encapsulation

Table 8.3.5.2-1. IPSec and Corresponding IETF RFCs

Item	RFCs	Item	RFCs
IPSec AH	4301, 4302	IPSEC IKE/IPv6	2407, 2408, 2409
IPSec ESP	4301, 4303, 2403, 2404, 2405	IKEv2	7296
IPSec IKE	2407, 2408, 2409	L2TP	2661
IPSec AH/IPv6	4301, 4302	PPTP	2637
IPSec ESP/IPv6	4301, 4303, 2403, 2404, 2405, 2406	IKEv2/IPv6	4306, 5996

8.4 Information Security

In order to protect confidentiality, integrity and privacy of the application and operation data maintained in the 5G Smart Poles, the data processing devices installed on these Smart Poles including the Pole Controllers, the Networked Video Servers and the Edge Servers must implement data security and enforce access control collectively on those data sets. Following subsections prescribe the minimal requirements that must be fulfilled by those devices.

8.4.1 Data Security Requirements in Core Components

Since the Pole Controller in the Equipment Chassis mounted on a 5G Smart Pole can maintain up to 30 days of the data collected by the Auxiliary Devices installed on the same pole in the absence of network connection and/or electric power, those data should be encrypted using a symmetric key dispatched from the Operation/Maintenance Platform.

The Video and Edge Servers should regard the Pole Controller as a secure storage device associated with these servers.

8.4.1.1 Recommended Practice: Disk Encryption

Mass storage devices with disc encryption capability MUST be used to store the data collected by the Auxiliary Devices installed on the same pole in the absence of network connection and/or electric power. The encryption key(s) SHOULD be maintained in the cryptographic processor on the storage devices.

8.4.2 Access Control Requirements in Core Components

The Service Support Platform and the Operation/Maintenance Platform will access application and operation data respectively from the Auxiliary Equipment through the Video and Edge Servers. Role or attribute (including identity) based access control should be enforced on all these remote data access.

8.5 Secure Computering Method

8.5.1 General Requirements

8.5.1.1 Hardware Root-of-Trust, hRoT

A hardware Root-of-Trust (hRoT) is a security module in a computer system that performs the cryptographic functions and maintains the cryptographic keys for the secure boot process of the computer system. It also serves as the anchor for a chain of trust between the hardware platform and the software running on that platform. The hRoT thus lays down the foundation of Trusted Computing.

Since the Controller Node including the Networked Video Server and the Edge Server may execute software applications downloaded from the Cloud-based Service Support Platform, these servers should have hRoTs installed on their hardware platforms and be capable of supporting Trusted Computing.

8.5.1.2 Secure Cryptographic Boot

Secure Boot is a process for loading and verifying digitally signed system software modules including: boot loader, firmware, operating system kernel and systems modules during the initial start of a computer system. The process uses the cryptographic functions and keys maintained in the hRoT to verify the digital signatures of the firmware and software modules. Only those modules signed with the private keys corresponding to the public keys maintained in the hRoT are allowed to be executed on that computer system. In addition to the Secure Boot, an Encrypted Boot further allows the firmware and soft- ware modules to be encrypted with a symmetric secret key shared between the firm- ware/software provider and the computer system. The encrypted modules are thus protected from illegitimate disclosure or use by unauthorized users.

As a Trusted Computing platform, the Controller Node should support Secure Boot. It may also support Encrypted Boot if its firmware and system software modules contains proprietary programs, models and/or configurations.

8.5.1.3 Information Isolation

Networked Video Servers and Edge Servers installed in the Controller Node, may be used as the frontend processors for the data streams coming from or going to individual Auxiliary Devices. In those cases, each of these data streams and its processing must be protected with information isolation from the other user application and the operation / management processes running on the same servers. One of the following three levels of information isolation must be employed to provide the necessary protection.

(a) Application Level Information Isolation: data to/from Auxiliary Devices MAY be processed by application programs wrapped in software containers running on a common operating system and managed by an orchestration program such as Kubernetes. Containers have separate namespaces and process resources, and can enforce information isolation among different applications; however, those separations vanish at the operating system level. Thus, containers can only be used to provide information isolation among applications running on a trusted system managed by a single operator.

(b) Kernel Level Information Isolation*:* data to/from Auxiliary Devices MAY be processed by application programs running in virtual machines instantiated on hyper- visors. Each virtual machine runs its own operating system kernel. Thus, virtual machines can enforce information isolation at the operating system level; however, this level of isolation can be breached if attacks can be launched against the hypervisor and the host operating system. In most cases, virtual machines will suffice to protect against information leakage among different users of an open multitenant system.

(c) Hardware Level Information Isolation: For those cases, in which privacy of the data gathered by the Auxiliary Devices need to be protected not only from other users but also from the owner and the operator of the Smart Pole system, hardware level information isolation SHOULD be employed to implement the Confidential Computing paradigm. Special functions including memory and I/O encryption SHOULD be added to the memory management unit (MMU) and the I/O management unit (IOMU) of the Video and Edge Servers in order to create protected memory partitions and I/O channels. These protected memory and I/O channels SHOULD then be bonded with processors or virtual machines to form secure enclaves. Private data MUST be processed within those secure enclave. They can be accessed only by their owners. Access to the results of private data processing MUST also be restrict- ed to the authorized users.

In addition to employing information isolation in the data processing environment, the data flows between the Auxiliary Devices and the Service Support Platform, which are often referred to as the data plane traffic, SHOULD be isolated through data encryption or channel separation from the information flows between the Auxiliary Devices and the Operation/ Maintenance Platform, which are often referred to as the control plane traffic.

8.5.1.4 Device loading and Service Opening

All the communication and data processing/storage devices installed on the 5G Smart Pole including the Ethernet switches, the fiber routers, the Pole Controllers, the Networked Video Servers and the Edge Servers should be deployed through a trusted device onboarding process consisting of the following steps. First, before the deployment of each device, a factory-default device identity and security credential, which can take the form of a private key and its associated public key certificate or an individual secret key, must be installed by the manufacturer into a protected memory in that device. Then, during the deployment process, the Operation/Maintenance Platform must authenticate the factory default identity and security credential of that device before establishing a permanent connection with that device. At the end of a successful authentication process, the Operation/Maintenance Platform should install a system-specific device identity and security credential into the authenticated device. Those identity and security credential should be used to establish secure communication and information access control of that devices with all the Core Components of the 5G Smart Pole system. As much as possible, those identity and security credential shall also be used in the information interchanges with the Peripheral Components of the system.

In addition to the use of Secure Boot mentioned in Section 5.1.2 to verify the system firmware and software, the data processing/storage devices on the 5G Smart Pole including the Pole Controllers, the Networked Video Servers and the Edge Servers should also verify the hash values and digital signatures of application programs before running them.

8.5.1.5 Security Firmware and Software Upgrade

As much as possible, the communication and data processing/storage devices installed on the 5G Smart Pole should update their system and application software using secure update including secure over-the-air (OTA) update processes. These secure update processes should verify the authenticity and validity of the new system and application software images based on their hash values and digital signatures issued by trusted third parties such as code signing authorities or software container notaries. These update processes should also authenticate those communication/processing devices using their system-specific device identities and security

credentials. These update processes should also be conducted over secure communication channels protected according to Section 8.2.1.

8.5.2 Recommended Practice: Trustful Edge Computing

By working with WG4 and WG6, members of WG5 reached a consensus that Edge Computing, especially Multiaccess Edge Computing (MEC) according to the ETSI standards, should be deployed as a service over the 5G Smart Poles. We also reached the following tentative agreements on its deployment:

(a) The data flows of 5G communications and the information flows among Smart Pole core components may go through different paths. For instance, the 5G infrastructure and the Smart Pole infrastructure may deploy separate optical fibers.

(b) The telecommunication switching centers may be the preferred location to install the Edge Servers. These air-conditioned equipment depots only 1 – 2 hops away from the base stations are the concentrating points of telecommunication traffic and potentially data communication traffic as well.

(c) In order to ensure interoperability, we recommend that the Edge Computing services should be delivered over cloud native computing platforms. The container-based cloud native computing paradigm promoted by Cloud Native Computing Foundation has been adopted by 5G RANs, Core Networks as well as Multiaccess Edge Computing systems. A broad-range of open-source software modules are available to aid quick development of cloud native network functions and applications.

8.5.2.1 **Cloud Native Computing**

As a part of Linux Foundation, Cloud Native Computing Foundation (CNCF) is promoting a collection of cloud native technologies that empower organizations to build and run scalable applications in Edge and Cloud Computing environments. It advocates the use of software containers, service meshes, microservices, immutable infrastructure, and declarative APIs to exemplify an approach to dynamic application and service management.

8.5.2.1.1 Software Containerization

All software running in Edge and Cloud Computing platforms shall be containerized according to the following recommendation:

(a) Specification: Open Container Initiative (OCI) image and runtime specifications

(b) Packaging Format: cloud native application bundles v1 (cnab1)

(c) Container Runtime: runc, reference implementation of OCI runtime,

(d) Container Runtime Interfaces (CRI): CRI-O, Kubernetes CRI for OCI compatible runtimes, or contained (v.1.1), new Docker container runtime

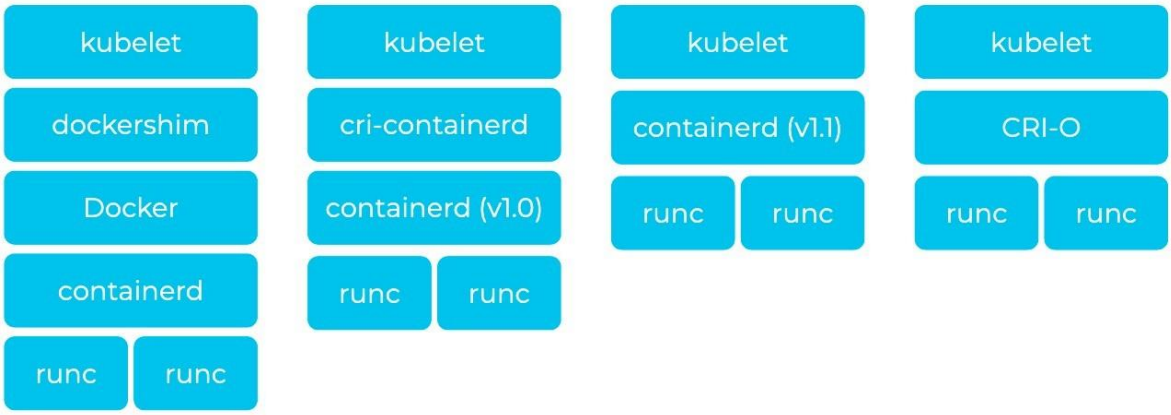


Figure 8.4.2 CNCF（Cloud Native Computing Foundation）
Container Software Stacks with Different Runtime

8.5.2.1.2 Continuous Integration / Continuous Delivery

Continuous Integration / Continuous Delivery or Continuous Deployment (CI/CD) enforces automation and monitoring throughout the lifecycle of an application, from integration and testing to delivery and deployment. Argo is the CNCF recommended declarative GitOps based container CD tool for Kubernetes orchestrator.

8.5.2.1.3 Container Management and Orchestration

Container management and orchestration is all about managing the lifecycles of containers, it include but not limited to provisioning and deployment of containers, redundancy and availability of containers, scaling up or removing containers to distributed the load evenly across host infrastructure, movement of containers between nodes, allocation of resource between

containers, external exposure of services running inside containers with the outside world, load balancing of service discovery between containers, health monitoring of containers and hosts, configuration of an application in relation to the containers of it.

Kubernetes (a.k.a. K8s) is the market-leading management and orchestration platform for automating deployment, scaling, and operations of application containers across clusters of hosts. Originally developed by Google, Kubernetes is the cornerstone of CNCF software architecture, and can be used to orchestrate software running in both Edge and Cloud Compu-ting environments.

8.5.2.1.4 Integrated Information Transmission

Communication between Edge and Cloud Computing Nodes/Servers must be protected using the service, transaction and security protocols tabulated in Section 8.2.4.

Communication among the micro-services running with Edge and Cloud Computing infrastructures MAY use gRPC as a unified communication mechanism.

gRPC (abbrev. for Goggle Remote Procedure Calls) initially developed at Google in 2015. gRPC uses HTTP v.2 for transport and Protocol Buffers / FlatBuffers as the cross-platform object serialization methods. It provides authentication, bidirectional streaming and flow control, blocking/non-blocking bindings as well as cancellation and timeouts.

8.5.2.1.5 Remote Deployment

In distributed Edge-Cloud Computing systems such as the Smart Poles, software updates are an attack vector exploited by hackers time and again; thus, they must be protected with strong cryptographic functions such as digital signatures to certify the authenticity and the integrity of the software objects and performed by a secure software distribution infrastructure with secure update protocols, trusted notaries, and safeguarded registries to counter various on-line attacks. Following are the essential components of this infrastructure.

(a) The Update Framework, TUF [106]

The Update Framework (TUF) is a CNCF de-facto standard for automatically identifying software updates and securely downloading them. A variant of TUF known as Uptane is widely used to perform secure over-the-air (OTA) software updates in the automobile industry.

TUF can meet the needs of updating a wide range of software objects including system

software, application software and software libraries. It operates by tracking verifiable records of the states of the software object through the creation of digitally signed metadata containing the hash values of the software objects, the identity of the signing keys and the expiry time of the metadata records. Using these metadata, TUF can identify necessary software updates, downloads them, and check their validity without the intervention of the host systems.

(b) Software Notary [107]

The Notary is a CNCF defacto standard for verifying the authenticity and integrity of software objects. The Notary operates as a trusted third party that certifies software objects by affixing its digital signatures to the hash values and the metadata of these objects. Consumers can then download these objects and verify their authenticity and integrity by checking the affixed digital signatures using the public key of the Notary. Notary is fully integrated with TUF to operate seamlessly as a software verification and update system.

(c) Software Registry

As the third component of the software update infrastructure, a registry is a repository, or collection of repositories, used to store verified software objects and make them available for download. In CNCF context, a container registry is a registry for Kubernetes, DevOps, and container-based application development. Currently, Harbor 2.0 is the first Open Container Initiative (OCI) compliant open-source registry providing full cloud native support on container images over multiple architectures including Docker and CNAB and OPA. In addition to working as a software repository, Harbor 2.0 also supports software vulnerability scanning using Trivy, secure intra-Harbor component communication using TLS and interactions with Slack using Webhook.

8.5.2.2 Secure Containers

Application-Level Information Isolation based on the use of CGroup and separate name-spaces is deemed insufficient to provide information protection among containers running in a multitenant environment. Hence, VM-based Container Runtime such as Kata Containers and gVisor are recommended for running OCI-compliant secure containers with micro-kernel encapsulation and I/O restriction.

8.5.2.3 Mandatory Access Control, MAC

In addition to the use of VM-based Container Runtime, mandatory access control (MAC) is also recommended to be used to control resource use and information interchanges among secure containers based on their capabilities and/or privilege levels. SELinux built into CentOS, Debian and Ubuntu Linux are commonly used to implement policy-based mandatory access control.

8.5.2.4 Trusted Computing

Trusted Computing with the following essential capabilities should be employed in Edge Computing Nodes and Servers interoperating with Cloud Computing facilities. [115]

8.5.2.4.1 Endorsement Key

These are 2048-bit RSA private/public key pairs generated during the manufacturing and the device onboarding process of the Edge Computing Nodes/Servers. They should be stored, managed, and used by hardware Root-of-Trusted such as TCG TPM 2.0 or ARM TrustZone trusted execution environments.

8.5.2.4.2 Secure Input and Output

All intra- and inter-node communications must be protected with confidentiality, integrity, and authentication services using the Communication Security mechanisms mentioned in Section 8.3.

8.5.2.4.3 Memory Masking or Protected Execution

(a) Memory used by applications belonging to different users MUST be isolated from one another to protect data confidentiality and integrity. Kernel or hardware level memory protection mechanisms including address space separation and memory encryption SHOULD be used to implement such separation.

(b) In addition to the enforcement of memory separation, applications belonging to different users SHOULD be executed in protected environments enforcing application, kernel or hardware level information isolation mentioned in Section 8.4.1.3. Mechanisms such as VM-based containers mentioned in Section 8.4.2.2 are RECOMMENDED to be employed.

8.5.2.4.4 Seal Storage

Content in the persistent storage of Edge and Cloud Computing Nodes/Servers SHOULD be encrypted using cryptographic keys derived from configuration parameters of those nodes/ servers such as the serial numbers of their hard disks or the MAC addressers of their network interface cards.

8.5.2.4.5 Remote Authority

Operators of 5G Smart Poles MUST authenticate the identity and configuration of the core components in the Security Architecture mentioned in Section 8.1.1 that are installed on those Smart Poles.

Direct Anonymous Attestation, a technology based on group public keys, MAY be used to this authentication process if specific equipment/device needs to maintain their anonymity.

8.5.2.4.6 Trusted third party

All hardware and software used in the core components of the Security Architecture mentioned in Section 8.1.1 MUST be certified by a ratified Certification Authority.

Remote deployment mentioned in Section 8.4.2.1.5 MUST use this Certification Authority to certify all the system and application software deployed on these Edge Computing Nodes/Servers on the Smart Poles.

9. Application Specifications (Managed by WG6)

9.1 Intelligent Lighting

9.1.1 LED Street Lights

(a) Scope of application: 5G smart pole road lighting LED street lights.

(b) Reference standards:

(1) Technical Specification for Setting LED Street Lights in the Whole Set [117]

(2) CNS 15233 LED Road Light Fixture [118]

(3) CNS 14335-2-3 Lights - Part 2-3: Individual Requirements for Lights for Road and Street Lighting [119]

(4) Code for Urban Road Lighting of the Construction Department of the Ministry of the Interior [120]

(b) Relevant provisions for LED street lights.

(1) LED street lights shall comply with relevant provisions of CNS 15233

(2) LED street light shall conform to the specifications in Table 9.1.1-1

Table 9.1.1-1 Specifications of LED Street Lights

Height of LED Street Light	Rated input power of LED street light	Relative color temperature (Mark)	Rated luminous efficiency	Other requirements
Lower than 6m	≦70W	Medium color temperature 5000K Low color temperature 3000K	≧120 lm/W	• Color rendering (Ra) not less than 70 • Dustproof and waterproof: IP65 or IP66
6m-8m	≦105W			
8m-10m	≦140W			
10m-12m	≦200W			
Higher than 12m	≦350W			

(3) The LED streetlights are simulated according to the road setting parameters in the technical specification for setting LED streetlights in the whole station. The uniformity of simulated illuminance shall be ≥ 0.33, and the simulated average illuminance shall be ≥ 10 lx. Or according to the road lighting requirements specified by the purchasing unit.

(4) The test laboratory, test report and lamp marking of LED streetlights shall meet the relevant requirements of Taiwan's technical specifications for setting LED street lamps.

(5) LED lamps need to reserve intelligent control interface to expand (build) intelligent lighting function later. If NEMA standard connector conforming to ANSI C136.41 [74] is used to install intelligent lighting controller for streetlights, the overall performance of lamps shall not be affected.

(c) Relevant provisions of LED street lamp power supply.

(1) The power supply of LED streetlights shall comply with the provisions in Table 9.1.1-2 with independent shell design.

Table 9.1.1-2 Specifications of LED Street Light Power Supply

Item		Specification
Input	Rated Voltage	100-277 Vac
	Rated Frequency	50/60 Hz
	PF	>0.92 @ 220Vac at 70% load & full load
	Efficiency	> 90% @ 220Vac at full load (Rated power of power supply>35W)
Output	Power Rating	Power range
	Current Rating	700mA ±5% ≦150W (Output power) 1,400mA ±5%＞150W (Output power)
	Voltage Rating	Voltage range
	Line Regulation	± 3 % full load
	Ripple current	± 20 % @ 220Vac at full load
	Interface	1～10V, DALI or dimming interfaces
Protection	SCP	Yes
	OVP	Yes
	OTP	Yes
Environment	Operation temperature	-20 ~50 ℃
	Operation Humidity	10 ~ 90 %
	Storage temperature	-40 ~ 80 ℃
	Storage Humidity	10 ~ 90 %
Safety & EMC	Safety Standards	CNS15467-1（101 version） [121] or IEC 61347-1 [122] CNS15467-1（2012 version） [121] or IEC 61347-1 [122]

	EMI	CNS14115（1998 version） [27] or CISPR 15 (IEC 55015) [125]
	Harmonics	According to: CNS14934-2（2005 version） [126] or IEC 61000-3-2 [127] Specification: C
	Surge	According to:CNS14676-5（2002 version） [128]or IEC 61000-4-5 [129] Specification :L-N: 2kV；L-PE: 4kV；N-PE: 4kV
Ingress Protection		According to:CNS14165（1998 version） [130] or IEC 60529 [131] Specification:IP65 或 IP66
Note: The new surge project requirements in this technical specification can be used as additional testing, but must be the same specification and model as the original LED street lamp power supply test report, and the test report must be issued by the same laboratory as the original LED street lamp power supply.		

(2) The power supply must be marked at obvious position

(2.1) Manufacturer's name or trademark

(2.2) Model type

(2.3) Rated input voltage, rated input frequency, power factor and input current

(2.4) Rated output power, rated output current and output voltage range

(2.5) IP protection grade

(2.6) Date or code of manufacture

(3) The power supply manufacturer must issue the test qualification report of the consortium legal person National Certification Foundation (TAF) or the internationally recognized third impartial unit certification laboratory. The test items include the input, output, safety regulation, electromagnetic interference, dust prevention and waterproof of the power supply, and a complete test report must be issued by the same laboratory.

9.1.2 Intelligent Lighting Controller

(a) Application Scope: Intelligent Lighting Controller of 5G Smart Pole.

(b) Reference Standards:

(1) CNS 13438 Information Technology Equipment - RF Disturbance Characteristics - Limits and Measurement Methods [132]

(2) CNS14336-1 Information Technology Equipment - Security - Part 1: General Requirements [133]

(3) Technical Specification for PLMN11 Mobile Broadband Service Narrow Frequency Terminal Equipment [134]

(4) Technical Specification for PLMN10 Mobile Broadband Service Broadband Terminal Equipment [135]

(5) LP0002 Technical Specification for Low Power RF Motor [136]

(6) TAICS TS-0027-1 V1.0 Intelligent Street Light System Information Safety Standard - Part I: General Requirements [137]

(7) TAICS TS-0027-2 V1.0 Intelligent Street Light System Information Safety Standard - Part II: Intelligent Lighting [138]

(8) TAICS TS-0028-1 V1.0 Intelligent Street Light System Information Safety Test Specification - Part I: General Requirements [139]

(9) TAICS TS-0028-2 V1.0 Intelligent Street Light System Information Safety Test Specification - Part II: Intelligent Lighting [140]

(10) TAICS TS-0034 V1.0 Intelligent Street Lamp Management Platform Data Format Standard and Test Specification - Lighting System [141]

(c) The intelligent lighting communication transmission can adopt wireless transmission (4G, NB-IOT, SUB-1G or other) or wired transmission (PLC, FIBER or other).

