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T/SUCA 001.4—2024

General Purpose Multimedia Interface Specification 1.0
Part 4: Power Supply

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Issued by Shenzhen 8K UHD Video Industry Cooperation Alliance

Contents

Foreword

This document was drafted in accordance with GB/T 1.1-2020 Directives for Standardization - Part 1: Rules for the Structure and Drafting of Standardizing Documents.

This document is Part 1 of T/SUCA 001 *General Purpose Multimedia Interface Specification*. T/SUCA 00 includes the following parts proposed to be published.

— Part 1: Architecture, specifying a general purpose multimedia interface (GPMI) architecture that supports information transmission between consumer electronic devices.

— Part 2: Protocols, specifying the protocols of the electrical layer, logical layer, transport layer, and adaptation layer of GPMI.

— Part 3: Connectors and Cables, specifying the technical requirements for connectors and cables using GPMI Type-B.

— Part 4: Power Supply, describing the architecture of the power supply for GPMIs, and specifying the electrical characteristics and timing requirements, physical layer, protocol layer, application layer, and power input and output requirements.

— Part 5: Alternate Mode over Type-C, specifying the method of using GPMI signals via USB Type-C ports.

This Standard was proposed by and is under the centralized management of Shenzhen 8K UHD Video Industry Cooperation Alliance.

This document was drafted by Huawei Technologies Co., Ltd., Hynetek Semiconductor Co., Ltd., China Electronics Standardization Institute, HiSilicon Technologies Co., Ltd., Shenzhen Chuangwei-RGB Electronics Co., Ltd., Shenzhen Skyworth Digital Technology Co., Ltd., Guilin University of Electronic Technology, Shenzhen CESI Information Technology Co., Ltd., Hangzhou Hikvision Digital Technology Co., Ltd., Guangdong Wire and Cable Association, Shenzhen Huntkey Chiyuan Science & Technology Co., Ltd., and Shenzhen 8K UHD Video Industry Cooperation Alliance.

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General Purpose Multimedia Interface Specification – Part 4: Power Supply

1 Scope

This document describes the architecture of the power supply for GPMIs, and specifies the electrical characteristics and timing requirements, the physical layer, protocol layer, application layer, and the power input and output requirements.

This document is applicable to the design and development of GPMI power supply systems, as well as the design and development of the power supply chips and power receiving chips that support GPMIs. It can also be used as a reference for consumer electronic devices or other electronic devices using GPMIs.

2 Normative References

The following documents constitute, through normative references in the text, indispensable provisions of this document. For dated references, only the editions cited apply. For undated references, the latest editions (including all amendments) apply.

T/SUCA 001.1-2024 General Purpose Multimedia Interface Specification—Part 1: Architecture

T/SUCA 001.2-2024 General Purpose Multimedia Interface Specification—Part 2: Protocols

T/SUCA 001.3-2024 General Purpose Multimedia Interface Specification – Part 3: Connectors and Cables

3 Term, Definition, and Abbreviation

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1 provider device

A device that provides electrical energy.

It is connected to consumer devices through cables to provide electrical energy.

Note: Provider devices include devices such as power adapters and docking stations.

3.1.2 consumer device

A device that receives electrical energy.

It is connected to a provider device through a cable to receive electrical energy.

Note: Consumer devices include devices such as TV sets.

3.1.3 cable e-marker

A chip including attribute information such as power supply information and communication information.

Note: Cable e-markers are also called cable markers.

3.1.4 data frame

The basic unit of data transmission, including a 1 start bit, 8 data bits, and 1 end bit.

3.1.5 data packet

A complete packet of information data, including data frames such as the training character, header, payload, and CRC.

3.1.6 handshake

An automated negotiation process for establishing a communication connection, usually between two parties, to ensure that both parties can exchange data normally.