(d) The smart lighting controller is recommended to use NEMA standard connector conforming to ANSI C136.41.

(e) The intelligent lighting controller shall comply with CNS 13438 Information Technology Equipment - Radio Frequency Disturbance Characteristics - Limits and Measurement Methods and CNS 14336-1 Information Technology Equipment - Security - Part 1: General Requirements, Except That The Controller Using Wireless Transmission Shall Comply with The Radio Frequency Reporting Requirements of NCC Specifications.

(f) The use of communication modules made in Chinese Mainland is prohibited in accordance with the "Principles of All Authorities on Restricting the Use of Products Dangerous to the National Information Security" issued by the Executive Yuan.

(g) After networking, the intelligent lighting controller can record the voltage, current, frequency, power consumption, power and other data of each lamp. It is also required to remotely control the ON/OFF or dimming (10~100%) and other actions of the lamps.

(h) Intelligent lighting controller shall meet the specifications in Table 9.1.2-1

TABLE 9.1.2-1 Specifications of Intelligent Lighting Controller

Item	Specification
Rated Voltage	100-277 Vac
Rated Frequency	50/60 Hz
Operation temperature	-20 ~50 ℃
Operation Humidity	10 ~ 90 %
Storage temperature	-40 ~ 80 ℃
Storage Humidity	10 ~ 90 %
Dim Interface	1~10V、DALI or other diming mode
Ingress Protection	IP65 or IP66

9.2 Impact on Monitoring and Security

9.2.1 Video Recording Function

(a) Supported image sources: web camera, general RTSP website, Onvif ProfileS camera

(b) Video compression (codec): H.264/H.265/MPEG-4/M-JPEG/MxPEG

(c) Video recording mode: continuous/scheduled/event recording, multiple event alarms, early warning (minimum 30 seconds) and post alarm (minimum 30 seconds) recording. When the camera model supports user-defined streams, all-weather recording, intelligent recording, and edge recording (Onvif Profile G client is supported)

(d) Automatic snapshot/image capture: every 1,2,3,4,5,6,10,12,15,30,60 minutes, and supports saving to remote targets
(e) 720pMegapixel video recording: support megapixel camera (resolution no less than 720p)
(f) Flow type: CBR/VBR
(g) Transmission protocol: TCP/UDP/HTTP
(h) Audio support: audio input/output
(i) Format: G711muLaw/G711aLaw/G726/AAC/PCM
(j) Video system: NTSC/PAL
(k) Download and export: download video files through web interface, FTP, SMB/CIFS video export during local playback and remote playback.
(l) Multi disk support: support the use of multiple spaces as video recording space.
(m) Replication retention rules: support specifying the number of days, recording normal and event video streams, or saving the maximum file size of files, and whether to overwrite old files to make room for new videos.
(n) File format: standard MP4
(o) Lowest channel: 4 channels

9.2.2 Video Recording Storage

Support storage configuration/dedicated storage: independent video space to ensure dedicated video space, high-quality recording and no performance interference. Different special video spaces can be allocated for different stream types (general video, event video).

9.2.3 Camera Integration

(a) Support transmission protocols: HTTP, RTSP RTP over TCP/UDP
(b) Onvif Profile support: Profile S, Profile T
(c) Camera form support: including standard fixed, fish eye, 360 degree camera and PTZ camera.
(d) Channel sharing via HTTP/RTSP:
    (1) Through HTTP sharing, users can directly watch the instant streaming on the browser.
    (2) Through RTSP sharing, users can obtain RTSP streaming website.

(e) Get playback stream through RTSP website

9.2.4 Real Time Monitoring and Video Playback

(a) Display resolution: 1366 x 760 or better, and support multiple monitors (image wall)

(b) Simultaneous monitoring of real-time video: minimum 32 channels（ 720p@H.264 @30fps）

(c) Simultaneous playback: minimum 16 channels

(d) Time from playing to viewing the recorded image: within 1 second.

(e) Methods and functions of connecting to the server:

  (1) Support secure login

  (2) Support remember password

  (3) Support automatic login

  (4) Support domain login

  (5) Support login history list

(f) Switching between real-time and playback: on the timeline, you can simply click to achieve real-time playback, playback and export

(g) View:

  (1) Stored in the server, the same view layout can be displayed by changing to another computer with the same user account

  (2) Dynamic View Editor

  (3) One screen with one view

  (4) The following information can be stored in one view

    (4.1) Position information of camera and hurdle

    (4.2) Image position of local region of interest

    (4.3) Local image position of restored fisheye camera

    (4.4) Local image position of digital scaling

    (4.5) Electronic map

  (5) When receiving the notification, the associated camera in the view will display a red box flashing notification

(h) Sequential carousel mode: at least two sequential carousel modes are provided:

  (1) Rotates views in the order they are defined

(2) Rotate the camera in a specific layout

(i) Playback method/obtaining video file: the following methods shall be provided:

(1) Click Play on the timeline of the camera, and even when it is in the real-time video screen, it will immediately switch to the playback image

(2) After selecting a date on the calendar, click the timeline to play the video image

(3) Drag the screenshot of the event notification to the view to play the image directly

(4) Drag the camera screenshot in the keyword search results to the view to play the image directly

(j) User time control interface:

(1) First five minutes/previous frame/pause/play/next frame/next five minutes

(2) Speed: 0.1/0.5/1/2/4/8/16/

(3) Skip to next event/skip to previous event

(4) Synchronous mode: let all cameras on the screen play back at the same time

(k) Support setting ROI

(l) Support automatic cruise/set the moving path of multiple preset points, set the moving camera according to the preset points, and the minimum number of preset points: 32

(m) Video file export mode needs to support:

(1) Fast export, the export of one hour long video files shall not exceed five minutes

(2) Attach time stamp, channel name on video

(3) Convert to specific format

(4) Sound cancellation

(5) AVI、MP4; Format support: AVI, MP4

(n) Snapshot picture: Support format: BMP / PNG / JPG, support adding superposition channel name, date and time into the picture

(o) Fish eye restoration: The image restoration function supports fish eye camera or fish eye lens camera. Image restoration can be operated under the following conditions: instant video, playback, fast rotation, and slow broadcast.

(p) Electronic map:

(1) Map file format: PNG/JPG/SVG

(2) Support the storage of electronic maps on the server, placing cameras and electronic maps on electronic maps

(3) It can rotate the map angle and display the status of the camera

(4) Support viewing instant images directly on electronic maps

(q) Hardware acceleration/GPU acceleration: support the compression format of GPU hardware acceleration: H.264/H.265

9.2.5 Incident Management and Record

(a) Rules: support users to create multiple event rules, and set schedule binding with events and actions

(b) Event: Support "OR" or "simultaneous" logic in event rules

(c) Supported event types (from the camera): dynamic detection/alarm input/sound detection/cross line detection/digital tracking/intrusion detection/masking detection/connection error/reconnection/video space error/video space warning/video space full/video space recovery/disk warning/disk error/disk usage hour warning/event URL

(d) Action: supported action types: event recording/alarm output/camera control (according to preset points), push notification, email, SMS

(e) Support to include camera screenshots in notification email

(f) Support Gmail SMTP (support two-step account verification)

(g) Client notification of desktop version: at least the following methods are provided: notification list, DING sound, electronic map change icon, camera frame flashing red

(h) Record type: system event record, system connection record, online user record, monitoring event record, monitoring setting record

9.2.6 Backup and Expansion

(a) Remote backup: It supports recording to remote storage devices, and can also schedule backup tasks regularly.

(b) It supports the function of regularly deleting the oldest video files of backup data in remote storage devices.

(c) External backup: copy the film file to the external device, and support the function of external expansion cabinet

(d) Cloud backup: supports backing up video files to cloud video space, at least including Amazon S3 and Google Drive

9.2.7 Setting and Management

(a) Desktop page:
  (1) Support multi window and multi task settings.
  (2) Smart desktop with main directory, smart dashboard and drag icon
  (3) Support Google Chrome, Mozilla Firefox browser

(b) Camera Management:
  (1) Auto search camera
  (2) Batch addition/modification of cameras
  (3) Can export/import camera online profile in CSV format

(c) Web based management interface: MP4 video files can be found through the browser, and video files can be shared safely through the sharing website

(d) Authorization upgrade: channel authorization can be expanded dynamically online as required

9.2.8 Security Protection

(a) Support secure online: HTTPS (and support two-step authentication), SSH

(b) Malicious virus removal tool: it can detect whether any malicious program has been implanted

(c) Network access protection: the list of allowed or blocked network IP can be set

(d) Automatic logout: set the idle time and automatically logoff the user

(e) User permission management: different permission settings can be customized for different users

  (1) Permission level: supports the functions of allowing, rejecting, and not deciding (using inheritance results)

  (2) Permission setting level: provides the functions of users, user groups and user roles

  (3) Privilege Report: supports the function of viewing the final permission setting result report

  (4) Function permission setting: system setting, monitoring setting, view viewing, camera, electronic map

9.2.9 Storage Management

(a) RAID types supported: RAID 0, RAID 1, RAID 5, RAID 50, RAID 5+hot spare, RAID 6, RAID 6+hot spare, RAID 10, RAID 10+hot spare

(b) RAID operation: online RAID capacity expansion, online RAID configuration transfer

(c) HDD tool: HDD S.M.A.R.T, bad track scanning

9.2.10 Network service

(a) Protocol: Support HTTP, HTTPS, TCP/IP, UDP, DHCP, Static IP, DNS, DDNS, UPnP, FTP, NTP, and SMTP

(b) Built in server: DHCP server, NTP server, NTP client, virtual switch

(c) Multiple network interfaces: fault tolerance, load balancing, and multiple network interfaces.

(d) File server: supports web page, FTP, SMB/CIFS functions

9.2.11 Multilingual Support

The interface at least supports languages: Traditional Chinese, English

9.2.12 Mobile Device Monitoring Application

(a) Support platform: at least compatible with iOS 12, Android 10 and above systems

(b) Camera control shall support control option functions, including sequential playback mode, PTZ control, automatic cruise and preset point switching control

(c) Notification list: supports receiving instant push notifications, playing movies according to event records, and switching between pre and post events

(d) Capture and share: capture important moments into photos and store them in the mobile device, and share the instant streaming URL to other users, who can view the streaming through the browser

(e) Multi camera viewing at the same time:

(1) When in single channel viewing mode, you can swipe left and right to view up/down channels

(2) Various viewing versions are available, including channel 2, channel 4, channel 6, channel 9, channel 12 and channel 16 or more

(3) Provide a variety of seconds intervals for rotation, including at least 10 seconds, 15 seconds, 30 seconds, and 60 seconds

(f) Electronic map

(1) Support to display camera position on electronic map

(2) Support to switch the display of event icon on the electronic map when an event occurs

(3) When the camera icon is clicked on, the corresponding camera image is displayed

(4) Display the status of the camera on the electronic map, including available, connected, set aside and error

(g) Dashboard: display NVR information, camera recording status, authorization information, recording space status and resource utilization

(h) Event Log

(1) Query event records by specific time interval

(2) Search event records through keywords

(3) Various notification methods, including sound, mute, and vibration

(4) Click the event contracted drawing to play back the event video file

(i) Login verification: support two-step verification during login, biometric authentication

9.2.13 Central Management System

(a) Multiple video server management: support at least 64 video servers

(b) Multiple servers can be edited and managed by batch

(c) The status of each video server can be displayed to eliminate potential problems in advance

(d) Customized event dashboard allows users to cooperate with the display and display the frequency and period of events

(e) User management and permission management: allows the use of a single account to manage and store many video servers for management and playback

(f) Cameras, electronic maps and view panels can be allowed to define whether they are available

9.2.14 Safety Regulation Certification

Necessary safety certification of the system: CE, FCC, BSMI

9.3 Microclimate Environment Monitoring

Microclimate refers to the phenomenon that is different from the surrounding climate within a small range. Microclimate monitoring uses multiple groups of environmental information such as temperature, humidity, wind direction, pressure, noise and air quality to integrate accurate and complete regional environmental information, thus helping relevant units to timely monitor and formulate solutions.

9.3.1 Microclimate Monitoring Project Requirements

(a) Real time temperature, humidity and atmospheric pressure measurement

(b) Real time air quality monitoring, including concentration of ozone (O3), fine suspended particulates (PM2.5, suspended particulates (PM10), carbon monoxide (CO), sulfur dioxide (SO2) and nitrogen dioxide (NO2)

(c) Real time wind direction and speed monitoring

(d) Record of rainfall and light illumination

(e) Monitoring and recording of ambient volume (noise)

9.3.2 Microclimate Monitoring Sensor Requirements

(a) Operating temperature range - 10 ° C~60 ° C; The working humidity range is 5%~95%.

(b) Support environmental data collection, remote control, status monitoring and other functions.

(c) It can be installed with flanges, slots and other ways.

(d) Micro environmental quality monitoring equipment in the form of "single structure" or "multi in one" can be used.

(e) The equipment shall meet the requirements of Wet Location, and can operate normally in outdoor rainy days.

(f) 802.3af PoE power supply is preferred for the device. Or DC power supply. If remote control is required, PoE splitter can be used to switch to DC connector. Use Ethernet or RS485 to communicate with the back-end control system.

(g) It is suggested to use digital vouchers to sign the firmware of the device itself, and it is suggested to update it online.

(h) Data transmission uses mainstream communication protocols (such as MQTT or RESTful API) for system integration. If the sensor uses RS485 communication interface, the general format

is MODBUS. It is recommended to convert it to MQTT or RESTful API through GATEWAY or platform for system integration.

(i) See Table 9.3.2-1 for monitoring indicators and measurement range:

Table 9.3.2-1 Monitoring Indicators and Measuring Range of Environmental Monitoring Sensor

Measurement index	Measuring range	Resolution ratio	Measurement accuracy	Unit of measurement
Temperature	-10~60˚C	0.1˚C	±0.3˚C	˚C
Relative humidity	5~95%	1%	±3%	%
PM2.5/PM10	0~1000 ug/m3	1 ug/m3	100 ug/m3	ug/m3
Noise	30~130dB	1 dB	±1.5 dB	dB
Barometric pressure	10~1300hPa	0.1 hPa	±1.0 hPa	hPa
Wind direction	0~360˚	0.1˚	±3˚	˚
Wind speed	0~60 m/s	0.1 m/s	± 0.3m/s	m/s
Rainfall	0~500 mm	0.2 mm	< 0.4 mm	mm
Illumination	0~200000 lx	1 lx	±10%	lx
CO	0~1000 ppm	0.1 ppm	--	ppm
NO2	0~20 ppm	5 ppb	--	ppb
SO2	0~20ppm	5ppb	--	ppb
O3	0~20 ppm	5 ppb	--	ppb
TVOC	0~100 ppm	5 ppb	--	ppb

9.4 Advertising Push

9.4.1 Player Hardware Device

(a) Industrial computer is suggested

(b) Include SSD30GB or more

(c) At least one set (including) of HDMI output shall be included in image output

(d) Two or more 10/100/1000Mbps Ethernet networks shall be provided

(e) A set of sound source output terminals (Phone Jack) and digital sound source output (HDMI) are required

(f) At least one set of USB interface is required

(g) Compliance with CE, FCC, RoHS [142], BSMI and other safety regulations

(h) A set of wall hangers shall be provided for installation and use

9.4.2 File Playing Format

(a) Web page format: Support HTML、JavaScript、CSS3、HTML5、RSS /ATOM feed format

(b) Image files: JPEG, GIF, BMP

(c) Video files: MPEG (MPG,VOB), AVI (H.264), WMV, WMA, MP3, MP4

(d) Encoding format: MPEG-1/ 2, MPEG-4 ISO, WMV 7/8/9, H.264, H.265 (HEVC)

(e) Audio visual streaming: RTB/RTP/RTSP/HTTP/MMS

9.4.3 Player Management Function - General

(a) Support screen resolution: 1280x720 (720p), 1920x10803840x2160 or above (30/60Hz, single/copy); User defined screen resolution is supported.

(b) The device requires to be managed directly from a web browser without installing additional software.

(c) Support external storage devices.

(d) Support manual setting of system time or automatic timing with NTP server.

(e) With scheduling function, one-time activities can be arranged, or periodic scheduling can be set according to daily, weekly, monthly and annual time zones. The operator can specify a date, time range, or even set a schedule for a specific day of a week in a month. In addition, the user can set the schedule according to the position to greatly increase the flexibility of flexible application of the schedule.

(f) With the concept of resource library, it can manage various multimedia materials including video files, fonts, clocks, panels, programs and playlists. Users can upload the required fonts themselves or download the latest template resources from the cloud service for free.

(g) The preview function is provided to view the screen capture currently being played by the player, and the thumbnail of pictures and movie files is provided to facilitate archiving.

(h) It provides self-healing function, and can restart, shut down, restore the system, and remotely backup and restore settings.

(i) The operator can set the schedule to turn the screen on/off, adjust the volume of the player or restart the system.

(j) The setting schedule can be used to turn on/off the screen, adjust the volume of the player or restart the system.

(k) When equipped with multiple groups of HDMI outputs, it can support more than two screens to perform four different modes: single, copy, extend, and separate. It can support multiple screens to display different playing content.

9.4.4 Player Management Function - Play Block

(a) You can use memory blocks or full screen production to achieve content updates. Memory blocks can be designed through built-in layout creation tools. Screen memory blocks can support video memory blocks (video files/streaming/sound), HTML memory blocks, picture memory blocks, marquee memory blocks, clock memory blocks, and background pictures. Full screen design can use any kind of web page editing tools to create an unlimited number of video memory blocks, picture memory blocks, and marquee memory blocks of HTML pages.

(b) It supports various mainstream multimedia formats, and can play 4K UHD movies, HTML5, CSS3, JavaScript, pictures, music and text marquee. Support all kinds of real-time content, such as news, weather, community websites, video streaming or specific messages on the web.

(c) The screen can be divided into several blocks, each block can have its own schedule and settings

(d) The size and position of each panel block can be adjusted freely through the web page layout editor. Web designers can also use any web page editing tool to create unlimited number of HTML pages for movie blocks, picture blocks and marquee blocks

9.4.5 Player Management Function - Network

(a) The system can log in to the player's management platform Web Manager through offline operation (local login), remote operation DHCP (automatic IP setting), and remote

operation static IP address, regardless of whether it is in a network connected environment.

(b) It is equipped with two LAN ports with built-in firewall function.

(c) Files can be uploaded to the player through network sharing (network neighbor), Web Manager, FTP, USB storage device and CMS server.

9.4.6 Product Safety Certification

(a) CE

(b) FCC

(c) CB

(d) BSMI

9.4.7 Management Server Software Features - General

(a) Flexible management software, intuitive user interface and online help

(b) The server can easily switch its management interface to three roles: primary server, platform server and backup server, providing greater flexibility for project design

(c) Flexible central scheduling function, editing and management for once, daily, weekly, monthly, or annual time units

(d) Quick click to broadcast emergency information

(e) It can be matched with backup service to provide a stable playing environment

(f) Support the function of virtual host and cloud host monitoring through web management interface

(g) The system can access the user interface and open the multimedia folder through the user name and password

(h) Create multiple user accounts and set different access permissions for each account

(i) Manage files in two browsing modes: icon and list, and select specific files with file filtering function

(j) Upload files to CMS through FTP, Network Neighborhood, and CMS Web Manager

(k) The system manager can establish multi-level groups to systematically manage the content update and project scheduling of the digital billboard player. The CMS server

will centrally manage the playlists of all players, and automatically synchronize and update the playing content to the specified player group.

(l) The content of multiple players can be updated simultaneously according to the type of voucher purchased

(m) Specify the group to which each multimedia file belongs, and automatically synchronize and update the playing content to the specified player group

(n) CMS supports backup services (failover). When the primary server stops working or cannot be connected, the backup server will automatically take over all online connections. When the main server is restored, it will also be automatically reconnected to the player

(o) Manage files in icon and list browsing modes, and select specific files with file filtering function

(p) Scheduling items include panels, programs, playlists, videos, pictures, marquees, or HTML

(q) Emergency information can be presented through panel, program, playlist, video, picture or HTML

(r) Manually set the system time, or automatically calibrate with the NTP server

(s) Provide Chinese (traditional) and English operation interfaces

(t) Provide system update files and firmware update notifications, and generate log files according to system status

(u) Be able to restart/shut down/restore the system, and remotely backup/restore settings

9.4.8 Management Server Software Functions - Advanced

(a) It should be able to view the detailed system information, log and content update status of multiple players at one time, without having to log in to the management interface of each player online.

(b) Support the batch setting function of multiple players. When the manager needs to set a large-scale player, he can first mark a benchmark player, and then synchronize the other players marked in the same group with the benchmark

(c) The system administrator can monitor the lists and files being played by multiple players at the same time in one screen, and preview the real-time playing screen

(d) When the player loses the connection with the CMS server, the system will mark the machine exception warning, and automatically send a warning email to all system administrators scheduled to receive it in real time (or according to the set schedule).

9.4.9 LCD Display Screen

(a) Outdoor full color lcd display single screen

(b) The installation methods are wall mounted and embedded. Wall mounted complete machine and embedded mechanism shall meet ip65 waterproof requirements of the complete machine, and the front of the display screen shall be installed with anti-collision glass to meet at least ik08 anti-collision requirements

(c) Average brightness>=1000 cd/m2, ensuring outdoor viewing demand

(d) Rated voltage/maximum power of the whole machine: 12 vdc,<40 w

(e) Suggested (but not limited to) size:<150 * 650 * 20 mm

(f) Suggested (but not limited to) weight: < 1 kg

(g) The lcd screen receives the audio and video of the media player through the hdmi or lvds interface and plays it on the lcd screen.

9.4.10 LED Display Screen

(a) It is suggested that p3.9 (but not limited to) outdoor full-color led display single screen

(b) The whole screen is composed of led modules for the convenience of subsequent maintenance and operation. The module box is formed by aluminum die casting

(c) The white balance brightness shall be at least 3000cd/m2 to fully ensure the outdoor viewing demand

(d) The best viewing distance ≥ 5m for video playback

(e) Rated voltage/input frequency/maximum power of the whole machine: 110/220 vac，50/60 hz，<200 w

(f) The whole display screen box (including power supply and signal interface) shall at least meet ip65 outdoor waterproof requirements

(g) Suggested (but not limited to) module size<130*500 mm

(h) Suggested (but not limited to) display box size<520*1500*100 mm

(i) Box weight:<25 kg

(j) The box is equipped with a led display control card, which can receive the signals from the media player and play them on the led display.