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

ACK: acknowledgement

CL: cableInfo link

CRC: cyclic redundancy check

DBUS: digital bus

DGND: digital GND

GND: ground

LSB: least significant bit

MSB: most significant bit

NCK: negative acknowledgment

NTC: negative temperature coefficient

OCP: over current protection

OTP: over temperature protection

OVP: over voltage protection

PBUS: power bus

PGND: power GND

SOC: system on a chip

4 Power Supply System Architectures

4.1 Power Supply System Architectures

The dual-lane power supply system architecture is as shown in Figure 1, and the single-lane power supply system architecture is as shown in Figure 2.

When the dual-lane architecture is used, the provider device supports high-power power supply by using PBUS or low-power power supply by using DBUS.

When the single-lane system is used, the provider device supplies power to consumer devices by using PBUS.

Note: An example of high-power power supply is supplying power to a backlight module of TV set, and an example of low-power power supply is supplying power to an SOC chip.

The devices include the provider device, the consumer device, and the cable. The communication between devices and between devices and cable e-markers relies on CL signal lines (CL1 signal line in Figure 1 and Figure 2), and devices supply power to cable e-markers through CL2 pins.

Figure 1 Dual-lane power supply system architecture

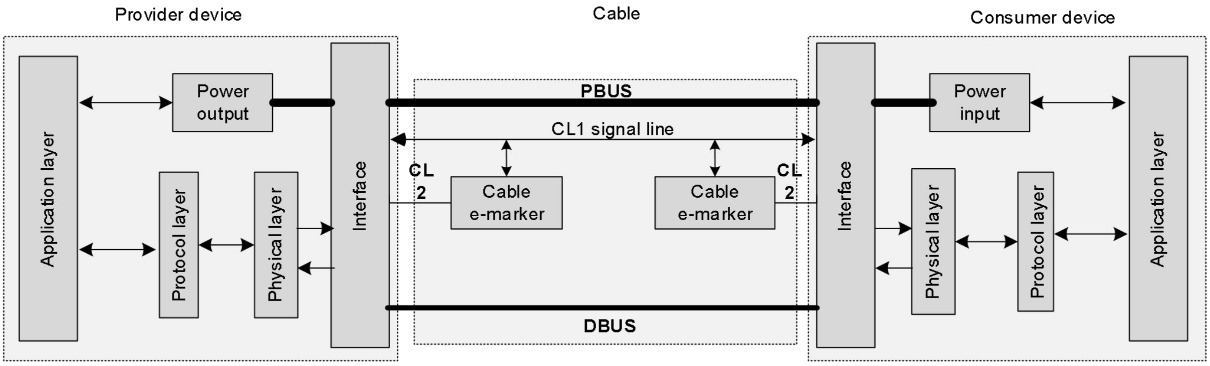
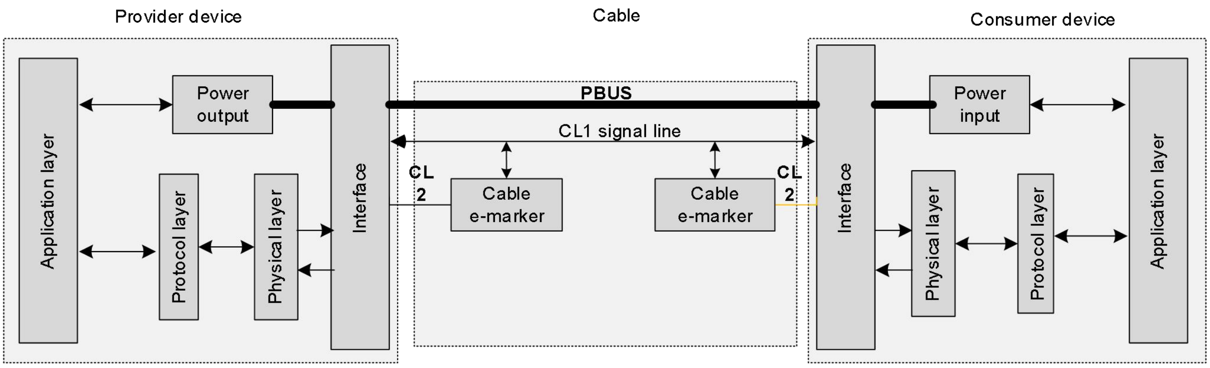


Figure 2 Single-lane power supply system architecture



The main modules in Figure 1 and Figure 2 have the following functions:

—— The interface provides pins to supply power. For example, PBUS pins and CL pins of the Type-B connector in Chapter 4 of T/SUCA 001.3-2024 shall be used to supply power to PBUS and CL, and RSV3/RSV4 pins of the Type-B connector in T/SUCA 001.3-2024 should be used to supply power to DBUS.

—— The physical layer, as the physical basis of the power supply protocol, undertakes plug-in/pull-out detection, single- and double-lane provider device identification, and data communication.

—— The protocol layer specifies the message types, message formats, and the sending, response, and execution order of messages based on the requirements of devices and information interaction between devices.

—— The application layer undertakes functions such as device control policies, authentication, device protection, and security monitoring.

—— The power input and output modules formulate different types of power supply ranges and output power voltage/current regulation requirements based on the power supply requirements of the device.

4.2 Physical Lane

The schematic diagram of the physical lanes in the reverse orientation is as shown in Figure 3.

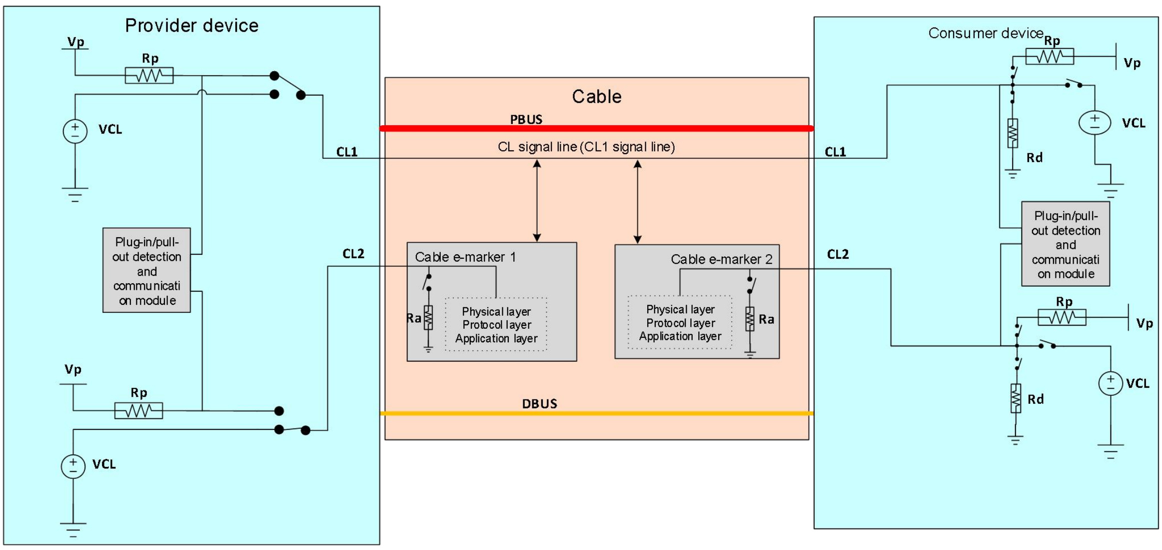
The provider device and the consumer device are connected to the CL signal line in the cable for power supply protocol negotiation communication. Both the provider device and the consumer device include Vp and VCL power supplies. Vp is used to support plug-in/pull-out detection, and VCL is used to supply power to cable e-markers.

In the forward orientation, the CL1 pin of the provider device is connected to the CL2 pin of the consumer device through the CL signal line, or the CL2 pin of the provider device is connected to the CL1 pin of the consumer device through the CL signal line.

In the reverse orientation, each of the provider device and consumer device is connected to the CL signal line through the CL1 pin for communication, and supplies power to cable e-markers through the CL2 pin.

Note: Unless otherwise specified, this document takes the reverse orientation as an example to illustrate the power supply workflow.