9.4.11 Network Speaker

(a) Functions:

(1) Network playback: the speaker can play audio files or instant audio streams from the remote end

(2) Real time broadcasting: remote computers can broadcast in real time

(b) Specification:

Table 9.4.11-1 Product Specification

Item	Symbol	Unit	Specification	Condition
Resonance Frequency	Fo	Hz	400 ± 20%	At 2.24V
Output S.P.L.		dB	92 ± 3dB (1W/1M)	At 1.0k,1.2k,1.5k,2.0Kz (Average figures)
Frequency Rang		Hz	Fo---10K	Output S.P.L. ±10dB
Distortion		%	5% Max.	At 1Kz , 1W, 50cm
Operating temp.		℃	-40℃ ~ +60℃	
Buzz & Rattle				Input 6.32V sine wave without abnormal sound from Fo to 10KHz
Material			Metal	The body is made of aluminum alloy
Environmental Protection Regulation			RoHS2.0 [143] / REACH [144]	Should comply with the latest directive requirements of the local government in the application field
Approvals			CE: EN 55032:2015 [145] EN 55035:2017 [146] EN 55024:2010 + A1:2015 [147] EN 50130-4:2011 + A1:2014 [148] EN 61000-6-3:2007 + A12011[149] EN 61000-6-1:2007 [150] FCC 47 CFR Part 15, Subpart B [151]	Should comply with the latest directive requirements of the local government in the application field

Network Interface			RJ45	10/100Base-TX Auto-Negotiation networ)
Network protocol			TCP、UDP、RTP、ARP、ICMP，DHCP，DNS，IGMP、HTTP	
Audio protocol			MP3、G.711a/u、G.722	
Power Supply			PoE Supply	Support IEEE 802.3af ，max.13W [152]
Power Consumption		W	<1W Static<1W 13W Max	No sound from speakers Speaker work
Waterproof			IP66 IP67	

9.5 Charging Post

9.5.1 Reference Scope

(a) CNS 15511-1 Electric Vehicle Conductive Charging System - Part 1: General Requirements [153]

(b) CNS 15511-2 Electric Vehicle Conductive Charging System – Part 2: Interface Requirements [154]

(c) CNS 15511-21 Electric Vehicle Conductive Charging System – Part 21: Electric Vehicle Requirements for Conductive Connection to an a.c./d.c. Supply [155]

(d) CNS 15,511-22 Electric Vehicle Conductive Charging System – Part 22: AC Electric Vehicle Charging Station [156]

(e) CNS 15511-3 Electric Vehicle Conductive Charging System – Part 3: Safety Requirements [157]

9.5.2 Application Speciation

Scope of application: The maximum input rated voltage of AC equipment is single-phase 220V, the maximum output rated voltage is single-phase 220V, and the maximum AC output rated current is 80A.

Charging mode: the definition of AC conductive charging standard is shown in

Figure 9.5.2-1 Electric vehicle charging mode:

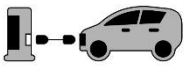
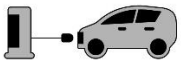
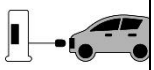
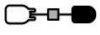
	AC conductive charging						DC conductive charging
	AC type 1		AC type 2A		AC type 2B		Direct current
Rated input voltage/input current of charging equipment	Rated current of single-phase AC 110V main line and shunt 15A/20A	Rated current of single-phase AC 220V main line and shunt 15A/20A	Single phase AC 220V main line and shunt rated current ≤ 100A		Single phase AC 220V main line and shunt rated current ≤ 100A		Triple AC 220V/380V
Rated output voltage/input current of charging equipment	110V, 12A/16A (AC)	220V, 12A/16A (AC)	220V, ≦80A (AC)		220V, ≦80A (AC)		≦600V (DC) ≦200A (DC)
Connection mode							
Illustration							
	Socket	15A/20A plug for general household	Special plug with communication function	Charging cable group with control box on cable	Charging cable group	Including electric control AC charging equipment	Including electric control DC charging equipment

Figure 9.5.2-1 Electric Vehicle Charging Mode (quoted from CNS 15511-3)

9.5.3 Safety Test Items

The safety test items specified in this standard and the charging system safety test items are divided into charging equipment test, power end plug and socket and vehicle end coupler test, and power supply equipment and electric vehicle integration test. Refer to CNS15511-3 for test contents.

(a) Safety test method for charging equipment

The charging equipment test process is described in Figure 9.5.3-1:

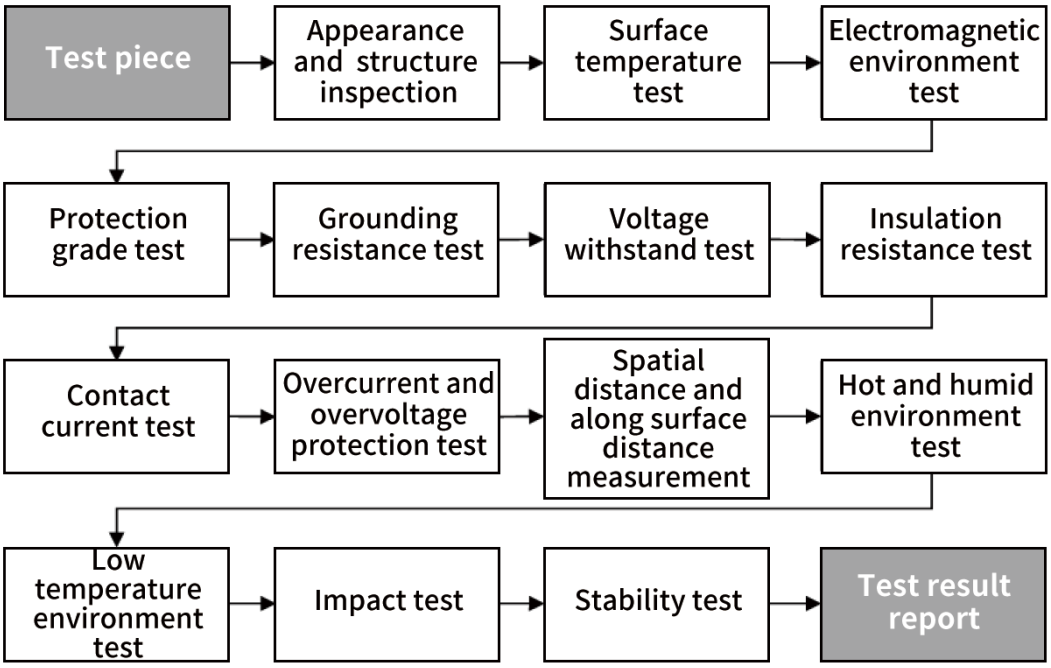


Figure 9.5.3-1 Charging Equipment Test Flow (Quoted from CNS15511-3)

Note 1: The number of samples required to complete all tests is recommended to be 1 group (if necessary, another new sample can be used for electromagnetic environment test). New samples can also be used for each test according to the manufacturer's requirements.

Note 2: The arrow direction indicates the test sequence.

(b) Power end plug, power socket and vehicle end coupler test

The test process of power plug, power socket and vehicle coupler test is shown in Figure 9.5.3-2:

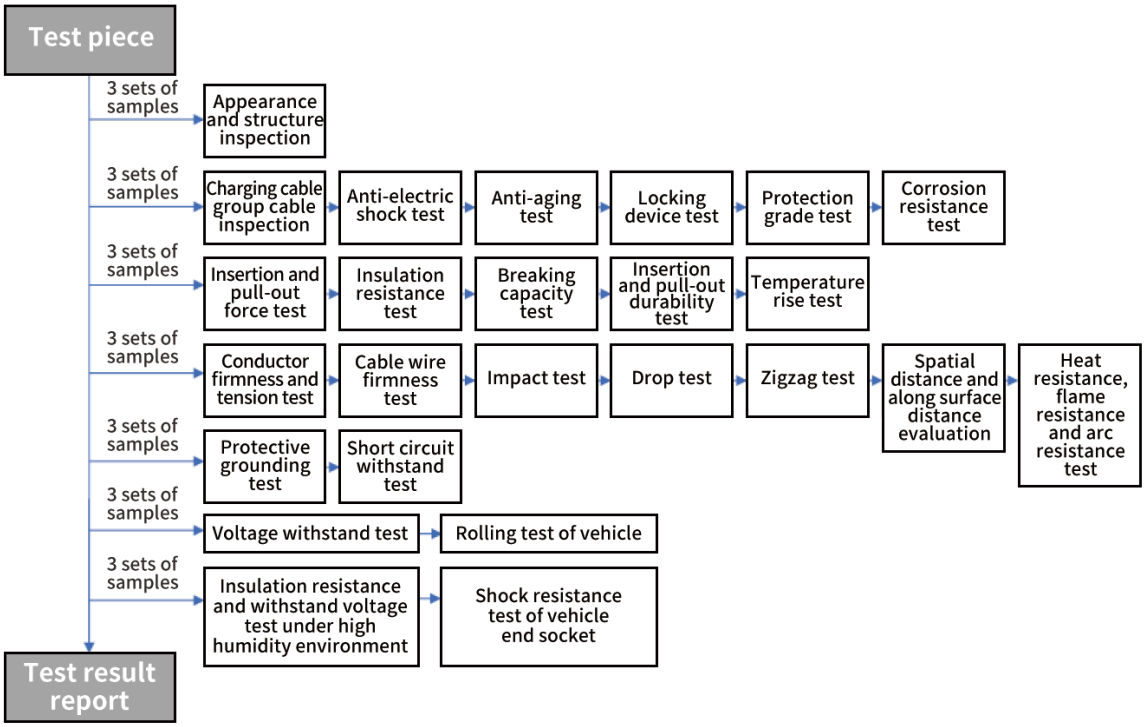


Figure 9.5.3-2 Test Process of Power End Plug, Power Socket and Vehicle End Coupler (Quoted from CNS15511-3)

Note 1: The number of samples required to complete all tests is suggested to be 21 groups (if necessary, a new sample can be added for corrosion resistance test). For test items without new samples, use the samples after the previous test. New samples can also be used for each test according to the manufacturer's requirements.

Note 2: The arrow direction indicates the test sequence.

(c) Integration test of power supply equipment and electric vehicle

The test process of integration test of power supply equipment and electric vehicle is shown in Figure 9.5.3-3:

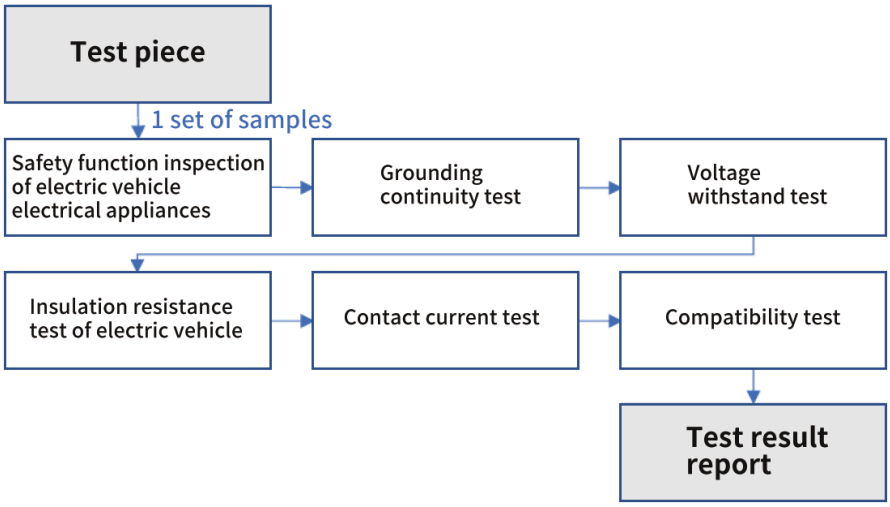


Figure 9.5.3-3 Integration Test Process of Power Supply Equipment and Electric Vehicle (Quoted from CNS15511-3)

9.5.4 Description of Charging Point and Central System Interface

OCPP is a standard open protocol for communication between charging point and central system, mainly regulating any type of charging technology. Smart charging, OCPP using JSON over Websocket, better diagnostic possibilities (causes), more charging point states, and TriggerMessage.

9.6 Emergency Call

9.6.1 Application Situation of Emergency Call System

(a) Application situation: In case of an emergency, you can call for help from the police in the area or the park guards through the "emergency call interphone" on the smart pole. After pressing the interphone button, the police can not only make real-time two-way calls, but also see the front scene images, to speed up the identification of the emergency situation and grasp the timeliness of reporting.

9.6.2 Software Function of Emergency Call System

(a) Emergency interphone function

(1) It can integrate the existing IP network system and support the international standard agreement for SIP calls.

(2) It can call 5 video phones on the desk at the same time (it can be placed in the police station and guard room).

(3) Real time video recording equipment or event triggered video recording equipment can be expanded.

(4) The guard room staff can actively connect each emergency interphone via video interphone, and can watch the real-time video and hear the on-site voice.

(5) In the future, IP host (such as SIP SERVER) can be used to record the intercom and rescue record of each emergency walkie talkie to obtain event video data.

(6) Advanced models shall have the following functions

(6.1) It has the detection functions of image dynamics, vandalism, sound, alarm, network

(6.2) Up to 1080P 30 FPS can be output simultaneously in four streams in H.264 or MJPEG format.

(6.3) Multi compression technology can compress digital images to 1080P and 720P resolutions.

(6.4) Built in audio and video intelligent analysis engine to transmit EMAIL or FTP snapshot alerts.

(6.5) Independent setting function for day and night image scheduling.

(6.6) The compression rate BIT RATE and the number of sheets can be dynamically adjusted.

(6.7) Support network time calibration (NTP) communication protocol.

(6.8) Support dynamic domain name server DDNS.

(6.9) Support ONVIF communication protocol.

(6.10) HTTP API software integration support.

(6.11) SD card local video recording.

(b) EMERGENCY INTERPHONE FUNCTION

(1) It supports 16 lines, up to 16 SIP accounts, up to 7 channels of audio conference and 3 channels of 720P 30FPS high-definition video conference. The phone book can contain up to 1000 contacts and 1000 call records.

(2) It supports two 10/100/1000MBPS self-adjusting switching network interfaces, dual band 2.4G and 5G WIFI (802.11A/B/G/N), POE/POE+, Bluetooth 4.0+EDR, USB, SD, HDMI, and built-in EHS module.

(3) 7 "(1024X600) capacitive (5-point) touch screen, tilting megapixel CMOS camera lens with hidden bezel.

(4) Support high-definition broadband audio, full duplex hands-free speaker with high-definition sound, acoustic echo cancellation and two-way communication performance.

(5) Support ANDROID system, use GOOGLE's API, and install required ANDROID applications according to business requirements.

9.6.3 Hardware Specification of Emergency Call System

(a) Requirements and specifications of emergency interphone

(1) The online mode supports ETHERNET network connection.

(2) Support SIP, TCP, UDP and RTSP communication protocols.

(3) The camera lens supports a 90 degree wide-angle lens.

(4) The image resolution shall be at least 1280 X 720.

(5) The image compression format shall at least support H.264 and MOTION JPEG.

(6) Support G.711 voice compression format.

(7) Support infrared LED fill light to avoid too dark at night.

(8) The loudspeaker is built in order to facilitate outdoor communication. The maximum sound pressure level (SPL) of the loudspeaker is defined as more than 70 dB (DB) under the test condition of 1W/1M in the silent room.

(9) Hardware chip eliminates echo.

(10) Built in high sensitivity microphone to improve outdoor radio quality.

(11) At least two installation modes are supported: embedded or wall mounted.

(12) Support IP65 waterproof grade.

(13) At least one set of DI dry contacts shall be built in to connect the emergency buckle.

(14) At least one set of DO dry contacts shall be built in and connected with flash drum, warning light, door opening controller and other devices.

(15) Rust proof material is required to avoid rust.

(16) High order models shall have the following specifications:

(16.1) Support IP66 waterproof grade

(16.2) It supports WDR wide dynamic, and can perfectly present the brightest and darkest memory blocks in the picture. WDR wide dynamic can extend the visibility of the picture itself and thus improve the image quality.

(16.3) Support night enhancement mode: it can provide high-quality images without dynamic blur when the light is insufficient. Even in the dark area at night, the picture can still be captured clearly.

(16.4) The built-in MICRO SD/SDHC memory card slot provides additional backup video protection. Its memory card can update video and image backup synchronously with the central image management software.

(b) Requirements and specifications of video telephone

(1) Support the following protocols/standards:

(2) The network interface supports two 10/10 0/1000MBPS switched self-adjusting Ethernet interfaces, POE/POE+

(3) Image display supports 7-inch high-definition capacitive touch screen, 5-point touch, resolution of 1024 × 600

(4) The camera lens is equipped with a hidden baffle that can be tilted. The camera lens is a megapixel CMOS camera lens, 720P@30FPS

(5) Integrated Bluetooth 4.0+EDR

(6) Wifi supports dual band 2.4 & 5GHz 802.11 a/b/g/n

(7) Auxiliary interface supports RJ 9 headset interface (matching PLANTRONICS EHS headset), USB2.0 interface, 3.5mm headset interface, SD card interface, standard HDMI interface (1.4 up to 720p30fps)

(8) Function keys shall include VOLUME+/-, HOME, MENU, BACK, and others

(9) Voice coding supports G.711μ/A, G.722 (WIDE BAND), G.726 32, ILBC, OPUS, G.729A/B IN BAND AND OUT OF BANDDTMF (INAUDIO,RFC2833,SIPINFO), VAD, CNG, AEC, PLC, AJB, AGC, ANS

(10) The image encoding capability supports H.264BP/MP/HP video resolution up to 720pHD, picture playback rate up to 30fps, bit rate up to 2Mbps, three party video conference, anti shake, auto focus and auto exposure.

(11) The telephone function shall support call holding, transfer, forwarding (unconditional transfer, no response transfer, busy transfer), call parking and receiving, seven party voice conference, SCA/BLA virtual MPK, downloading phone book (XML, LDAP), call waiting, call recording, flexible dialing rules, HOT DESKING, personalized ring tone, server redundancy fault-tolerant transfer.

(12) HD audio shall have distortion free full broadband audio receiver and full duplex with echo cancellation. Handsfree handset speaker.

(13) The base has its own bracket, which supports multi angle placement and wall mounting bracket.

(14) QOS Supports LAYER 2 QOS (802.1Q [158], 802.1P [159]) and LAYER 3 (TOS, DIFFSERV, MPLS) QOS。

(15) User and administrator level access rights, MD5 and MD5-SESS authentication, 256 bit AES encryption profile, TLS/SRTP/HTTPS/802.1x media access control.

(16) Support multiple languages, such as Chinese, English, German, Italian, French, Spanish, Portuguese, Russian, Croatian, Korean, Japanese and others

(17) Input： 100 240V AC 50～60HZ；Output： 12VDC 1.5A (18W)

(17.1) PoE*802.3 at Class3 [160]

(17.2) PoE+802.3 at Class4 [161]

(18) Certification standards

(18.1) FCC: Part 15 (CFR 47) Class B; UL 60950 (power adapter) [162]; Part68 (HAC) [163]

(18.2) CE: EN55022ClassB [164], EN55024 [165], EN61000 3 2, EN61000 3 3 [166], EN60950 1 [167], EN62479 [168], RoHS [142]

(18.3) RCM: AS/ACIF S004 [169]; AS/NZS CISPR22 [170] /24 [171]; AS/NZS 60950 [172]; AS/NZS 4268 [173]

(18.4) IC: ICES 003 [174], RSS 247 [175], CS 03 [176], RSS 102 [177]

9.7 Edge Computing

Because the edge computing system needs to be placed in the loop control box of the smart stick, and because the outdoor environment is not as harsh as the indoor environment, it needs to

maintain long-term and stable operation. Because the edge computing system needs to be placed in the loop control box of the smart stick, and because the outdoor environment is not as harsh as the indoor environment, it needs to maintain long-term and stable operation.

9.7.1 Hardware Specification

(a) In order to meet the needs of high-speed and artificial intelligence computing, it is necessary to configure the latest multi-core processor with high computing power and graphics processor, such as Intel's 10th generation Xeon®W or Core ™ (or above) processor, or a platform equivalent to AMD.

(b) In order to meet the requirements of high-speed and huge data processing, it is necessary to configure a large memory with a capacity of at least 128G.

(c) In order to meet the application of edge computing, it must be able to support the hardware design of virtual machine (VM) and container.

(d) In order to meet the huge data demand of high-speed and artificial intelligence computing, it provides a variety of storage device interfaces: SATA, M.2 or CFAST and RAID 0/1/5/10 data storage backup and hot plug functions. The 2.5 inch SATA or U.2, U.3 or E1.S storage devices can be directly replaced outside the enclosure to facilitate rapid maintenance.

(e) Different kinds of expansion cards can be configured, such as PCIe x16/PCIe x8/PCIe x4 or PCI interface cards, which can accommodate PCIe x16 GPU cards (NVIDIA's latest AMPERE RTX A2000 architecture display card) to support information collection required for expanding industrial applications and accelerate AI computing capabilities.

(f) I/O interfaces with diversity and electrostatic and surge protection design: COM, DI, DO, USB. These interfaces can connect a variety of sensors and peripheral devices, and can avoid sudden abnormal high voltage or high current intrusion and equipment damage caused by static electricity.

(g) To meet the data upload and download requirements and remote management function configuration, more than 3 Ethernet interfaces need to be configured. Among them, two Ethernet interfaces are preferred to support Ethernet power supply interface (IEEE 802.3 AF, PSE).

(h) Configure diversified wireless communication capabilities, such as WIFI, Bluetooth, 4G LTE, 5G, etc., to flexibly handle the lack of cable transmission alternatives.

(i) In order to meet the requirements of the use environment, the size of the machine (202mm (W) x 290mm (D) x 209.3mm (H)) must be able to be accommodated in the narrow smart pole loop control box, and have IP31 dust-proof and waterproof protection.

(j) The anti-seismic design of the whole machine shall meet the requirements of IEC-60068 [178] specification and the operating temperature range of the system can operate normally at -40~70 ° C to cope with the harsh outdoor operating environment.

(k) It supports flexible power supply voltage input range (9~36 V) and is equipped with OVP/UVP/OCP, power reverse insertion protection function and surge protector to avoid system damage due to unstable voltage and wrong operation.

9.7.2 Application Service

(a) Collect various forms of data through various interfaces, such as the health status of the smart stick, environmental detection data and other data, and then perform operational analysis and form control decisions or alarm processing.

(b) The camera attached on the smart pole captures the image and video, and then performs AI image analysis to complete the vehicle flow and license plate recognition function.

9.8 Ethernet Switch

(a) It is recommended (but not limited to) 10/100/1000 Base-T port IEEE 802.3 AF/AT industrial POE network management type ethernet network switch with RJ45 interface. The power output of each group of POE PORT can be provided through the management software. If it is a non network management POE SWITCH, it is necessary to use other metering methods to measure the power output of each group of POE PORT;

(b) It is recommended to have SFP PORT at the same time (but not limited to) and can install SINGLE MODE or MULTI-MODE OPTICAL TRANSCEIVER;

(c) Recommended (but not limited to) 48~57VDC Input

(d) Working temperature：-40℃~70℃, Working humidity：5%~95%；

(e) Recommended size (but not limited to): 154 MM (H) x 96.4 MM (W) x 105.5 MM (D);

(f) Weight:<2KG

(g) Installation mode: Industrial guide rail type and wall mounted type;

(h) SNMP swPoEMIB (1.3.6.1.4.1.171.12.24) shall be supported and at least the following items shall be included:

swPoEPortInfoEntry (1.3.6.1.4.1.171.12.24.4.1.1)

swPoEPortInfoPortIndex (1.3.6.1.4.1.171.12.24.4.1.1.1)

swPoEPortInfoClass (1.3.6.1.4.1.171.12.24.4.1.1.2)

swPoEPortInfoPower (1.3.6.1.4.1.171.12.24.4.1.1.3)

swPoEPortInfoVoltage (1.3.6.1.4.1.171.12.24.4.1.1.4)

swPoEPortInfoCurrent (1.3.6.1.4.1.171.12.24.4.1.1.5)

swPoEPortInfoStatus (1.3.6.1.4.1.171.12.24.4.1.1.6)

swpoEPortInfoLedStatus (1.3.6.1.4.1.171.12.24.4.1.1.7)

9.9 Wireless Network Controller

(a) It can manage WIFI AP on smart poles, and provide various public login and account management mechanisms to control WIFI access and QOS of users on each AP.

(b) If there is no compatible WIFI AP, it can also be placed in the loop control box. Flow confirmed by actual control user.

(c) The minimum specifications of the controller are shown in the following table:

Table 9.9-1 Minimum Specifications of Controller

Connecting port	
Ethernet	At least 4 networks above GbE
Performance	
Throughput (Gbps)	4 Gbps above
Number of management APs	Minimum 64
Wireless network function	
Wireless Network Security Mode	Yes
Dynamic channel selection	Yes
AP multicast settings	Yes
AP Load Balancing	Yes
AP planning and inspection	Yes (AP planning and coverage detection)
Frequency band selection detection	Yes
Client signal strength limit	Yes
AP automatic backup	Yes
Safety function	
IEEE 802.1X	Yes
Layer 2 isolation	Yes
Web authentication	Yes

Firewall function	Yes
MAC filtering	Yes
External RADIUS authentication	Yes
Microsoft AD Authentication	Yes
LDAP authentication	Yes
Built in RADIUS server	Yes
Identity based user security management	Yes
Illegal AP detection	Illegal AP detection and illegal AP suppression
Control and configuration functions	
Manage AP Discovery	Broadcast/DHCP option/DNS/Manual
CAPWAP	Optional
AP data transmission mode	Distributed (local forwarding)/centralized (data channel)
Management interface	HTTP/HTTPS/Telnet/SSH/SNMP
Output power control	Yes
Package capture	Wired/Wireless
Network function	
VLANs	Yes
DHCP client	Yes
DHCP relay, server	Yes
NAT	Yes
Static route	At least 1024
Policy based routing	At least 1024
Access control	
MAC control list	Yes
MAC authentication	Yes (Inside/Outside RADIUS)
Customized login page	Yes
Quality service	
WMM	Yes
WMM Energy Saving	Yes
DiffServ logo	Yes
AP Load Balancing	Yes
Management function	
SSH Command Line Interface	Yes
SSL Web based management interface	Yes
SNMP	v1, v2c, v3
Multi level management authority	Admin, guest operator
User/Application Management	
Certification	RADIUS/Microsoft AD/LDAP/Local
Built in user database	Yes (At least 4096 users)
User/Group Policy	Yes
Mandatory login authentication	Yes
External login page	Yes
Login page upload	Yes
Others	
System analysis tools	Yes
Device backup capacity	Yes
Authentication	

Electromagnetic interference	·EMI and susceptibility (Class A) [179] ·FCC Part 15.107 [180]and 15.109 [181] ·CE EN55022 [164], EN55024 [165] ·ERP Lot 6 [182] ·BSMI CNS13438 [132]
Security	·LVD EN60950-1: A12 ·BSMI CNS14336

Appendix A Reference Design of Pole Top Chamber and Interface Flange for Small Base of Telecommunication Network

A.1 Pole Top Chamber for Small Base of Telecommunication Network

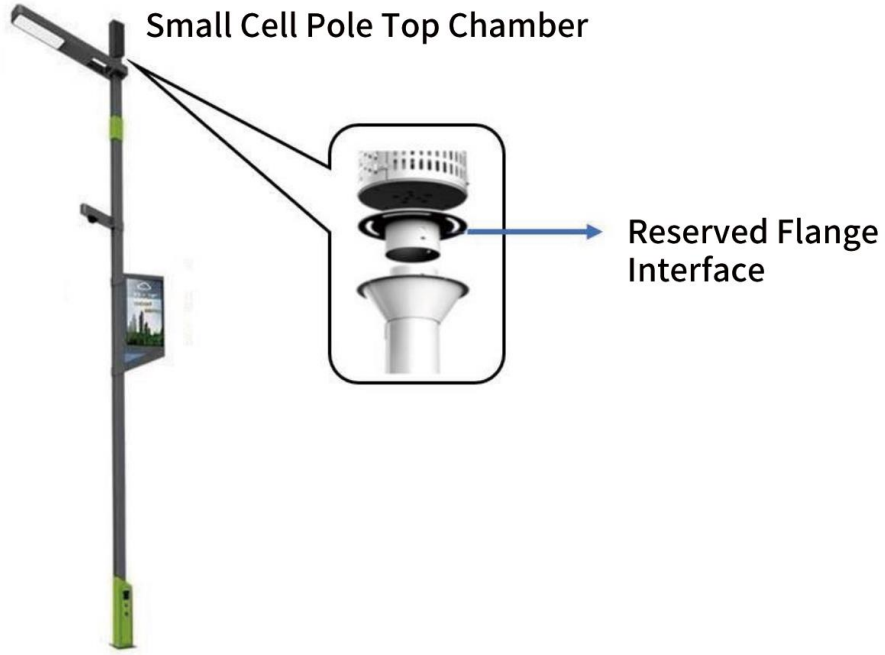


Figure A.1 Diagram of the pole top chamber for small base

Figure A.2 Diagram of the pole top chamber for small base (Cylindrical)

A.2 Reference specification of small base pole top chamber

Reference dimensions and specifications of bucket type small base pole top chamber:

Outer diameter：φ380 mm，height：1100 mm。weight：Less than 90 kg

A.3 Pole top flange interface requirements

The flange plate interface is reserved on the top of the 5G smart pole, and the flange plate can be fixed on the top of the pole by splicing or welding. Splicing should be adopted, and the recommended length of splicing part should be 400 mm.。

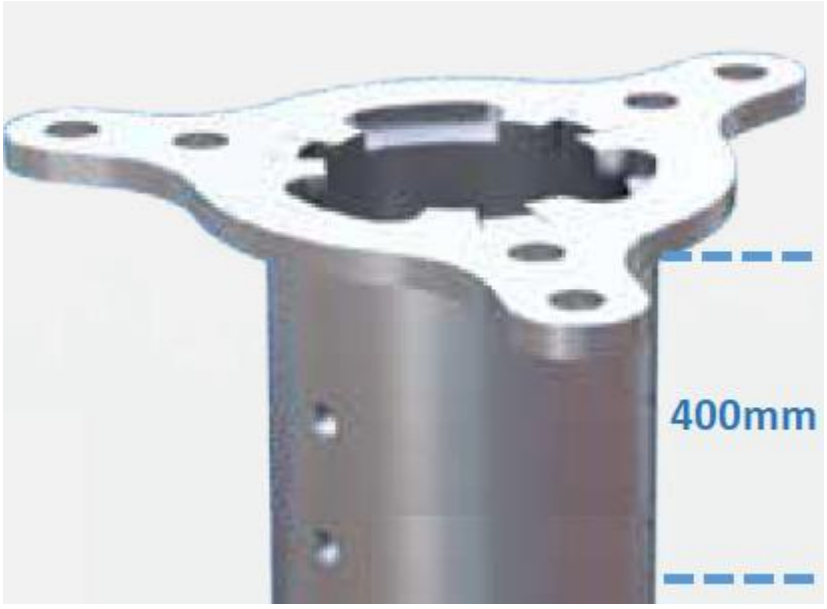


Figure A.3 Diagram of Pole Top Flange Interface

The three waist shaped holes of the flange plate are connected with the top chamber of the small base bench, so that the horizontal angle can be adjusted and the scale can be printed. The size of flange waist hole is shown in Figure A.4, except the outer diameter φ 380 can be adjusted properly, and other dimensions are recommended to be consistent with the following figure.

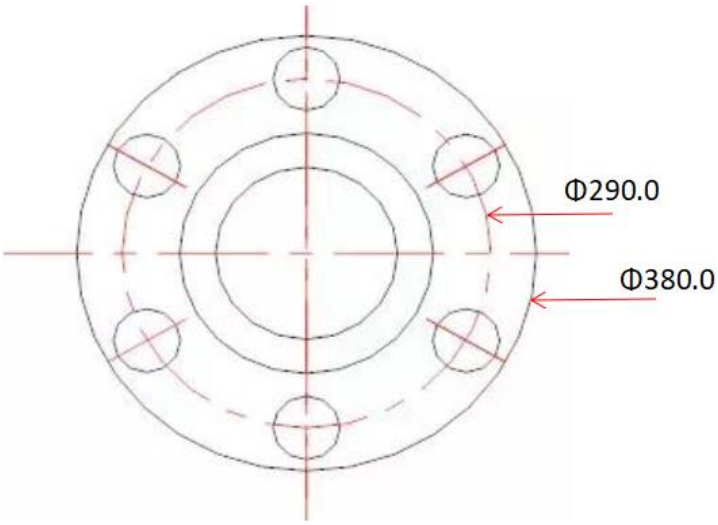


Figure A.4 Diagram of Pole Top Flange Interface Dimensions

The inner diameter of flange plate should be greater than 90 mm (for the convenience of reserving enough space for power line and optical fiber routing of small base platform), and the actual size should be determined according to the pole size. The thickness and strength of the flange plate shall be designed according to the actual use of the small base platform top pole chamber.

Appendix B Extension of Reference Design for Smart Poles of Type 2 Main Trunk Roads

B1 Cable Routing

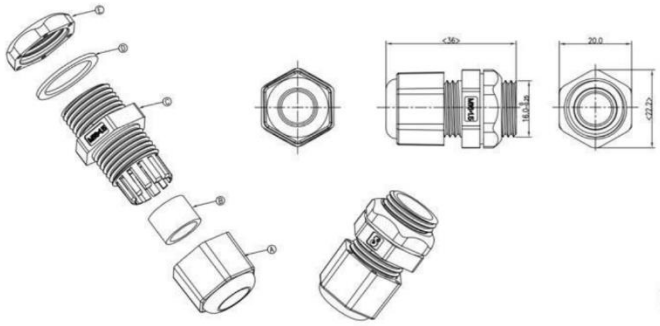
B2 Connector Model and Specification Suggestions

– SINGATRON：

Cable Gland Waterproof Connector

SGConn 2CT3100/ 2CJ30XX series
Cable Gland/ Cable Joint, IP67, IP68 Waterproof Connector

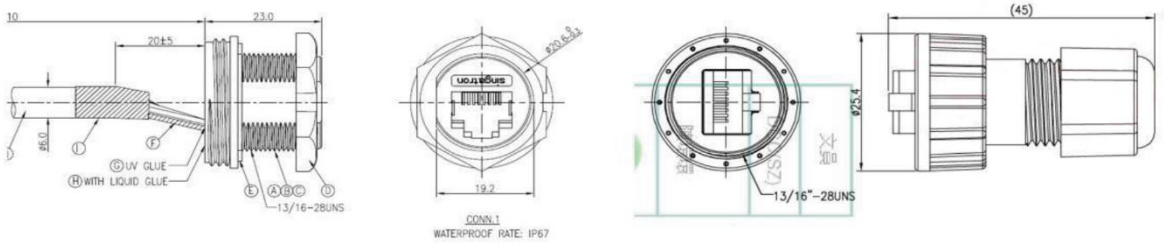
Product application: large machines and tools, industrial conveying equipment, outdoor lighting, outdoor network communication equipment (AP/Bridges)



RJ45 Waterproof Connector

SGConn 2TJ30XX series RJ Waterproof Connector
RJ45, CAT-5e/ CAT-6, IP67 Waterproof Connector

Product application: outdoor electronic signage,
outdoor electronic signs, outdoor network communication
equipment (AP/Bridges/Base Station), security system



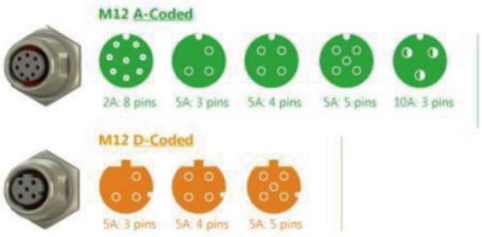
M12 Waterproof Connector

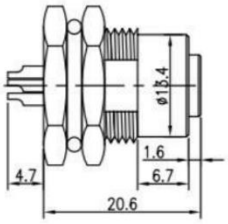
SGConn 2MT30XX series M12 series waterproof connector
M12 Size, Sensor, IP67, IP68 Waterproof Connector

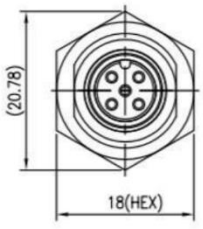
Product Application: Large Heavy Machine,
Industrial Control Panel, Sensor, Electric Bicycle

Terminal Type

- Applicable Current：0.5A, 2A, 5A
- Number of Terminals：3-5, 8 Contacts







Circular Waterproof Connector（Middle Size）

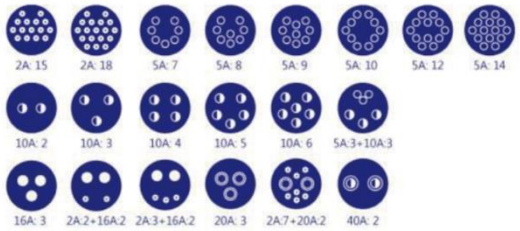
SGConn 2CM3OXX series circular waterproof connector
Circular Middle Size, IP67 Waterproof Connector

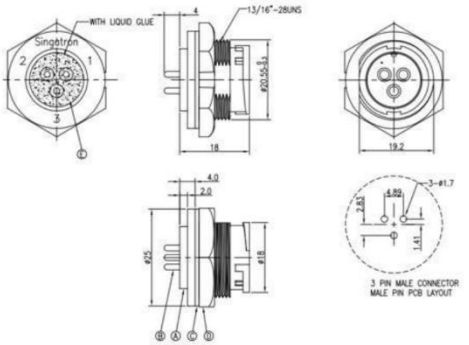
Product application: industrial control panel, outdoor lighting, outdoor electronic signage, outdoor electronic signs, measuring machines and tools, agricultural electronic equipment

Terminal Type

- Applicable current：2A, 5A, 10A, 16A, 20A, 40A, 5A+10A, 2A+16A, 2A+20A
- Number of terminals：2~10, 12, 14, 15, 18, 7+2 contacts

Circular Middle Size
2A: 15, 18 pins
5A: 7-10, 12, 14 pins
10A: 2-6 pins
5A+10A: 3+3 pins
16A: 3 pins
2A+16A: 2+2, 3+2 pins
20A: 3 pins
2A+20A: 7+2 pins
40A: 2 pins





– JPC：

JPC connectivity

Waterproof Connector

Waterproof Connectors-M8

JPC connectivity

Plug

Plug Cable

Receptacle

Waterproof Connectors-M12 D-Code

Plug

Plug Cable

Receptacle

Panel Mount

Waterproof Connectors-M12 A-Code

JPC connectivity

Plug

Plug Cable

Receptacle

Panel Mount

DIP For PCB

Waterproof Connectors-M12 X-Code

Plug

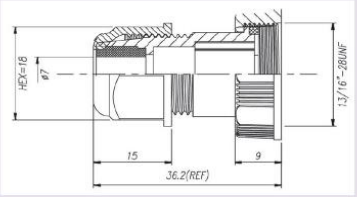
Receptacle

DIP For PCB

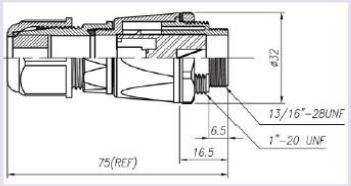
Waterproof Connectors-RJ45

JPC connectivity

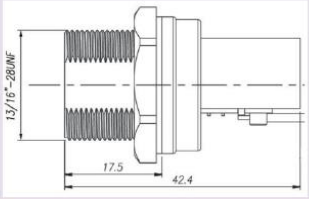
Plug



Plug Adapter



Receptacle Adapter



M12 X-Code Cable assy

JPC connectivity

10 Gbps

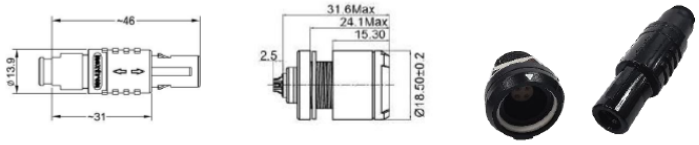
M12 X-coded to RJ45 cable

M12 X-coded to M12 X-coded cable

Product specification

1. Cat.6A data transmission rate up to 10Gbps(500MHz)
2. IP67 waterproof rating
3. Vibration proof
4. Corrosion resistant
5. UL 94V-0 rated material
6. Compliant with IEC 61076-2-109
7. Current rating: 0.5A (max)
8. Rated voltage: 50V (max)
9. Insulation impedance(DC 500V, 1 minute, the results comes out): 100 MΩ MIN
10. Withstanding voltage: AC 800V, 1 minute
11. Contact resistance: DC 1A the results comes out Max 10 Ω
12. 1000 mating cycles
13. M12 screw locking mechanism
14. Temperature range: -40°C to +85°C

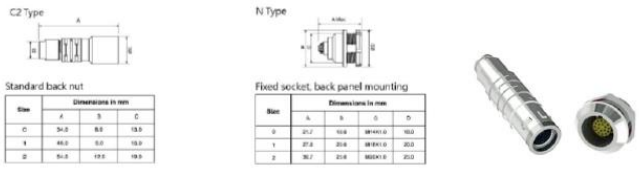
Plastic IP67 Push-pull connector



- Size: 1P/2P
- 1P Pin number: 2~14 pin
- 2P Pin number: 2~34 pin
- Solder cup contact
- Cable diameter: Ø2.7mm to 6.5mm
- Mating cycle: over 2,000 times
- Working temperature: -50 ~ +90 ℃

Number of contacts		02	03	04	05	06	07	08	09	10	14
View from termination side	Male										
	Female										
Test voltage(kv rms)		1.2	1.2	1.2	1.05	1.05	1.05	1.05	0.85	0.85	0.8
Rated current		10	10	8	7	6	5	5	3	3	2
Creepage and clearance distance(mm)		1.3	1.3	1.2	0.8	0.85	0.85	0.8	0.65	0.5	0.5
Cable MAX. AWG		20	20	22	22	26	26	26	28	28	28
Solder bucket Φ(mm)		1.1	1.1	0.85	0.85	0.65	0.65	0.65	0.45	0.45	0.45
Contact Φ(mm)		1.3	1.3	0.9	0.9	0.7	0.7	0.7	0.5	0.5	0.5

Metal IP67 Push-pull connector

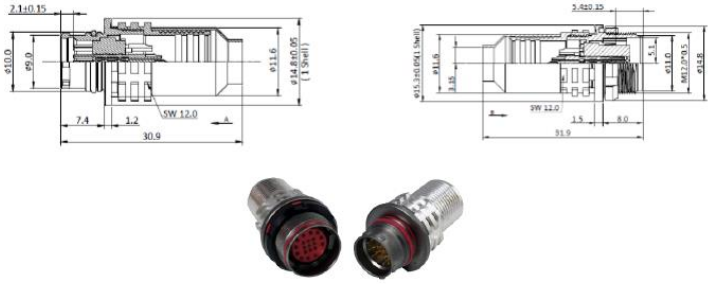


- Size: 0K/1K/2K
- 0K Pin number: 2~9 pin
- 1K Pin number: 2~16 pin
- 2K pin number: 2~32 pin
- Solder cup contact
- Cable diameter: Ø1.0mm to 8.5mm
- Mating cycle: over 5,000 times
- Working temperature: -55 ~ +200 ℃

Type	1B / 1T / 1K									
Male										
Female										
Contact Code	02	03	04	05	06	07	08	10	14	16
No.of Contacts	2	3	4	5	6	7	8	10	14	16
ContactsØ(mm)	1.3	1.3	0.9	0.9	0.7	0.7	0.7	0.5	0.5	0.5
Test Voltage (kv rms)	1.50	1.30	1.35	1.25	1.05	0.95	0.95	0.90	0.80	0.80
Current (A)	15	12	10	9	7	7	5	2.5	2	1.5

JPC connectivity

Metal IP67 Break-away connector



- Size: 00/0/1
- Size 00 : 4 or 5 pin
- Size 0 : 10 pin
- Size 1 : 21 pin
- Solder cup contact
- Mating cycle: over 2,500 times
- Working temperature: -51 ~ +125 ℃

Size	Diameter	Pin number	Signal type	High frequency
1	Ø14.8	21	HDMI	10.2 Gb/s
0	Ø12.8	10	USB 3.1(gen1)	10 Gb/s
00	Ø9.8	4 & 5	USB 2.0	480 Mb/s

—ACES

ACES GROUP

- Receptacle / Plug with Waterproof Cable Glands & Joints
- IP67 Fiber Optic Patch Cables Designated for Outdoor Application
- Field Installation Type
- Customized Cable Assembly Service to Fit-in Poles

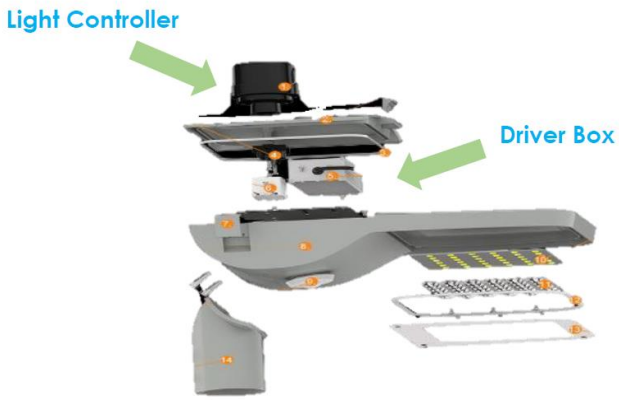
ACES GROUP

- IP54 or IP55 cabinets, can do cables at the same level if needed.
- Integrated sensor cables(Twilight, Thermal) to connect with controllers / circuit boards.
- Ring type cables for power connections
- Ethernet / Fiber-Optic connectors and cables
- USB receptacle for data access
- Related connectors / cables for HMI panel
- RF Antenna products for WiFi usage

ACES GROUP

Exploded Drawing for Street Lighting

1. Micro & Mini Fit / WTBs / Pin Headers for Light Controller and Driver Box
2. VDE Certificate is discussable



ACES GROUP

Exploded Drawing for Surveillance Camera

Our Products used in CCTV Cameras –

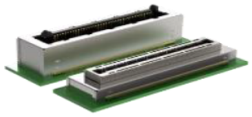
1. Wifi Antenna
2. RF Coaxial connector
3. BNC / SMA / RCA
4. WTBs
5. FPCs
6. RJ45s

ACES GROUP

Stack-shield series family

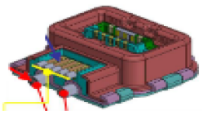
Aces ***Stack-shield*** series has a high data transfer rate up to PCIe Gen3/Gen4 and also has full shielding with multiple grounds for mitigating EMI issue.