Figure 3 Schematic diagram of physical lanes of dual-lane power supply system in reverse orientation



The CL signal line in Figure 3 is also called the CL1 signal line, which means that the provider device and the consumer device are connected to the CL signal line through the CL1 pins.

5 Electrical Characteristics and Timing Requirements

5.1 Electrical Requirements

5.1.1 Power Supply

Vp and VCL power supplies shall comply with the requirements in Table 1.

Table 1 Requirements for Vp and VCL power supplies

Voltage	Minimum Value	Typical Value	Maximum Value	Load Capacity
Vp	3.1 V	3.3 V	3.5 V	≥ 2 mA
VCL	3.1 V	3.3 V	3.5 V	≥ 500 mA
Note: Vp is for plug-in/pull-out detection, and VCL is used to supply power to cable e-markers.				

5.1.2 Electric Resistance

The resistance values of Rp, Rd1, Rd2, and Ra shall comply with the requirements in Table 2.

Table 2 Resistance value ranges of Rp, Rd, and Ra

Resistance	Minimum Value	Typical Value	Maximum Value	Accuracy Error
Rp	11.4 kΩ	12 kΩ	12.6 kΩ	5%
Rd1	4.08 kΩ	5.1 kΩ	6.12 kΩ	20%
Rd2	19 kΩ	20 kΩ	21 kΩ	5%
Ra	0.95 kΩ	1 kΩ	1.05 kΩ	5%
Note: Rd1 and Rd2 are the resistance values of the resistor Rd in the consumer device, and are used to determine whether the consumer device needs single- or dual-lane power supply. For details, see 6.2. Rp is the pull-up resistor of the Vp power supply. Ra is used to determine whether it supports cable e-markers.				

The detected levels at the CL pins on the provider device side shall comply with the requirements in Table 3.

Table 3 Detected levels at CL pins on provider device side

Connection Condition	Minimum Value	Typical Value	Maximum Value	Recommended Detection Threshold
Pulled out	3.1 V	3.3 V	3.5 V	2.8 V
CL level-Rd2 plugged in	1.864 V	2.063 V	2.269 V	2.6 V
CL level-Rd1 plugged in	0.758 V	0.984 V	1.223 V	1.56 V
CL level-Ra plugged in	0.217 V	0.254 V	0.295 V	0.65 V

Due to ground level differences caused by current between the consumer device and the provider device, the detected levels at the CL pins on the consumer device side shall comply with the requirements in Table 4.

Table 4 Detected levels at CL pins on consumer device side

Connection Condition	Minimum Value	Typical Value	Maximum Value	Recommended Detection Threshold
VRd2	1.720 V	1.913 V	2.113 V	2.6 V
VRd1	0.70 V	0.913 V	1.139 V	1.56 V
VRa	0.201 V	0.235 V	0.275 V	0.65 V
Pulled out	—	0 V	0.24 V	0.5 V

The electrical parameters of CL communication on the provider device side shall comply with the requirements in Table 5.

Table 5 Electrical parameters on provider device side

Symbol	Parameter	Minimum Value	Typical Value	Maximum Value
Vp_INT_SLV	Communication drive voltage	3.1 V	3.3 V	3.5 V
VOH	Valid output (high)	1.85 V	—	Vp_INT_SLV
VOL	Valid output (low)	0 V	—	0.3 V
Io	Output load capability	2 mA	—	—
VIH	Valid input (high)	1.5 V	—	5 V
VIL	Valid input (low)	–0.3 V	—	0.9 V
Iin	Input current	—	—	2 mA

The electrical parameters of CL communication on the consumer device side shall comply with the requirements in Table 6.

Table 6 Electrical parameters on consumer device side

Symbol	Parameter	Minimum Value	Typical Value	Maximum Value
Vp_INT_MST	Communication drive voltage	3.1 V	3.3 V	3.5 V
VOH	Valid output (high)	1.85 V	—	Vp_INT_MST
V	Valid output (low)	0 V	—	0.3 V
Io	Output load capability	2 mA	—	—
VIH	Valid input (high)	1.5 V	—	5 V

Symbol	Parameter	Minimum Value	Typical Value	Maximum Value
VIL	Valid input (low)	–0.3 V	—	0.6 V
Iin	Input current	—	—	2 mA

The electrical parameters of cable e-marker shall comply with the requirements in Table 7.