Ideal for router, server, desktop, all in one NB, edge computing and other telecom relevant applications.



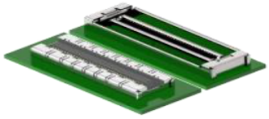
- **BTB 0.8p 10~15H(Available)**
  p/n : 51079,51080
  Pin counts: 40 , 80
  Data rate : PCIE 4.0
  2.45 / 5G EMI shield

- **Micro coaxial connector 0.4p 2.2h(Available)**
  P/n : 51495 , 51496
  Data rate : PCIe4 , USB3.1 , eDP1.4 , TBT3
  2.45 / 5G EMI shield

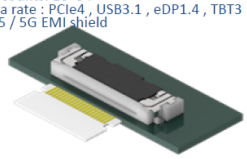


- **mmwave antenna flyover cable solution(sample 7/E)**
  antenna : Qualcom QTM525 module
  2.45 / 5G EMI shield

- **BTB 0.5p 3~7H(in develop)**
  Pin counts: 40 , 80
  Data rate : PCIE 5.0
  2.45 / 5G EMI shield



- **FPC To B 0.5p 1.5mm H(in develop)**
  Pin counts: 10~34
  Data rate : PCIe4 , USB3.1 , eDP1.4 , TBT3
  2.45 / 5G EMI shield



ACES GROUP

2.92mm High Frequency RF

ACES

Operation frequency : 40GHz
VSWR: 1.3 MAX
Operation temperature : -55~105 degree C

2020 Q4 | 2021 Q1 | 2021 Q2 | 2021 Q3

1. 2.92 female to female
2. 2.92 male to female
3. 2.92 male to male
4. 2.91 vertical mount

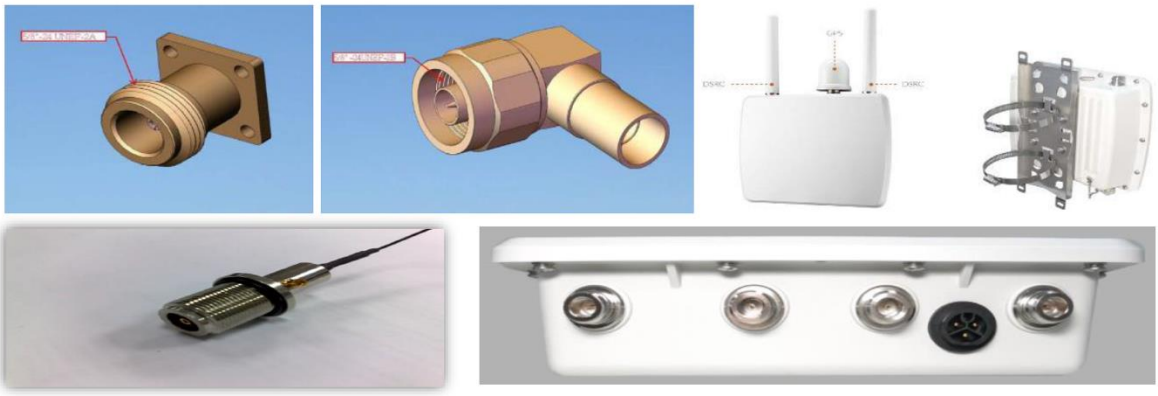
2.92 edge mount with screws

ACES GROUP

High Frequency RF

N Type Connectors

For Small Cells
Operation frequency : 40GHz



ACES GROUP

Our Cable Types

Customized Cables which meets outdoor circumstances –
Storage Temperature -40˚ C~85˚ C , UL94V-0…etc.

PTC, NTC Sensor Cables

Power Cables
Grounding Cables…etc.

ACES GROUP

Our Cable Types(Continued)

Patch cord: RJ45 / AOC / Oculink
Pigtail: Harness / AOC

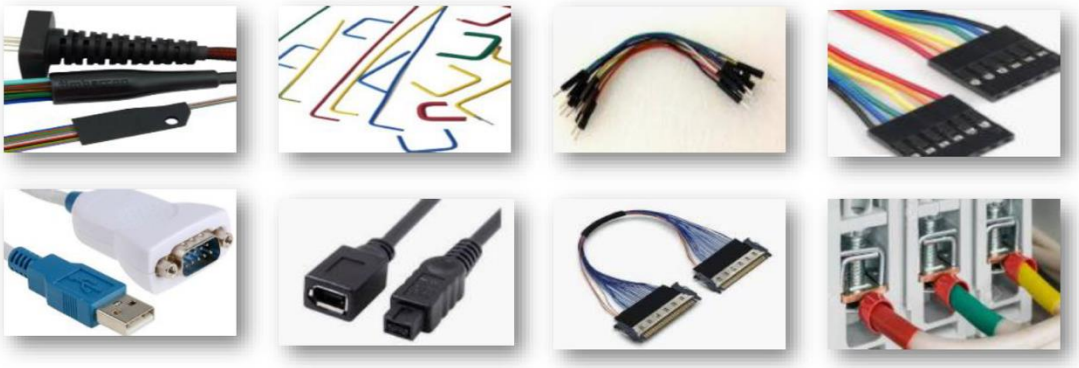
Patch Cord

Pigtail

ACES GROUP

Our Cable Types(Continued)

Molding Cables / Bending Wire / Power Cord /
RS232-485 / IEEE1394 / LVDS / Jumper / Breaker

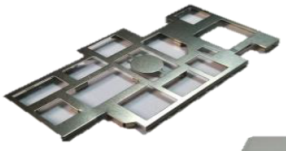


ACES GROUP

Customized Stamping Parts

Processing Scope:

1. **Stamping Service for All Kinds of Metallic Materials**
   - a) **Small Size**：
     EMI Shielding , HD Bracket, CPU Bracket, Fan Bracket...etc.
     Size Range(Unfolded): 10*10mm ~ 100*100mm
     Applicable Machine Tonnage: 20T ~ 100T
   - b) **Medium Size:**
     SATA Box, Router, Mini PC, Switch, Heat Spreader, Middle Frame...etc.
     Size Range(Unfolded): 100*100mm ~ 500*500mm
     Applicable Machine Tonnage : 80T ~ 250T
   - c) **Large Size:**
     Server, Kiosk, Indoor / Outdoor Control Box, Automotive Parts
     Size Range(Unfolded): 100*100mm ~ 500*500mm
     Applicable Machine Tonnage: 100T ~ 400T



2. **Additional Processing**
   - a) **Assembling Accessories:**
     Mylar Sticking, Riveting, Tapping, Component Assembling
   - b) **Finishing:**
     Plating, Electrochemical Corrosion, Paint Baking, Sandblasting, Laser Engraving, Brushing, Anodizing, Passivation Treatment, Printing
3. **Samples and Small Batch Production are Available**
   Our PEC Factory is Available to Prototype and Small Batch Manufacturing(50~100 pcs Per Month)
4. **All Our Dies are Designed and Manufactured In-House**

B3 Attached Equipment Specification Reference

B3.1 Pole Top

B3.1.1 Telecommunication Equipment (Movable to WG3)

B3.2 Upper Layer

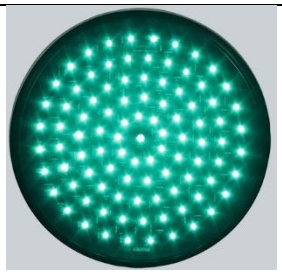
B3.2.1 Intelligent Lighting

Product appearance			
Product model	Everlight Electronics., Ltd. SL-Victory-101W	Delta Electronics, Inc. SLDF Series	Taiwn Ouri Optoelectronic SL-150W-001
Features	LED Street Light	LED Street Light	LED Street Light
Luminous flux/color temperature	14140Lm / 5000K	19494Lm / 5000K	15000Lm / 5700K
Power input	100-277V AC	110~277Vac	100-240V AC

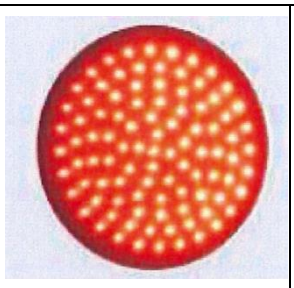
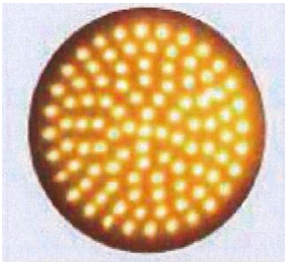
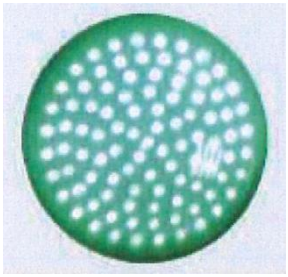
Dimming control interface	0/1～10V	0/1～10V	0/1～10V
Watts consumed (W)	101	150	150
Appearance dimension (mm)	407 x 207 x 124	710 x 350 x 121	620 x 240 x 70
Weight (kg)	3	8	15
Waterproof coefficient	IP65	IP66	IP65

Product appearance	
Product model	Excellence Optoelectronics Inc. SL3 Series
Features	LED Street Light
Luminous flux/color temperature	18023Lm / 5000K
Power input	100-277V AC
Dimming control interface	0/1～10V
Watts consumed (W)	120
Appearance dimension (mm)	667 x 312 x 128
Weight(kg)	6
Waterproof coefficient	IP66

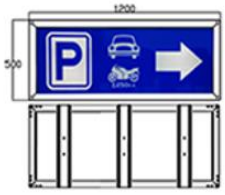
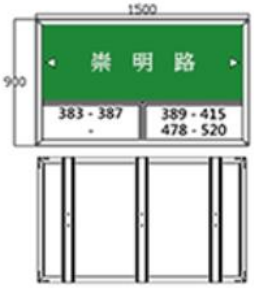
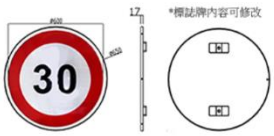
B3.2.2 Traffic Signs

Product appearance			
Product model	Sobright V09-R12THA120PC	Sobright V09-Y12THA120PC	Sobright V09-G12THA120PC
Working temperature	20~+74 ℃	20~+74 ℃	20~+74 ℃
Working voltage	80-240 VAC	80-240 VAC	80-240 VAC
Power consumption (W)	≦ 15W	≦ 15 W	≦ 15 W
Appearance dimension (mm)	Diameter 300 ±5 mm	Diameter 300 ±5 mm	Diameter 300 ±5 mm

Weight (kg)	≦ 1.3 kg	≦ 1.3 kg	≦ 1.3 kg
Waterproof coefficient	IP54	IP54	IP54

Product appearance			
Product model	EOI TRV-R12D72A1	EOI TRV-Y12D72A1	EOI TRV-G12D72A2
Working temperature	-40~+74 ℃	-40~+74 ℃	-40~+74 ℃
Working voltage	80-240 VAC	80-240 VAC	80-240 VAC
Power consumption (W)	10 W	10 W	13 W
Appearance dimension(mm)	Diameter 300 ±5 mm	Diameter 300 ±5 mm	Diameter 300 ±5 mm
Weight (kg)	≦ 1.3 kg	≦ 1.3 kg	≦ 1.3 kg
Waterproof coefficient	IP54	IP54	IP54

B3.2.3 Road Marking

Product appearance			
Product model	Sobright IRL050120-0000	Sobright IRL150090-0000	Sobright IRS065000-0000
Working temperature	90~240 VAC	90~240 VAC	90~240 VAC
Working voltage	80-240 VAC	80-240 VAC	80-240 VAC
Power consumption(W)	≦ 15 W	< 33 W	≦ 9 W
Appearance dimension(mm)	500 x 1200	1500 x 900	Diameter 650
Weight (kg)	12.5 kg	26 kg	11.2 kg
Waterproof coefficient	IP54	IP54	IP54

B3.2.4 Video Surveillance

B3.2.4.1 Gun Camera

Product appearance			
Product model	VIVOTEK IB9387-EHT-A	DYNACOLOR S5-B Series	LILIN Z2R8152X-P
Video format	H.265, H.264, MJPEG	H.265, H.264, MJPEG	H.265 and H.264,MJPEG
Power input	POE 802.3at	POE 802.3af	POE 802.3at
Communicating interface	RJ-45	RJ-45	RJ-45
Watts consumed(W)	20 W (PoE)	11.74 (POE)	14.5 (POE)
Appearance dimension(mm)	Ø 118 x 294.6	Ø 92x224.6	Ø 102.5 × 258
Weight (kg)	1.3	0.78	1.02
Waterproof coefficient	IP67	IP66	IP68

B3.2.4.2 Fish-eye Camera

Product appearance			
Product model	VIVOTEK MA9321-EHTV	DYNACOLOR U2-8 Series	LILIN Z5R6422X3
Video format	H.265, H.264, MJPEG	H.265, H.264, MJPEG	H.265, H.264, MJPEG
Power input	POE 802.3at	PoE 802.3af	PoE 802.3af
Communicating interface	RJ-45	RJ-45	RJ-45
Watts consumed(W)	7 W (PoE)	12.95 (POE)	9.6 (PoE)

Appearance dimension(mm)	Ø 210 x 110.4	Ø 130x57.8	Ø120 × 106 mm
Weight (kg)	1.6	0.565	0.76
Waterproof coefficient	IP66	IP66	IP67

B3.2.4.3 PTZ (Pan-Tilt-Zoom) Camera

Product appearance			
Product model	VIVOTEK SD9364-EHL-V2	DYNACOLOR 831- Series	LILIN IPS4308EA
Video format	H.264, MJPEG & MPEG-4	H.265, H.264, MJPEG	H.264, MJPEG
Power input	PoE 802.3at	UPoE,	POE 802.3at
Communicating interface	RJ-45	RJ-45	RJ-45
Watts consumed(W)	51W (PoE)	39(PoE)	14W (POE)
Appearance dimension(mm)	237 x 326 x 499	Ø207.43 x 300.39	Ø 210 x 332
Weight (kg)	3.66	3.8	3.2
Waterproof coefficient	IP67	IP66	IP66

B3.2.5 Environmental Monitoring

Product appearance		
Product model	Delta BA-SCDB-A01E	SYSINNO IAeris3
Features	Outdoor PM2.5/PM10/temperature and humidity sensor	Temperature, humidity, suspended particle PM10, fine suspended particle PM2.5, total volatile gas

		TVOC, carbon monoxide, ozone sensor
Working environment	-10 ~ +60°C	-10℃ ~ 50℃, lower than 90% RH
Power input	12~36Vdc	110-220V AC
Communicating interface	RS485	NB - IoT、4G、WiFi、RS485
Watts consumed(W)	1	2.5
Appearance dimension(mm)	Ø 138 x 26	180 x 265 x 138
Weight (kg)	1.2	1
Waterproof coefficient	IP65	IP65

B3.2.6 Intelligent Transport (C-V2x)

Product appearance			
Product model	WNC C-V2X Roadside device	Askey CRU-0100	Unex RSU-301U
Working temperature	-40°C ~ 75°C	-40°C ~ +85°C	-40°C ~ +85°C
Working voltage	PoE 802.3at	PoE 802.3at	PoE 802.3at
Power consumed(W)	26	TBD	12
Appearance dimension(mm)	190 × 250 × 60	290 x 80 x 200	128 x 221 x 73
Weight (kg)	TBD	TBD	5
Waterproof coefficient	IP67	IP67	IP67

B3.2.7 Intelligent Transport (LiDAR)

Product appearance		
Product model	Velodyne Puck	Velodyne HDL-32E
Working environment	-10℃~+60℃	-10℃~+60℃
Power input	9 ~18 V DC	9 ~18 V DC
Communicating interface	Ethernet	Ethernet
Watts consumed(W)	8	12
Appearance dimension (mm)	Ø103.3 x 71.7	Ø85.3 x 144.2
Weight (kg)	0.83	1
Waterproof coefficient	IP67	IP67
Detection distance (m)	100	100
Field of View	Vertical : 30° Horizontal : 360°	Vertical : 41.33° Horizontal : 360°

B3.2.8 Intelligent Transport (radar)

Product appearance		
Product model	Smartmicro UMRR-11Type44	Smartmicro UMRR-11 Type132
Working environment	-40℃~+85℃	-40℃~+85℃
Power input	8 ~32 V DC	8 ~32 V DC
Communicating interface	Ethernet, RS485, CAN Bus	Ethernet, RS485, CAN Bus
Watts consumed(W)	5	5
Appearance dimension (mm)	110 x 99 x 31.7	94.7 x 84.4 x 26.4
Weight (kg)	0.36	0.274

Waterproof coefficient	IP67	IP67
Detection distance(m)	100	100
Field of View	Vertical : 30° Horizontal : 360°	Vertical : 41.33° Horizontal : 360°

B3.2.9 Other Important Equipment

B3.2.9.1 Gateway

Product appearance		
Product model	ASRock Industrial iEP-5000G	ASUS PE100A
Working environment	-40~+70°C	-20~+60°C
Power input	6~36 VDC	DC 12-24V
Communicating interface	3 x 1GbE 3 x COM RS-232/422/485 2 x USB 3.2 Gen1x1 2 x USB 2.0 1 x HDMI 1 x VGA	2xRJ-45 10/100/1000 Mbps 1xRS-232/RS422/RS485 1xRS-232/CAN 1xUSB3.2 1xHDMI
Watts consumed (W)	TBD	TBD
Appearance dimension (mm)	157 x 125 x 58	145 x 78 x 55.5
Weight (kg)	1.3	0.775
Waterproof coefficient	IP30	IP30

B3.2.9.2 Layer 2 Switch

Product appearance		
Product model	EtherWAN EX78900X Series	Oring IGPS-9084GP-60W
Working environment	-40~+75°C	-40~+75°C
Power input	50~57 VDC	52~57 VDC
Communicating interface	RJ-45 x 12 SFP x 4 (PoE x12 IEEE802.3bt 90W per port; total 360W)	RJ-45 x 8 SFP x 4 (PoE x 8 IEEE802.3at 60W per port; total 240W)
Watts consumed (W)	TBD	TBD
Appearance dimension (mm)	72 x 140 x 170	96.4 x 105.5 x 154
Weight (kg)	1.5	1.29
Waterproof coefficient	IP30	IP30

B3.3 Lower Layer

B3.3.1 Other Important Equipment

B3.3.1.1 NVR

Product appearance		
Product model	QNAP TS-i410X	QNAP QVP-41B
Working environment	-40°C~+70°C	0°C~+40°C
Power input	12VDC(Adapter) or 9-36V DC 擇一	100~240V AC

	12VDC(Adapter) or 9-36V DC alternative	
Communicating interface	RJ-45	RJ-45
Watts consumed(W)	25.6	100 In addition, a total of 140W PoE x16 (Max.30W per port) is provided
PoE	N/A	16 port 30W 共140W 16 port 30W totally 140W
Appearance dimension (mm)	65 × 180 × 254	130 x 295 x 224.8
Weight (kg)	2.54	4.08
Waterproof coefficient	N/A	N/A

B4 Type 2 Power Supply Network Diagram/Distribution Panel Configuration Diagram/Distribution Panel Equipment List

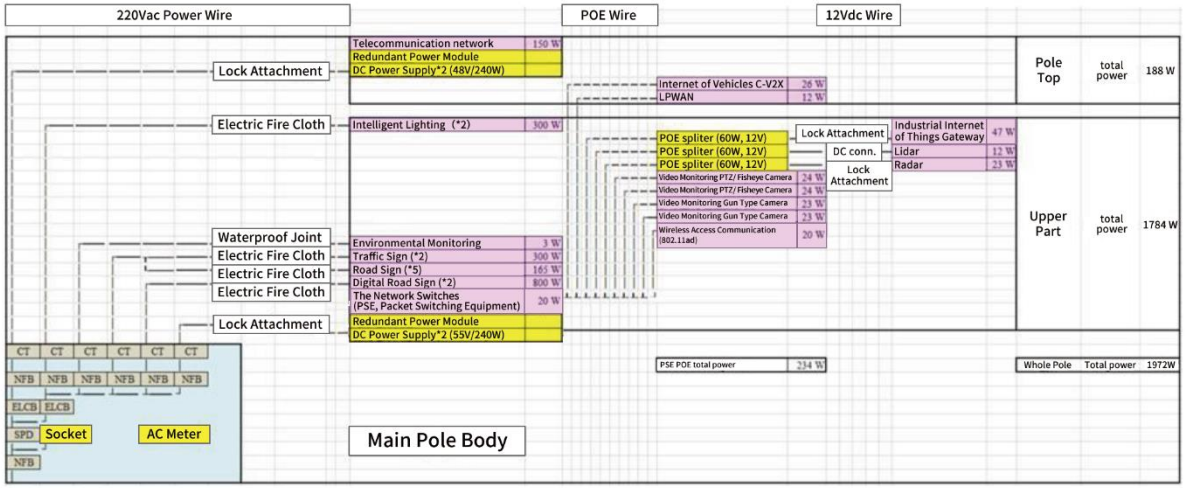


Figure B4-1 Type 2 Power Supply network Diagram

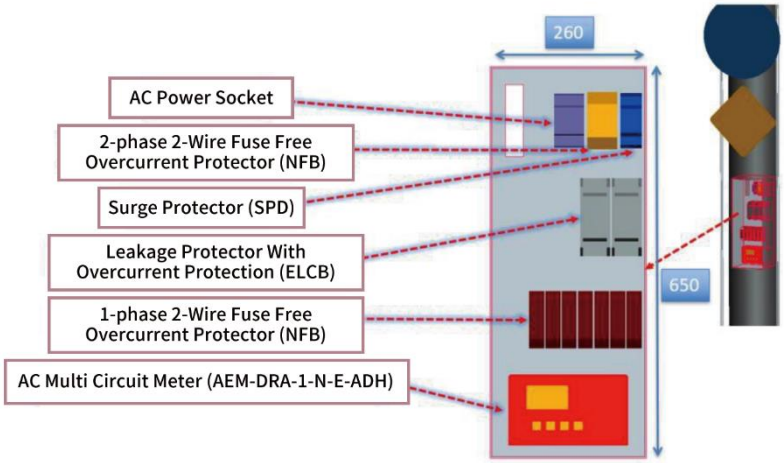


Figure B4-2 Type 2 Distribution Panel Configuration Diagram

Figure B4-1 Type 2 Distribution Panel Equipment List

Name	Refer to manufacturer's model	Specification	Quality	Size
Non fusible circuit breaker (NFB)	NF100SN	30A/25kA/220V/2P	1	50x130x90mm
Surge protector (SPD)	BHP30	30kA/2P	1	36x91x66mm
Earth leakage circuit breaker (ELCB)	NV-50HS	30mA/100mA/300mA/2P	2	50*115*80mm
Non fusible circuit breaker (NFB)	BHA31C6	1~6A/6kA/220V/1P	6	18x84.5x74mm
AC multi circuit ammeter	AEM-DRA-1-N-E-ADH	RJ45 Interface	1	199x118x77mm
Current transformer (CT)	US-CTV-10-005A	5A/333mV/1%	6	30.8*28.8*42.8mm

B5 System Architecture (GPON+ Ring)

B6 Flow Bandwidth

According to the different applicable fields of the poles, the uplink and downlink reference bandwidth of the attached equipment required on each pole is estimated. Refer to the Type2 smart light pole layout diagram.

Table B6.1 Estimation of Up and Down Bandwidth of Type 2 Smart Pole

Application name	Vendor	Vendor P/N	Quantity	Bandwidth (Mbps)	Subtotal of bandwidth (Mbps)
Intelligent lighting	Delta Electronics	SLDF Series	2	0.001	0.002
Image monitoring (gun type camera)	VIVOTEK	IB9387-EHT	2	7.34	14.680
Image monitoring (fisheye type camera)	VIVOTEK	MA9321-EHTV	2	41.09	82.180
Road digital sign (Instant alert caption)	Shon Hunser	TBD	1	0.001	0.001
Internet of Vehicles (C-V2X)	Unex	RSU-301U	1	27	27.000
Internet of Vehicles (lidar)	Velodyne	Puck	1	100	100.000
Internet of Vehicles (radar)	Smartmicro	UMRR-11Type44	1	0.01	0.010
Total of bandwidth (Mbps)					223.873
Buffer (Mbps)					300

Appendix C Type 3 Park Hiking Smart Pole Design Extension

C1 Cable Routing

C2 Connector Model and Specification Suggestions

C3 Mounted Equipment Specification Reference

C3.1 Pole Top

C3.1.1 Telecommunication Equipment (movable to WG3)

C3.2 Upper Layer

C3.2.1 Intelligent Lighting

Product appearance			
Product model	Everlight Electronics., Ltd. SL-Victory-101W	Delta SLDF Series	Taiwn Ouri Optoelectronic SL-150W-001
Features	LED Street Light	LED Street Light	LED Street Light
Luminous flux/color temperature	14140Lm / 5000K	19494Lm / 5000K	15000Lm / 5700K
Power input	100-277V AC	110~277Vac	100-240V AC
Dimming control interface	0/1～10V	0/1～10V	0/1～10V
Watts consumed(W)	101	150	150
Appearance dimension(mm)	407 x207 x 124	710 x 350 x 121	620 x 240 x 70
Weight (kg)	3	8	15
Waterproof coefficient	IP65	IP66	IP65

Product appearance	
Product model	Excellence Optoelectronics Inc. SL3 Series
Features	LED Street Light
Luminous flux/color temperature	18023Lm / 5000K
Power input	100-277V AC
Dimming control interface	0/1～10V
Watts consumed(W)	120
Appearance dimension(mm)	667 x 312 x 128
Weight (kg)	6
Waterproof coefficient	IP66

C3.2.2 Video Surveillance

C3.2.2.1 Gun Camera

Product appearance			
Product model	VIVOTEK IB9387-EHT-A	DYNACOLOR S5-B Series	LILIN Z2R8152X-P
Video fomat	H.265, H.264, MJPEG	H.265, H.264, MJPEG	H.265 and H.264,MJPEG
Power input	POE 802.3at	POE 802.3af	POE 802.3at
Communicating interface	RJ-45	RJ-45	RJ-45
Watts consumed (W)	20 W (PoE)	11.74 (POE)	14.5 (POE)
Appearance dimension(mm)	Ø 118 x 294.6	Ø 92x224.6	Ø 102.5 × 258
Weight (kg)	1.3	0.78	1.02
Waterproof coefficient	IP67	IP66	IP68

C3.2.2.2 Fish-eye Camera

Product appearance			
Product model	VIVOTEK MA9321-EHTV	DYNACOLOR U2-8 Series	LILIN Z5R6422X3
Video fomat	H.265, H.264, MJPEG	H.265, H.264, MJPEG	H.265, H.264, MJPEG
Power input	POE 802.3at	PoE 802.3af	PoE 802.3af
Communicating interface	RJ-45	RJ-45	RJ-45
Watts consumed (W)	7 W (PoE)	12.95 (POE)	9.6 (PoE)
Appearance dimension(mm)	Ø 210 x 110.4	Ø 130x57.8	Ø120 × 106 mm
Weight (kg)	1.6	0.565	0.76
Waterproof coefficient	IP66	IP66	IP67

C3.2.2.3 PTZ (Pan-Tilt-Zoom) Camera

Product appearance			
Product model	VIVOTEK SD9364-EHL-V2	DYNACOLOR 831- Series	LILIN IPS4308EA
Video fomat	H.264, MJPEG & MPEG-4	H.265, H.264, MJPEG	H.264, MJPEG
Power input	PoE 802.3at	UPoE,	POE 802.3at
Communicating interface	RJ-45	RJ-45	RJ-45
Watts consumed (W)	51W (PoE)	39(PoE)	14W (POE)
Appearance dimension(mm)	237 x 326 x 499	Ø207.43 x 300.39	Ø 210 x 332
Weight (kg)	3.66	3.8	3.2
Waterproof coefficient	IP67	IP66	IP66

C3.2.3 Environmental Monitoring

Product appearance		
Product model	Delta BA-SCDB-A01E	SYSINNO IAeris3
Features	Outdoor PM2.5/PM10/temperature and humidity sensor	Temperature, humidity, suspended particle PM10, fine suspended particle PM2.5, total volatile gas TVOC, carbon monoxide, ozone sensor
Working environment	-10 ~ +60°C	-10°C ~ 50°C, lower than 90% RH

Power input	12~36Vdc	110-220V AC
Communicating interface	RS485	NB - IoT、4G、WiFi、RS485
Watts consumed (W)	1	2.5
Appearance dimension(mm)	Ø 138 x 26	180 x 265 x 138
Weight (kg)	1.2	1
Waterproof coefficient	IP65	IP65

C3.2.4 Public Push Notification

Product appearance			
Product model	Kingstate KS251824 IP	PORTech IS-650P	Axis Communications C1310-E
Working environment	-40~+60°C	TBD	-40~+60°C
Power input	POE IEEE 802.3af	POE IEEE 802.3af	POE IEEE 802.3af/at Type1 Class3
Communicating interface	Ethernet	Ethernet	RJ45 10BASE-T/100BASE-TX PoE I/O: 4-pin 2.5 mm terminal block for one input and one output
Watts consumed (W)	13	8	Max. 12.95W
Appearance dimension(mm)	248 x 180 x 336	280 x 200 x 280	164 x 225 x 305
Weight (kg)	1.5	2.02	1.3
Waterproof coefficient	IP66, IP67	IP66	IP66, IP67

C3.2.5 Digital Advertising Billboard

Product appearance			
Product model	Radi RD425SP	Radi RD525LO	Excellence Optoelectronics Inc. LD Series
Working environment	-5~+50°C	-5~+50°C	-20~+50°C
Power input	AC 100 - 240 V	AC 100 - 240 V	AC 100 - 240 V
Communicating interface	RJ45 / WIFI / USB	RJ45 / WIFI / USB	RJ45 / WIFI / USB
Watts consumed (W)	250	180	360(ave.)
Appearance dimension(mm)	971.6 x 559.8 x 88	1242.6 x 713.6 x 74.3	1220 x 640 x 110
Weight (kg)	75	110	34
Waterproof coefficient	IP56	IP56	IP56

C3.2.6 Other Important Equipment

C3.2.6.1 Gateway

Product appearance		
Product model	EtherWAN EX78900X Series	Oring IGPS-9084GP-60W
Working environment	-40~+75°C	-40~+75°C
Power input	50~57 VDC	52~57 VDC
Communicating interface	RJ-45 x 12 SFP x 4 (PoE x12 IEEE802.3bt 90W per port; total 360W)	RJ-45 x 8 SFP x 4 (PoE x 8 IEEE802.3at 60W per port; total 240W)
Watts consumed (W)	TBD	TBD
Appearance dimension(mm)	72 x 140 x 170	96.4 x 105.5 x 154
Weight (kg)	1.5	1.29
Waterproof coefficient	IP30	IP30

C3.2.6.2 Layer 2 Switch

Product appearance		
Product model	EtherWAN EX78900X Series	Oring IGPS-9084GP-60W
Working environment	-40~+75°C	-40~+75°C

Power input	50~57 VDC	52~57 VDC
Communicating interface	RJ-45 x 12 SFP x 4 (PoE x12 IEEE802.3bt 90W per port; total 360W)	RJ-45 x 8 SFP x 4 (PoE x 8 IEEE802.3at 60W per port; total 240W)
Watts consumed (W)	TBD	TBD
Appearance dimension(mm)	72 x 140 x 170	96.4 x 105.5 x 154
Weight (kg)	1.5	1.29
Waterproof coefficient	IP30	IP30

C3.3 Lower Layer

C3.3.1 Interactive Digital Signage

Product appearance	
Product model	Nextec NTWP190-2 V500E
Working environment	-30~+85°C
Power input	100~240VAC
Communicating interface	RJ45/USB/RS232
Watts consumed (W)	70
Appearance dimension(mm)	402 x 331 x 59 (±2)
Weight (kg)	4.9
Waterproof coefficient	IP65

C3.3.2 Emergency Call

Product appearance				
Product model	DGO TECH Emergency Button nEI	Ever Guard Emergency button SG-EV02T-F07-IP	AvaDesign Technologies Emergency Interphone DP-902	Axis Communications A8105-E
Working environment	-10~+50°C	-20~+50°C	0~+85°C	-25~+55°C
Power input	802.3af PoE	POE 802.3af	PoE 802.3af	POE IEEE 802.3af/at Type1 Class3
Communicating interface	RJ45、RS485	RJ45	RJ45	RJ45 10BASE-T/100BASE-TX PoE I/O: 6-pin 3.81 mm terminal block for 2 I/O, 12V output (max 350mA) and 1 relay
Watts consumed (W)	5	1.5	10	Max. 12.95W
Appearance dimension(mm)	150 x 102 x 250	164 x 104 x 35	120 x 200 x 38	147.5 x 35 x 48
Weight (kg)	2.05	0.623	TBD	0.28
Waterproof coefficient	IP65	IP65	IP65	IP65

C3.3.3 Other Important Equipment

C4 Type 3 Power Supply Network Diagram/Distribution Panel Configuration Diagram/Distribution Panel Equipment List

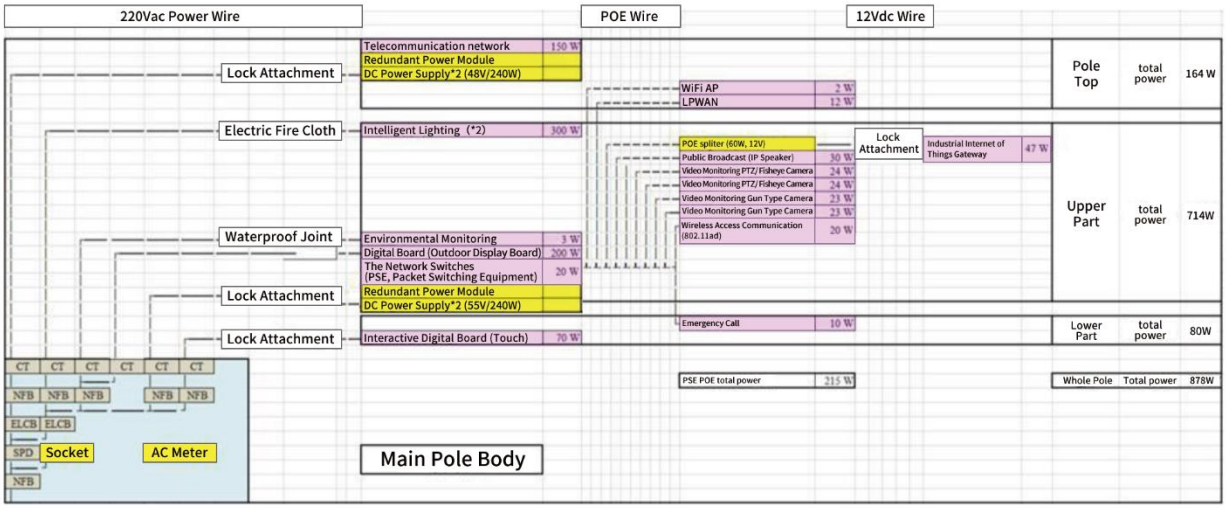


Figure C4-1 Type 3 Power supply network Diagram

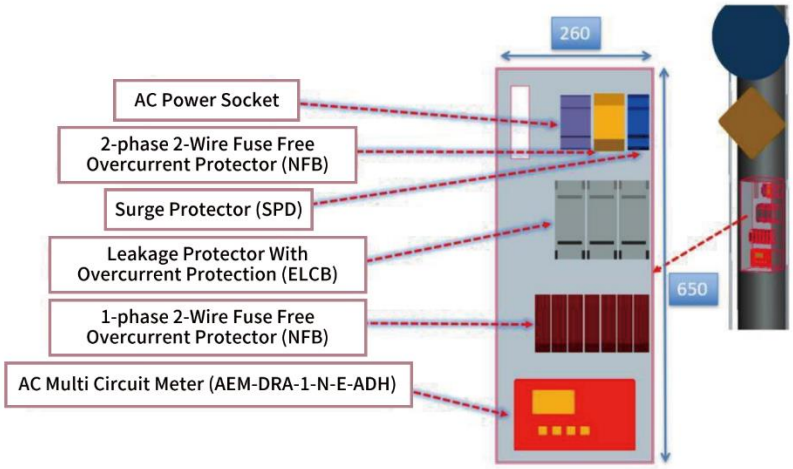


Figure C4-2 Type 3 Distribution Panel Configuration Diagram

Table C4-1 Type 3 Distribution Panel Equipment List

Name	Manufacturer's model(reference)	Specifications	Quantity	Size
Non fusible circuit breaker (NFB)	NF100SN	30A/25kA/220V/2P	1	50x130x90mm
Surge protector (SPD)	BHP30	30kA/2P	1	36x91x66mm
Earth leakage circuit breaker (ELCB)	NV-50HS	30mA/100mA/300mA/2P	2	50*115*80mm
Non fusible circuit breaker (NFB)	BHA31C6	1~6A/6kA/220V/1P	5	18x84.5x74mm

AC multi circuit ammeter	AEM-DRA-1-N-E-ADH	RJ45 INTERFACE	1	199x118x77mm
Current transformer (CT)	US-CTV-10-005A	5A/333mV/1%	6	30.8*28.8*42.8mm

C5 System Architecture (GPON+Star)

C6 Flow Bandwidth

According to the different applicable fields of poles, refer to the Type3 smart light pole layout diagram to estimate the uplink and downlink reference bandwidth of the attached equipment on each pole.

Table C6.1 Estimation of Uplink and Downlink Bandwidth of Type 3 Smart Pole

App Name	Vendor	Vendor P/N	Quantity	Bandwidth (Mbps)	Subtotal of bandwidth (Mbps)
Intelligent lighting	Delta	SLDF Series	2	0.001	0.002
Video surveillance (gun type camera)	VIVOTEK	IB9387-EHT	1	7.34	7.340
Video surveillance (fisheye type camera)	VIVOTEK	MA9321-EHTV	1	41.09	41.090
IP Speaker	Kingstate	KS251824 IP	1	0.091	0.091
Interactive digital signage Digital screen (outdoor display signage)	Radi	RD425SP RD525LO	1	5	5.000
Interactive digital signage Interactive Kanban (touch)	Nextech	NTWP190-2 V500E	1	0.1	0.100
SOS	DGO TECH	nEI	1	4.000	4.000
Total of bandwidth (Mbps)					57.623
Buffer (Mbps)					100

Appendix D Type 4 Smart Pole Design Extension

D1 Cable Routing

D2 Connector Model and Specification Suggestions

D3 Mounted Equipment Specification Reference

D3.1 Pole Top

D3.1.1 Telecommunication Equipment (movable to WG3)

D3.2 Upper Layer

D3.2.1 Intelligent Lighting

Product appearance			
Product model	Everlight Electronics., Ltd. SL-Victory-101W	Delta SLDF Series	Taiwn Ouri Optoelectronic SL-150W-001
Features	LED Street Light	LED Street Light	LED Street Light
Luminous flux/color temperature	14140Lm / 5000K	19494Lm / 5000K	15000Lm / 5700K
Power input	100-277V AC	110~277Vac	100-240V AC
Dimming control interface	0/1～10V	0/1～10V	0/1～10V
Watts consumed (W)	101	150	150
Appearance dimension (mm)	407 x207 x 124	710 x 350 x 121	620 x 240 x 70
Weight (kg)	3	8	15
Waterproof coefficient	IP65	IP66	IP65

D3.2.2 Video Surveillance

D3.2.2.1 Gun Camera

Product appearance			
Product model	VIVOTEK	DYNACOLOR	LILIN

	IB9387-EHT	S5-B Series	Z2R8152X-P
Video format	H.265, H.264, MJPEG	H.265, H.264, MJPEG	H.265 and H.264,MJPEG
Power input	POE 802.3at	POE 802.3af	POE 802.3at
Dimming control interface	RJ-45	RJ-45	RJ-45
Watts consumed (W)	12 W (PoE)	11.74 (POE)	14.5 (POE)
Appearance dimension (mm)	Ø 118 x 294	Ø 92x224.6	Ø 102.5 × 258
Weight (kg)	1.254	0.78	1.02
Waterproof coefficient	IP66	IP66	IP68

D3.2.2.2 Fish-eye Camera

Product appearance			
Product model	VIVOTEK MA9321-EHTV	DYNACOLOR U2-8 Series	LILIN Z5R6422X3
Video format	H.265, H.264, MJPEG	H.265, H.264, MJPEG	H.265, H.264, MJPEG
Power input	POE 802.3at	PoE 802.3af	PoE 802.3af
Dimming control interface	RJ-45	RJ-45	RJ-45
Watts consumed (W)	7 W (PoE)	12.95 (POE)	9.6 (PoE)
Appearance dimension (mm)	Ø 210 x 110.4	Ø 130x57.8	Ø120 × 106 mm
Weight (kg)	1.6	0.565	0.76
Waterproof coefficient	IP66	IP66	IP67

D3.2.2.3 PTZ (Pan-Tilt-Zoom) Camera

Product appearance			
Product model	VIVOTEK SD8364E/64E-M	DYNACOLOR 831- Series	LILIN IPS4308EA
Video format	H.264, MJPEG & MPEG-4	H.265, H.264, MJPEG	H.264, MJPEG
Power input	PoE 802.3at	UPoE,	POE 802.3at
Communicating interface	RJ-45	RJ-45	RJ-45
Watts consumed (W)	19W (PoE)	39(PoE)	14W (POE)
Appearance dimension (mm)	Ø: 205 x 321	Ø207.43 x 300.39	Ø 210 x 332
Weight (kg)	3.66	3.8	3.2
Waterproof coefficient	IP67	IP66	IP66

D3.2.3 Other Important Equipment

D3.2.3.1 Gateway

Product appearance		
Product model	ASRock Industrial iEP-5000G	ASUS PE100A
Working environment	-40~+70°C	-20~+60°C
Power input	6~36 VDC	DC 12-24V
Communicating interface	3 x 1GbE 3 x COM RS-232/422/485 2 x USB 3.2 Gen1x1 2 x USB 2.0	2xRJ-45 10/100/1000 Mbps 1xRS-232/RS422/RS485 1xRS-232/CAN 1xUSB3.2

	1 x HDMI 1 x VGA	1xHDMI
Watts consumed (W)	TBD	TBD
Appearance dimension (mm)	157 x 125 x 58	145 x 78 x 55.5
Weight (kg)	1.3	0.775
Waterproof coefficient	IP30	IP30

D3.2.3.2 Layer 2 Switch

Product appearance		
Product model	EtherWAN EX78900X Series	Oring IGPS-9084GP-60W
Working environment	-40~+75°C	-40~+75°C
Power input	50~57 VDC	52~57 VDC
Communicating interface	RJ-45 x 12 SFP x 4 (PoE x12 IEEE802.3bt 90W per port; total 360W)	RJ-45 x 8 SFP x 4 (PoE x 8 IEEE802.3at 60W per port; total 240W)
Watts consumed (W)	TBD	TBD
Appearance dimension (mm)	72 x 140 x 170	96.4 x 105.5 x 154
Weight (kg)	1.5	1.29
Waterproof coefficient	IP30	IP30

D3.2.4 Video Surveillance

D3.2.4.1 Gun Camera

Product appearance			
Product model	VIVOTEK IB9387-EHT-A	DYNACOLOR S5-B Series	LILIN Z2R8152X-P
Video format	H.265, H.264, MJPEG	H.265, H.264, MJPEG	H.265 and H.264,MJPEG
Power input	POE 802.3at	POE 802.3af	POE 802.3at
Communicating interface	RJ-45	RJ-45	RJ-45
Watts consumed (W)	20 W (PoE)	11.74 (POE)	14.5 (POE)
Appearance dimension (mm)	Ø 118 x 294.6	Ø 92x224.6	Ø 102.5 × 258
Weight (kg)	1.3	0.78	1.02
Waterproof coefficient	IP67	IP66	IP68

D3.2.4.2 Fish-eye Camera

Product appearance			
Product model	VIVOTEK MA9321-EHTV	DYNACOLOR U2-8 Series	LILIN Z5R6422X3
Video format	H.265, H.264, MJPEG	H.265, H.264, MJPEG	H.265, H.264, MJPEG
Power input	POE 802.3at	PoE 802.3af	PoE 802.3af
Communicating interface	RJ-45	RJ-45	RJ-45
Watts consumed (W)	7 W (PoE)	12.95 (POE)	9.6 (PoE)
Appearance dimension (mm)	Ø 210 x 110.4	Ø 130x57.8	Ø120 × 106 mm
Weight (kg)	1.6	0.565	0.76
Waterproof coefficient	IP66	IP66	IP67

D3.2.4.3 PTZ (Pan-Tilt-Zoom) Camera

Product appearance			
Product model	VIVOTEK SD9364-EHL-V2	DYNACOLOR 821- Series	LILIN IPS4308EA
Video format	H.264, MJPEG & MPEG-4	H.265, H.264, MJPEG	H.264, MJPEG
Power input	PoE 802.3at	PoE	POE 802.3at
Communicating interface	RJ-45	RJ-45	RJ-45
Watts consumed (W)	51W (PoE)	39(PoE)	14W (POE)
Appearance dimension (mm)	237 x 326 x 499	Ø207.43 x 300.39	Ø 210 x 332
Weight (kg)	3.66	3.8	3.2
Waterproof coefficient	IP67	IP66	IP66

D3.2.5 Other Important Equipment

D3.2.5.1 Gateway

Product appearance		
Product model	ASRock Industrial iEP-5000G	ASUS PE100A

Working environment	-40~+70°C	-20~+60°C
Power input	6~36 VDC	DC 12-24V
Communicating interface	3 x 1GbE 3 x COM RS-232/422/485 2 x USB 3.2 Gen1x1 2 x USB 2.0 1 x HDMI 1 x VGA	2xRJ-45 10/100/1000 Mbps 1xRS-232/RS422/RS485 1xRS-232/CAN 1xUSB3.2 1xHDMI
Watts consumed (W)	TBD	TBD
Appearance dimension (mm)	157 x 125 x 58	145 x 78 x 55.5
Weight (kg)	1.3	0.775
Waterproof coefficient	IP30	IP30

D3.2.5.2 Layer 2 Switch

Product appearance		
Product model	EtherWAN EX78900X Series	Oring IGPS-9084GP-60W
Working environment	-40~+75°C	-40~+75°C
Power input	50~57 VDC	52~57 VDC
Communicating interface	RJ-45 x 12 SFP x 4 (PoE x12 IEEE802.3bt 90W per port; total 360W)	RJ-45 x 8 SFP x 4 (PoE x 8 IEEE802.3at 60W per port; total 240W)
Watts consumed (W)	TBD	TBD
Appearance dimension (mm)	72 x 140 x 170	96.4 x 105.5 x 154
Weight (kg)	1.5	1.29

Waterproof coefficient	IP30	IP30

D3.3 Lower Layer

D3.3.1 Charging Post

Product appearance			
Product model	YES-Energy Service Co., LTD., U-Charger Plus	Delta AC MAX	PHIHONG TECHNOLOGY CO., LTD., AW series
Working environment	-30~+50°C	-30~+50°C	-30~+50°C
Power input	AC200-240V	AC220	AC200-240V
Communicating interface	Ethernet/RS485	Ethernet/RS485	Ethernet/RS485
Watts consumed (W)	7k	17.6k	7.6k
Appearance dimension (mm)	272 x 147 x 352	167 x 218 x 371	260 x 100 x 280
Weight (kg)	6	3.8	4
Waterproof coefficient	IP55	IP55	IP55

D3.3.2 Other Important Equipment

D4 Type 4 Power Supply Network Diagram/Distribution Panel Configuration Diagram/Distribution Panel Equipment list

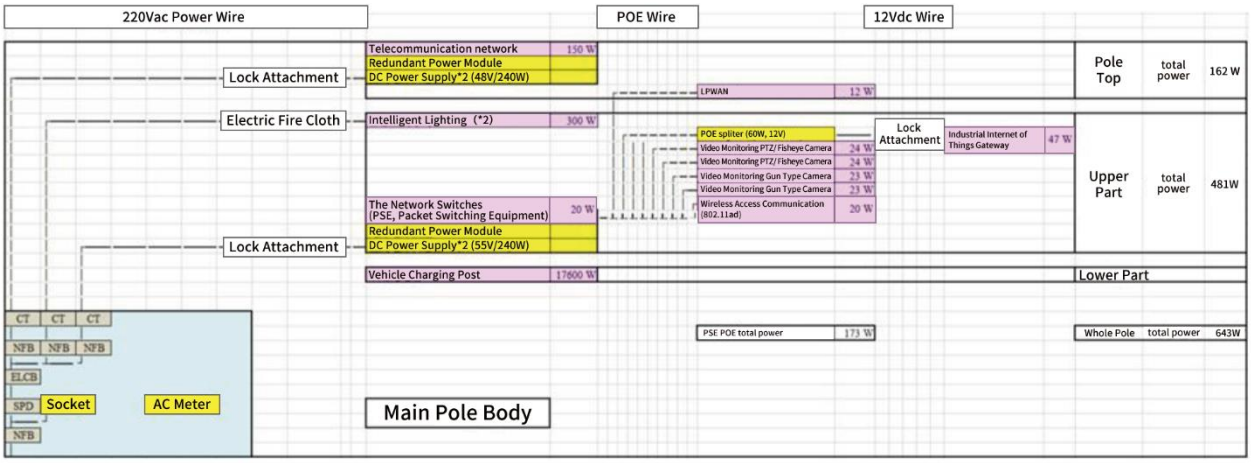


Figure D4-1 Type 4 Power Supply Network Diagram

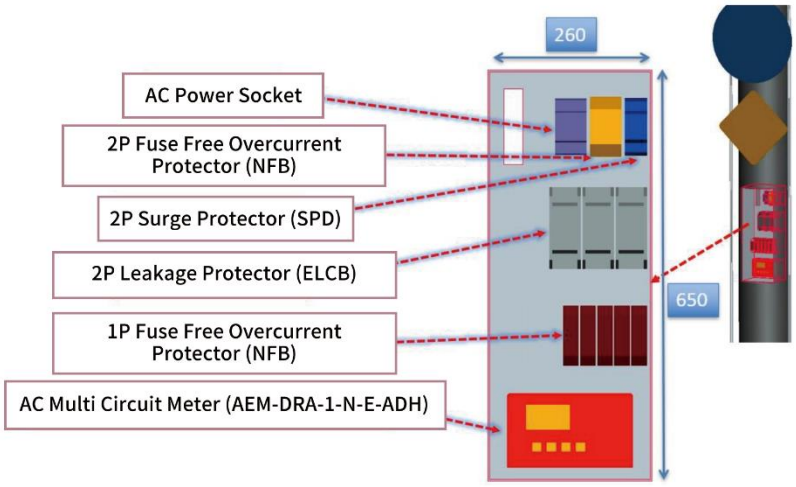


Figure D4-2 Type 4 Distribution Panel Configuration Diagram

Table D4-1 List of Type 4 Distribution Panel Equipment List

Name	Manufacturer's model(reference)	Specifications	Quantity	Size
Non fusible circuit breaker (NFB)	NF100SN	30A/25kA/220V/2P	1	50x130x90mm
Surge protector (SPD)	BHP30	30kA/2P	1	36x91x66mm
Earth leakage circuit breaker (ELCB)	NV-50HS	30mA/100mA/300mA/2P	1	50*115*80mm
Non fusible circuit breaker (NFB)	BHA31C6	1~6A/6kA/220V/1P	3	18x84.5x74mm
AC multi circuit ammeter	AEM-DRA-1-N-E-ADH	RJ45 INTERFACE	1	199x118x77mm

Current transformer (CT)	US-CTV-10-005A	5A/333mV/1%	3	30.8*28.8*42.8mm

D5 System Architecture (GPON+Star)

D6 Flow Bandwidth

According to the different applicable fields of poles, refer to the Type4 smart light pole layout diagram to estimate the uplink and downlink reference bandwidth of the attached equipment on each pole.

Table D6.1 Estimation of Up and Down Bandwidth of Type 4 Smart Pole

App Name	Vendor	Vendor P/N	Quantity	Bandwidth (Mbps)	Subtotal of bandwidth (Mbps)
Intelligent lighting	Delta	SLDF Series	1	0.001	0.001
) Video surveillance (gun type camera)	VIVOTEK	IB9387-EHT	1	7.34	7.340
Video surveillance (fisheye type camera)	VIVOTEK	MA9321-EHTV	1	41.09	41.090
Charging post	Delta/ YES-Energy Service Co., LTD.,/ PHIHONG TECHNOLOGY CO., LTD.,		1	TBD	
頻寬總計 (Mbps); Total of bandwidth (Mbps)					48.431
Buffer (Mbps)					100

Appendix E Design Extension of Loop Control Box

E1 Cable Routing

E2 Connector Model and Specification Suggestions

E3 Mounted Equipment Specification Reference

E3.1 Wavelength Division Multiplexer (WDM)

E3.1.1 CWDM

Product Appearance		
Product model	CTCU WPC-100091WB	Ficer FCWM-xxxxxxxxx-LGPxx-xx
Wavelength Channel	9	9
Wavelength band	1271/1291/1311/1331/1351/1371/13 91/1411/1431/1451/1471/1491/1511/ 1531/1551/1571/ 1591/1611nm	1271/1291/1311/1331/1351/1371/13 91/1411/1431/1451/1471/1491/1511/ 1531/1551/1571/ 1591/1611nm
Working environment	-40°C~+85°C	-10°C~+70°C
Power input	N/A	N/A
Communicating interface	LC/UPC	LC/UPC
Watts consumed (W)	N/A	N/A
Appearance dimension (mm)	270 x 180 x 50	420 x 354 x 139.5
Weight (kg)	TBD	2.6
Waterproof coefficient	IP65	IP65

E3.1.2 DWDM

Product Appearance	
Product model	CTCU WPC-1000-1211WB
Wavelength Channel	12

Wavelength band	C20,C21,C22,C23,C24,C25,C26,C27,C28,C29, C30,C31,C32,C33,C34,C35,C36,C37,C38,C39, C40,C41,C42,C43
Working environment	-40°C~+85°C
Power input	N/A
Communicating interface	LC/UPC
Watts consumed (W)	N/A
Appearance dimension (mm)	270 x 180 x 50
Weight (kg)	TBD
Waterproof coefficient	IP65

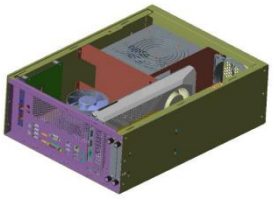
E3.2 Optical Network Unit (ONU)

Product Appearance	
Product model	Zyxel PMG5617
Working environment	0°C~+45°C
Power input	DC 12 V
Communicating interface	RJ-45
Watts consumed (W)	17
Appearance dimension (mm)	250 x 160 x 35
Weight (kg)	0.447
Waterproof coefficient	N/A

E3.3 Layer 3 Switch

Product Appearance		
Product model	EtherWAN EX78900X Series	Oring IGPS-9084GP-60W
Working environment	-40~+75°C	-40~+75°C
Power input	50~57 VDC	52~57 VDC
Communicating interface	RJ-45 x 12 SFP x 4 (PoE x12 IEEE802.3bt 90W per port; total 360W)	RJ-45 x 8 SFP x 4 (PoE x 8 IEEE802.3at 60W per port; total 240W)
Watts consumed (W)	TBD	TBD
Appearance dimension (mm)	72 x 140 x 170	96.4 x 105.5 x 154
Weight (kg)	1.5	1.29
Waterproof coefficient	IP30	IP30

E3.4 Edge Computer

Product Appearance			
Product model	ASRock Industrial iEPF-9000S-EX4	ASUS PE400D	ASUS PE7000D
Working environment	35W CPU: -40°C~75°C 65W CPU: -40°C~55°C 80W CPU: -40°C~45°C	-20~+60°C	0 to 40°C
Power input	9 to 36 VDC	9 to 36 VDC, 2-pin terminal block	Integrated850W ATX PSU 90 to 264 VAC
Communicating interface	RJ-45/RS-232/RS-422/RS-485/	RJ-45/RS-232/RS-422/RS485/USB2.0/	RJ-45/SFP/USB3.2 /USB2.0

	USB3.2 Gen2x1/USB2.0/ DP/VGA	USB3.0/HDMI/DP	
Watts consumed (W)	400	TBD	TBD
Appearance dimension (mm)	202 x 290 x 209.3	250 x 210 x 176.6	400 x 133.5 x 300
Weight (kg)	10	TBD	TBD
Waterproof coefficient	IP30	IP30	IP30

E3.5 WiFi Controller

Product Appearance	
Product model	Zyxel NXC5500
Working environment	0°C~+40°C
Power input	AC 100-240V
Communicating interface	RJ-45
Watts consumed (W)	138W
Appearance dimension (mm)	438 x 302.7 x 44
Weight (kg)	8.525
Waterproof coefficient	N/A

E3.6 NVR

Product Appearance		
Product model	QNAP TS-i410X	QNAP QVP-41B
Working environment	-40°C~+70°C	0°C~+40°C
Power input	Adapter 12VDC or	100~240V AC

	9-36V DC	
Communicating interface	RJ-45	RJ-45
Watts consumed (W)	25.6	100 In addition, a total of 140W PoE x16 (Max.30W per port) is provided
Appearance dimension (mm)	N/A	16 port 30W totally 140W
Weight (kg)	65 × 180 × 254	130 x 295 x 224.8
Waterproof coefficient	2.54	4.08
	N/A	N/A

E4 Circuit Control Box Power Supply Network Diagram / Distribution Panel Configuration Diagram/Distribution Panel Equipment List

E4.2 Reference Specifications of UPS

The following two types of UPS host reference models are listed according to different ambient temperatures. If the operating ambient temperature is 0~50 ℃, it is recommended to use 10KVA UPS. If the high and low temperature requirements of the environment are high, it is recommended to select Kefeng industrial uninterruptible system host, but the power consumption of the system should be less than 3kW.

Table E4.2-1 Reference Models of UPS Host and Battery

Name	Manufacturer	Manufacturer's model(reference)	Working temperature	Quantity	Size
UPS host	Vertiv	Libert ITA2 10KVA	0~50℃		430*85*500mm
UPS host	Powercom Co., Ltd.	TC-3000 (3KVA)	-37~+74℃		432*460*133mm
Lithium iron phosphate battery	Formosa Plastic Group	SB-0480525	Discharge -10~60℃ Charging 2~50℃		505*183*238mm

E5 System Architecture (GPON)

E6 Flow Bandwidth

Appendix F 5G Smart Pole Supply Chain Survey

F1 Mounting an Application Device

Item	Application	Function description	Vendor
1	Intelligent lighting	Lighting fixture LED lamp/LED driver/street lamp controller	Everlight Electronics Co., Ltd., Delta Electronics, Inc., ORing Industrial Networking Corp., Excellence Optoelectronics Inc.
2	Environmental monitoring	Outdoor PM2.5/PM10/temperature and humidity sensor	Delta Electronics, Inc., Sysinno Technology Inc.
3	Traffic signs/road markings	Driving signal lamp/lamp box/LED interior illuminated square signboard	So Bright Electronics Co.,LTD, Excellence Optoelectronics Inc.
4	Gateway	Network managed Ethernet switch	ORing Industrial Networking Corp., ETHERWAN SYSTEMS, INC.
5	System communication equipment	Edge computing server/industrial Internet of Things gateway	ASUSTeK Computer Inc., ASRock Industrial Computer Corporation
6	Video surveillance (NVR)	Camera real-time video recording monitoring system	QNAP Systems, Inc.
7	Video surveillance	360 ° PTZ/fish eye/gun camera	VIVOTEK INC., DYNACOLOR, INC., MERIT LILIN ENT. CO., LTD.
8	Road digital sign	Real time alert caption	SHON HUN SER TECHNOLOGY CO., LTD.
9	Internet of Vehicles (Lida/Radar)	Driving/obstacle detection	Smartmicro、Velodyne
10	Emergency call for help	Two way intercom/one-way video	VISIONSOFT INC.
11	Charging post	Electric vehicle charging equipment	YES-Energy Service Co., LTD., Delta Electronics, Inc., PHIHONG TECHNOLOGY CO., LTD., Fortune Electric Co., Ltd.
12	Digital board	Electric vehicle charging equipment	RADI INTERNATIONAL CO., LTD., Excellence Optoelectronics Inc.
13	Interactive digital board	Interactive board (touch)	NEXTECH CO., LTD.

14	Public broadcast	IP Speaker	KINGSTATE ELECTRONICS CORPORATION, PORTECH COMMUNICATIONS INC.

F2 Power and System Equipment

Item	Application	Function description	Vendor
1	DC power supply	Redundant Module; 5G wireless communication equipment DC 48V power supply, Redundant Module	Delta Electronics, Inc.
2		DC 55V power supply for network managed Ethernet switch	MEAN WELL ENTERPRISES CO., LTD.
3		Lida/radar/gateway DC 12V PoE splitter	ORing Industrial Networking Corp.
4	Distributor power system	AC multi loop ammeter and current detector	ADTEK ELECTRONICS CO., LTD.
5		Fuse free overcurrent protector (NFB), surge protector (SPD)	Shihlin Electric and Engineering Corporation
6		Earth leakage protector (ELCB)	WULING ELECTRIC CO., LTD.
7	UPS uninterruptible system	UPS Host	POWERCOM CO.,LTD., Avocent Taiwan Co., Ltd.
8		UPS Backup lithium iron battery	Formosa Lithum Iron Oxide Corporation
9	Waterproof wire and connector	Power/Signa wire, waterproof connector	SINGATRON ENTERPRISE CO., LTD., ACES ELECTRONIC CO., LTD., JESS-LINK PRODUCTS CO., LTD.

F3 5G Telecommunication and Wired Communication Equipment

Item	Application	Function description	Vendor
1	Smart pole optical network architecture	Optical cable wiring	Taiwan Intelligent Fiber Optic Network
2		Full band corrugated steel tape armored single-mode optical cable, metal free anti rodent bite single-mode optical cable	TA YA ELECTRIC WIRE & CABLE

3		Optical fiber distribution box	TAI TUNG COMMUNICATION CO., LTD.
4		Sparse wave multiplexer (CWDM), dense wave multiplexer (DWDM)	CTC UNION TECHNOLOGIES CO., LTD.
5		CWDM, DWDM optical fiber transceiver module (SFP Transceiver)	FICER TECHNOLOGY CO., LTD.
6	Smart pole 5G wireless architecture	Optical fiber transmission system equipment (ONU), 5G wireless communication equipment	Compal Electronics, Inc., Sercomm Corporation, Alpha Networks Inc., ASKEY COMPUTER CORP., Zyxel Communications Corp.
7		Wireless access communication equipment (802.11ad)	Wistron NeWeb Corporation

Appendix G Relevant Attachments

5G Smart Pole Standard Essential Patent License Statement

Patent holder：FiduciaEdge Technologies Co. Ltd. / SHAO, CHIA-CHIEN

Contactor：SHAO, CHIA-CHIEN

Address：Rm. 107, 4F.-1, No. 5, Xin'an Rd., East Dist., Hsinchu City

Tel：(03) 668-7008 #102

Email: john.zao@fiduciaedge.com

I hereby declare that the 5G Smart Bar standard promotes the standards or manuscripts developed/revised and issued by the Alliance. If they involve patents/patent applications held by me or related parties, please list the relevant data in the attached table and make the following licensing commitments (choose one):

☐ **Any party implementing the standard is licensed to use the above patent free of charge.**

■ **On the condition that it is fair, reasonable and non-discriminatory, any party implementing this standard is allowed to use the above patents.**

☐ **Refuse to grant the above patent license.**

In addition, after making this license statement, if the patent or patent application involved in this statement has been transferred, I guarantee that the transferee is still bound by this license statement.

Declarer (company seal)：_____

Authorized representative (signature)：_____

Date：_____

Attached list:

Patent Information Disclosure Form

No.	Patentee	Patentee	Country of application	Application No.	Legal status	Corresponding standard chapters
1	SHAO, CHIA-CHIEN	2020/8/14	Canada (PCT)	WO 2021/030903 A1	Under maintenance	V0.4/8.5.2
2	SHAO, CHIA-CHIEN	109/8/14	Taiwan	109127820	Under maintenance	V0.4/8.5.2

Note:

1. **Additional pages can be added to this table.**
2. **Legal status includes protection/issued/expired**

For the corresponding standard chapters, please indicate the standard version and chapter number, ex: V0.4/5.7.2

Responsibilities and Work Items of SIG1 WG

Workgroup	Responsibilities	Relevance
WG1 Structural System	Determine the size, load, safety protection (lightning, wind, water, insect, dust), wiring duct, structure configuration of related carriers, modular design and assembly	Related to WG2 and WG3
WG2 Product Power Safety System	Determine the independent design and integration of power supply wattage, power transmission, heat dissipation, charging pile, backup system, and power supply modules of various elements in the pole	Related to WG1, WG3, WG6
WG3 5G and wireless communication module	Determine the 5G communication function modules (CU, DU, RU, etc.) and supported 3GPP versions, spectrum, antenna, network feature, 5GC specification of nuclear network, MEC function, public/private network sharing (including Shared Access, Private Access, RAN sharing, etc.), other wireless and IoT related communication systems (Wire/Wireless backhaul, RSU, WiFi, Lora, Surveillance, Sensor, Traffic Light, Drones, charging pile) and equipment	Related to WG1-6
WG4 information interoperability and management system	Determine the various interfaces/API integration and support platform equipment (servers) of the smart pole control centre platform, cloud management, Internet of Things data platform, streaming media platform	Related to WG3-6
WG5 INFORMATION SYSTEM	Determine the design of encryption system, cloud security, network firewall	Related to WG3 and WG4
WG6 Application Development	Determine the application and demand of intelligent transportation, lighting, security, environmental monitoring, advertising push and other hardware equipment (speaker, LCD, lamps, and others.)	Related to WG2 and WG4

References

[1] Code for Design of Steel Structures of Steel Structures,URL:https://www.cpami.gov.tw/%E6%9C%80%E6%96%B0%E6%B6%88%E6%81%AF/%E6%B3%95%E8%A6%8F%E5%85%AC%E5%91%8A/30-%E5%BB%BA%E7%AF%89%E7%AE%A1%E7%90%86%E7%AF%87/10491-%E9%8B%BC%E6%A7%8B%E9%80%A0%E5%BB%BA%E7%AF%89%E7%89%A9%E9%8B%BC%E7%B5%90%E6%A7%8B%E8%A8%AD%E8%A8%88%E6%8A%80%E8%A1%93%E8%A6%8F%E7%AF%84.html

[2] CNS-2473-G3039, Rolled Steel for General Structure

[3] CNS-4435-G3102, Carbon Steel Tubes for General Structure

[4] CNS-2253-H3025, Aluminium and Aluminium Alloy Sheets, Strips and Plates

[5] CNS-2257-H3027, Aluminum and Aluminum Alloy Extruded Profiles

[6] CNS-10007-H3116, Hot Dip Galvanized Coatings on Iron And Steel

[7] CNS-1247-H2025, Methods of Test for Hot Dip Galvanized Coatings

[8] CNS-601-K2006, Ready Mixed Paint (Synthetic Resin Type)

[9] CNS-1157-K2029, Alkyd Resin Enamel

[10] CNS-4908-K2059, Anticorrosive Primer for General Use

[11] CNS-8886-Z8026, Methods of Salt Spray Testing

[12] Code for Wind Resistance Design of Buildings and Its Interpretation, URL:https://www.cpami.gov.tw/%E6%9C%80%E6%96%B0%E6%B6%88%E6%81%AF/%E6%B3%95%E8%A6%8F%E5%85%AC%E5%91%8A/30-%E5%BB%BA%E7%AF%89%E7%AE%A1%E7%90%86%E7%AF%87/10479-%E5%BB%BA%E7%AF%89%E7%89%A9%E8%80%90%E9%A2%A8%E8%A8%AD%E8%A8%88%E8%A6%8F%E7%AF%84%E5%8F%8A%E8%A7%A3%E8%AA%AA.html

[13] Code for Design of Building Foundation Structure, URL:https://www.cpami.gov.tw/%E6%9C%80%E6%96%B0%E6%B6%88%E6%81%AF/%E6%B3%95%E8%A6%8F%E5%85%AC%E5%91%8A/30-%E5%BB%BA%E7%AF%89%E7%AE%A1%E7%90%86%E7%AF%87/10423-%E5%BB%BA%E7%AF%89%E7%89%A9%E5%9F%BA%E7%A4%8E%E6%A7%8B%E9%80%A0%E8%A8%AD%E8%A8%88%E8%A6%8F%E7%AF%84.html

[14] Code for Design of Concrete Structures, URL:https://www.cpami.gov.tw/%E6%9C%80%E6%96%B0%E6%B6%88%E6%81%AF/%E6%B3%95%E8%A6%8F%E5%85%AC%E5%91%8A/10431-%E6%B7%B7%E5%87%9D%E5%9C%9F%E7%B5%90%E6%A7%8B%E8%A8%AD%E8%A8%88%E8%A6%8F%E7%AF%84.html

[15] Seismic design specification and interpretation of buildings, URL:https://www.cpami.gov.tw/%E6%9C%80%E6%96%B0%E6%B6%88%E6%81%AF/%E6%B3%95%E8%A6%8F%E5%85%AC%E5%91%8A/10471-%E5%BB%BA%E7%AF%89%E7%89%A9%E8%80%90%E9%9C%87%E8%A8%AD%E8%A8%88%E8%A6%8F%E7%AF%84%E5%8F%8A%E8%A7%A3%E8%AA%AA.html

[16] CNS 15200-7-7-K61152-7-7, General Test Methods for Paints - Part 7-7: Long Term Performance of Coatings - Accelerated Weathering Resistance (Ultraviolet Fluorescent Lamp and Water)

[17] 」Cite the "Smart Pole Technical Specifications and Verification Industry Cooperation" of the Asset Policy Commission

[18] Chapter 19 of Code for Design of Urban Roads and Ancillary Works, URL:https://www.cpami.gov.tw/filesys/file/chinese/dept/ep/1040810606.pdf

[19] URL:https://pkl.gov.taipei/News_Content.aspx?n=68E4428AAD994DE1&s=BA051419A2B3066B

[20] Professional services for the integration of street lights, signs, pole accessories and hanging facilities in Taipei, URL:https://pkl.gov.taipei/News.aspx?n=15732EBFCFCA1240&sms=852936DF5B713569

[21] Kaohsiung City's comprehensive replacement of energy-saving (intelligent) street lamps and maintenance case,URL:https://pwbmo.kcg.gov.tw/EngineeringDetailC003000.aspx?Cond=66d5ae2b-df3f-4092-8a8b-ff1ed29c0fb3

[22] Rules for Setting Road Traffic Signs, Markings and Signs, URL:https://law.moj.gov.tw/LawClass/LawAll.aspx?pcode=K0040014

[23] IEEE 802.11, Wireless Local Area Networks

[24] CNS-15233-C4504, LED Road Lighting Fixture
[25] CNS-14115-C6392, Limits and Measurement Methods for RF Disturbance Characteristics of Electrical Lighting and Similar Equipment
[26] CNS-61347-1-C4519-1, Light Source Control Gear - Part 1: General and Safety Requirements
[27] CNS-61347-2-13-C4519-2-13, Light Source Control Gear - Part 2-13: Particular Requirements for DC or AC Electronic Control Gear for LED Modules
[28] CNS-14165-C1147, Classification of Electrical Enclosure Protection (IP code)
[29] Compiled With Reference to the "Regulations on Street Lamp Design" (1986) of the Ministry of Economy and the "Traffic Engineering Manual" (1980) of the Ministry of Transport
[30] CNS-16120, Video Surveillance System Security
[31] Regulations of Taipei Municipality on the Administration and Autonomy of the Installation of Video Surveillance System, URL:https://www.laws.taipei.gov.tw/lawsystem/wfLaw_Information.aspx?LawID=P10C1003-20130701&RealID=10-03-1003
[32] Key points for setting up and managing the security surveillance video system of the police station of Xinbei Municipal Government,URL:https://www.tamsui.police.ntpc.gov.tw/dl-14108-16ca0968-e595-4bd1-b256-7175169dd384.html
[33] Regulations of Taoyuan Municipality on the Administration of the Establishment of Surveillance and Video Recording System,URL:https://law.tycg.gov.tw/LawContent.aspx?id=GL000263
[34] CNS-14546-C7259, Traffic Signal Light Surface and Light Box
[35] CNS-14676-5-C6424-5, Electromagnetic Compatibility - Testing and Measurement Techniques - Part 5: Surge Immunity Test
[36] CNS-13438-C6357, Information Technology Equipment - Radio Frequency Disturbance Characteristics - Limits and Measurement Methods
[37] CNS-14165-C1147, Classification of Electrical Enclosure Protection (IP Code)
[38] Setting Standards for Fire Safety Equipment in Various Places,URL:https://law.moj.gov.tw/LawClass/LawAll.aspx?pcode=D0120029

[39] CNS-14657-C6418, Acoustics - Precision Level Method for The Determination of Sound Power Level of Noise Sources - For Silent and Semi Silent Rooms
[40] CNS-14677-C7269, Sound System Equipment
[41] CNS-10522-Z2052, Emergency Broadcasting Equipment for Fire Protection
[42] CNS-14555-C7262, LED Text Display Traffic Information Signage for Roads
[43] CNS-62087-C6461, Audio Visual and Related Equipment - Determination of Power Consumption
[44] CNS-12506-C5226, General Rules for Liquid Crystal Display Panel
[45] IDOOH-210-IR, URL::https://www.ibase.com.tw/jp/ProductDetail/IndustrialPanelPC/IDOOH-210-IR
[46] CNS-15511-2-C4524-2, Electric Vehicle Conductive Charging System - Part 2: Interface Requirements
[47] Cable Gland, URL:http://denkovi.com/cable-glands-pg-type-set-of-five-pieces
[48] Cable Gland, URL:https://www.power-wiring.com/cable-glands-market-to-witness-comprehensive-growth-by-2028/
[49] ITU-G.652, URL:https://www.itu.int/rec/T-REC-G.652/en
[50] ITU-G.651G, URL:https://www.itu.int/rec/T-REC-G.651/en
[51] ANSI/TIA-598-D, URL: https://incab.co/files/tia-598-d.pdf
[52] CNS-3301-C2058, 600V PVC Insulated and Covered Cables
[53] CNS-689-C3011, Inspection Methods for Plastic Insulated Wires and Cables
[54] ISO/IEC 11801, URL:https://www.iso.org/standard/66182.html
[55] UL444, URL:https://standardscatalog.ul.com/ProductDetail.aspx?productId=UL444
[56] ANSI/TIA-568,

URL: https://www.csd.uoc.gr/~hy435/material/Cabling%20Standard%20-%20ANSI-TIA-EIA%20568%20B%20-%20Commercial%20Building%20TeleTransport%20Cabling%20Standard.pdf

[57] ANSI-T568A, URL:https://webstore.ansi.org/Standards/IEC/IEC61918Ed2018?source=preview

[58] Wire managing device URL:https://world.taobao.com/item/538038560331.htm

[59] Diagram of Split Wave Tube, URL:https://seller.pcstore.com.tw/S102519328/C1174314509.htm

[60] Chapter 16062 Grounding and Bonding of Electric Equipment – Chapter 1 General Rules, URL:https://www.cpami.gov.tw/kids/filesys/file/chinese/dept/bw2/16062.pdf

[61] Rules for Consumer Electrical equipment, URL:https://law.moj.gov.tw/LawClass/LawAll.aspx?pcode=J0030018

[62] Branch Pipe Diagram, Cable Trench Diagram, Cable Pipeline Diagram, URL:https://duct.cpami.gov.tw/pubWeb2/Duct/P3_1.aspx

[63] Administrative Measures for Construction of Attached Cables of Sewer Bridge Tunnel in Taipei City URL:https://www.laws.taipei.gov.tw/lawsystem/wfLaw_ArticleContent.aspx?LawID=P06G1013-20130925&RealID=06-07-4012&PN=ALL

[64] Regulations of Taipei Municipality on the Administration of Cables Attached to Sewer Bridges and Tunnels URL:https://www.laws.taipei.gov.tw/lawsystem/wfLaw_ArticleContent.aspx?LawID=P06G1011-20111116&RealID=06-07-1010&PN=ALL

[65] Diagram of side ditch, URL:https://www.laws.taipei.gov.tw/lawatt/Law/P06G1013-20130925-5000-001.pdf

[66] Regulations of Taipei Municipality on the Administration of Road Excavation URL:https://www.laws.taipei.gov.tw/lawsystem/wfLaw_ArticleContent.aspx?LawID=P06E1002-20141210&RealID=06-05-1002&PN=ALL

[67] Construction Specifications of Taipei Municipal Government, URL:https://www.laws.taipei.gov.tw/lawsystem/wfLaw_ArticleContent.aspx?LawID=P06C2005-20120927&LAWNO=3000&SLNO=86000&ELNO=106000

[68] ASTM D6024-96, URL:https://www.astm.org/DATABASE.CART/HISTORICAL/D6024-96.htm

[69] Annex to Construction Specifications of Taipei Municipal Government Project "Chapter 02742 Asphalt Concrete Pavement - Annex"URL:https://www.laws.taipei.gov.tw/lawatt/Law/P06C2005-20120927-0000-012.pdf

[70] CNS-12390-A3288, Test Method for Compactness of Asphalt Pavement

[71] CNS-14335-2-3-C4480-2-3, Luminaires - Part 2-3: Particular requirements for Luminaires for Road and Street Lighting

[72] CNS-2931-C4085, No Fuse Breaker

[73] CNS-5422-C4176, Residual Current Circuit Breaker

[74] ANSI C136.41, URL:https://www.amphenol-icc.com/product-series/fla-dimming-receptacle.html?utm_source=google&utm_medium=cpc&utm_campaign=nema-fla-series-asia&gclid=CjwKCAjw7rWKBhAtEiwAJ3CWLMOmId9Vg5o9k7ng-1cXg3tC2UPuzLXXiSdtdTWucSMO164bkCdHhRoClkQQAvD_BwE&__cf_chl_jschl_tk__=pmd_nSaiEf76TRMqA3JR282sCuuSVmaGleDZZyHSML2j_Jg-1632488537-0-gqNtZGzNAyWjcnBszQel

[75] CNS-1302-K3006, Rigid PVC Wire Conduit

[76] O-RAN Alliance，URL: https://www.o-ran.org/

[77] Technical Specifications for Mobile Broadband Base Station Verification, URL: URL:https://www.rootlaw.com.tw/LawContent.aspx?LawID=A040410001013500-1090518

[78] URL:https://en.wikipedia.org/wiki/WebRTC

[79] URL:https://en.wikipedia.org/wiki/Session_Initiation_Protocol

[80] URL: https://en.wikipedia.org/wiki/Data_Distribution_Service

[81] URL: https://www.redhat.com/en/topics/api/what-is-a-rest-api#:~:text=A%20REST%20API%20(also%20known,by%20computer%20scientist%20Roy%20Fielding

[82] URL:https://en.wikipedia.org/wiki/Hypertext_Transfer_Protocol

[83] URL:https://en.wikipedia.org/wiki/Constrained_Application_Protocol

[84] URL:https://en.wikipedia.org/wiki/WebSocket

[85] URL:https://mqtt.org/

[86] URL:https://en.wikipedia.org/wiki/Advanced_Message_Queuing_Protocol

[87] URL:https://www.omg.org/spec/DDSI-RTPS/

[88] URL:https://datatracker.ietf.org/doc/html/rfc5246

[89] URL:https://datatracker.ietf.org/doc/html/rfc6347

[90] Content in this section was extracted from the III 5G Smart Pole System Architecture, 2021. [draft]

[91] FIPS PUB 140-2 Annex C: Approved Random Number Generators for Security Requirements for Cryptographic Modules.

[92] See NIST 800-38D.

[93] See RFC 2104 and FIPS 198.

[94] URL:https://zh.wikipedia.org/wiki/%E5%8F%AF%E4%BF%A1%E5%B9%B3%E5%8F%B0%E6%A8%A1%E5%9D%97

[95] ITU-X.805: Security architecture for systems providing end-to-end communications, October 2003. URL: https://www.itu.int/rec/T-REC-X.805-200310-I/en.

[96] URL:https://opcfoundation.org/about/opc-technologies/opc-ua/

[97] URL:http://www.mtconnect.org/

[98] This paragraph and the enclosed table were copied from IEEE 1934-2018™ Standard on OpenFog Reference Architecture for Fog Computing, Annex A, 2018.

[99] URL:http://mqtt.org/

[100] URL:https://kubernetes.io/

[101] Nataraj Nagaratnam, “What is Confidential Computing?”, IBM Cloud Learn Hub, October 16, 2020. URL: https://www.ibm.com/cloud/learn/confidential-computing.

[102] Docker is not compatible with CRI

[103] URL:https://grpc.io/

[104] URL:https://en.wikipedia.org/wiki/Protocol_Buffers

[105] URL:https://google.github.io/flatbuffers/

[106] URL:https://theupdateframework.io/

[107] URL:https://github.com/theupdateframework/notary

[108] URL:https://www.redhat.com/en/topics/containers/what-is-kubernetes

[109] URL:https://www.redhat.com/en/topics/devops

[110] URL:https://github.com/goharbor/harbor/releases/tag/v2.0.0

[111] URL:https://www.opencontainers.org/

[112] URL:https://github.com/aquasecurity/harbor-scanner-trivy

[113] URL:https://katacontainers.io/

[114] URL:https://gvisor.dev/

[115] URL:https://en.wikipedia.org/wiki/Trusted_Computing

[116] URL:https://en.wikipedia.org/wiki/Direct_Anonymous_Attestation#:~:text=Direct%20Anonymous%20Attestation%20(DAA)%20is,privacy%20of%20the%20platform's%20user.

[117] Technical Specifications for Setting LED Street Lights in Taiwan , URL: URL:https://www.ledlighting.itri.org.tw/_admin/_upload/news/sheet/8/file/%E5%85%A8%E8%87%BA%E8%A8%AD%E7%BD%AELED%E8%B7%AF%E7%87%88%E6%8A%80%E8%A1%93%E8%A6%8F%E7%AF%84(104%E5%B9%B42%E6%9C%8817%E6%97%A5%E5%85%AC%E5%91%8A).pdf

[118] CNS 15233, LED Road Lighting Fixture

[119] CNS 14335-2-3, Luminaires - Part 2-3: Particular Requirements for Luminaires for Road and Street Lighting

[120] Code for Urban Road Lighting of the Construction Department of the Ministry of the Interior, URL: URL:https://law.moj.gov.tw/LawClass/LawAll.aspx?pcode=D0070156

[121] CNS15467-1(Version), Light Source Control Gear - Part 1: General and Safety Provisions

[122] IEC 61347-1, Light controlgear - Part 1: General and Safety Requirements

[123] CNS15467-2-13（Version）, Light Source Control Gear - Part 2-13: Particular Provisions for DC or AC Electronic Control Gear for LED Modules

[124] IEC 61347-2-13, Light controlgear - Part 2-13: Particular requirements for d.c. or a.c. supplied electronic controlgear for LED modules

[125] CISPR 15 / IEC 55015, Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment

[126] CNS14934-2（2005 Version, Electromagnetic Compatibility - Limits - Part 2: Limits of Harmonic Current Emission (Input current of each phase of equipment is below 16A)

[127] IEC 61000-3-2, Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤16 A per phase)

[128] CNS14676-5(2002 Version), Electromagnetic compatibility - Testing and Measurement Techniques - Part 5: Surge Immunity Test

[129] IEC 61000-4-5, Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test

[130] CNS14165（199 Version）, Classification of Electrical Enclosure Protection (IP Code)

[131] IEC 60529, Degrees of protection provided by enclosures (IP Code)

[132] CNS 13438, Information Technology Equipment - Radio Frequency Disturbance Characteristics - Limits and Measurement Methods

[133] CNS14336-1, Information Technology Equipment - Security - Part 1: General Requirements

[134] PLMN11, Technical Specification for Narrowband Terminal Equipment of Mobile Broadband Service

[135] PLMN10, Technical Specification for Mobile Broadband Service Broadband Terminal Equipment

[136] LP0002, Technical Specification for Low Power RF Motor

[137] TAICS TS-0027-1 v1.0, Information Safety Standard for Intelligent Street Lamp System - Part I: General Requirements

[138] TAICS TS-0027-2 v1.0, Information Safety Standard for Intelligent Street Lamp System - Part II: Intelligent Lighting

[139] TAICS TS-0028-1 v1.0, Intelligent Street Light System Information Safety Test Specification - Part I: General Requirements

[140] TAICS TS-0028-2 v1.0, Intelligent Street Lamp System Information Safety Test Specification - Part II: Intelligent Lighting

[141] TAICS TS-0034 v1.0, Data Format Standard and Test Specification of Intelligent

Street Lamp Management Platform - Lighting System

[142] RoHS, Restriction of Hazardous Substances

[143] RoHS2.0, Restriction of Hazardous Substances 2.0

[144] REACH, Registration Evaluation Authorization and Restriction of Chemicals

[145] CE EN 55032:2015, Electromagnetic compatibility of multimedia equipment - Emission Requirements

[146] CE EN 55035:2017, Electromagnetic compatibility of multimedia equipment - Immunity requirements

[147] CE EN 55024:2010 + A1:2015, Information technology equipment - Immunity characteristics - Limits and methods of measurement

[148] CE EN 50130-4:2011 + A1:2014, Alarm systems - Part 4: Electromagnetic compatibility - Product family standard: Immunity requirements for components of fire, intruder, hold up, CCTV, access control and social alarm systems

[149] CE EN 61000-6-3:2007 + A12011, Electromagnetic compatibility (EMC) - Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments

[150] CE EN 61000-6-1:2007, Electromagnetic compatibility (EMC) - Part 6-1: Generic standards - Immunity for residential, commercial and light-industrial environments

[151] FCC 47 CFR Part 15, Subpart B, Radio Frequency Devices-Unintentional Radiators

[152] IEEE 802.3af, Power Over Ethernet Standard

[153] CNS 15511-1, Electric Vehicle Conductive Charging System - Part 1: General Requirements

[154] CNS 15511-2, Electric Vehicle Conductive Charging System - Part 2: Interface Requirements

[155] CNS 15511-21, Electric Vehicle Conductive Charging System - Part 21: Requirements for Electric Vehicles With Conductive Connection to AC/DC Power Supply

[156] CNS 15511-22, Electric Vehicle Conductive Charging System - Part 22: AC Electric Vehicle Charging Station

[157] CNS 15511-3, Electric Vehicle Conductive Charging System - Part 3: Safety

Requirements

[158] IEEE 802.1Q, IEEE Standard for Local and Metropolitan Area Networks—Bridges and Bridged Networks

[159] IEEE 802.1P

[160] PoE*802.3 at Class3

[161] PoE+802.3 at Class4

[162] FCC UL 60950 (power adapter), Information Technology Equipment - Safety - Part 1: General Requirements

[163] FCC Part68 (HAC), Connection Of Terminal Equipment To The Telephone Network

[164] CE EN55022ClassB, Information technology equipment– Radio disturbance characteristics– Limits and methods of measurement

[165] CE EN55024, Information technology equipment - Immunity characteristics - Limits and methods of measurement

[166] CE EN61000 3 3, Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <= 16 A per phase and not subject to conditional connection

[167] CE EN60950 1, Information technology equipment - Safety - Part 1: General requirements

[168] CE EN62479, Assessment of the compliance of low power electronic and electrical equipment with the basic restrictions related to human exposure to electromagnetic fields (10 MHz to 300 GHz)

[169] RCM AS/ACIF S004, Voice performance requirements for customer equipment

[170] RCM AS/NZS CISPR22, Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement

[171] RCM AS/NZS CISPR24, Information technology equipment - Immunity characteristics - Limits and methods of measurement

[172] RCM AS/NZS 60950, Information technology equipment - Safety Part 1: General

requirements

[173] RCM AS/NZS 4268, Radio equipment and systems - Short range devices - Limits and methods of measurement

[174] IC ICES 003, Information Technology Equipment (including Digital Apparatus)

[175] IC RSS 247, Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

[176] IC CS 03, Requirements for Terminal Equipment (TE) and Related Access Arrangements Intended for Direct Connection to Analog Wireline Facilities

[177] IC RSS 102, Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)

[178] IEC-60068, Enviromental testing, URL: https://en.wikipedia.org/wiki/IEC_60068_-_Environmental_testing

[179] EMI and susceptibility (Class A)

[180] FCC Part 15.107, Conducted limits, URL: URL:https://www.law.cornell.edu/cfr/text/47/15.107

[181] FCC Part 15.109, Radiated emission limits, URL: URL:https://www.law.cornell.edu/cfr/text/47/15.109

[182] ERP Lot 6, Environmental Regulations for Energy Consuming Products in Standby and Shutdown Modes; URL: https://proj.ftis.org.tw/isdn/Article/ArticleView/14?mid=91&page=1&groupid=20&subgroup=17