Table 7 Electrical parameters of cable e-marker side

Symbol	Parameter	Minimum Value	Typical Value	Maximum Value
VOH	Valid output (high)	1.85 V	—	VCL
VOL	Valid output (low)	0 V	—	0.3 V
Io	Output load capability	2 mA	—	—
VIH	Valid input (high)	1.5 V	—	5 V
VIL	Valid input (low)	–0.3 V	—	0.9 V
Iin	Input current	—	—	2 mA

5.2 DC Impedance

The DC impedance of the power path shall comply with the requirements in Table 8.

Table 8 DC impedance of ground circuit of power path

Name	DC Impedance Description	Requirements
DC impedance of DBUS ground loop	The equivalent impedance of DBUS ground loop of the provider device and the consumer device (DGND)	≤ 80 mΩ
DC impedance of PBUS ground loop	The equivalent impedance of PBUS ground loop of the provider device and the consumer device (PGND)	≤ 40 mΩ

The DC impedance of the CL signal path shall be less than 50 Ω.

5.3 Communication Timing Sequence

The timing requirements for the CL signal line are as shown in Figure 3. The specific parameter shall comply with the requirements in Table 9.

Figure 4 Timing requirements for signal cable

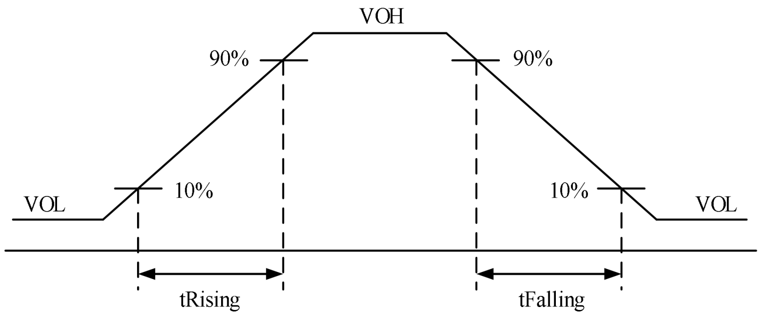


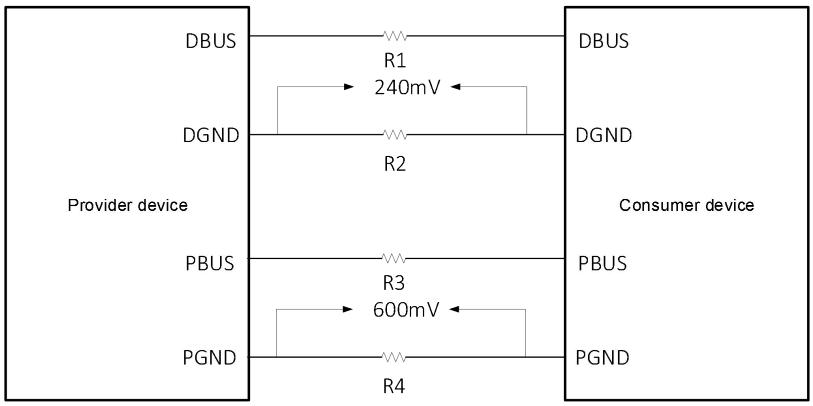
Table 9 Timing parameter requirements for signal cable

Parameter	**Test Conditions**	**Minimum Value**	**Typical Value**	**Maximum Value**
Rise time (tRising)	CL = 200 Pf, 10% VOH to 90% VOH	600 ns	—	1000 ns
Fall time (tFailing)	CL = 200 Pf, 90% VOH to 10% VOH	600 ns	—	1000 ns

5.4 Pressure Drop Requirements

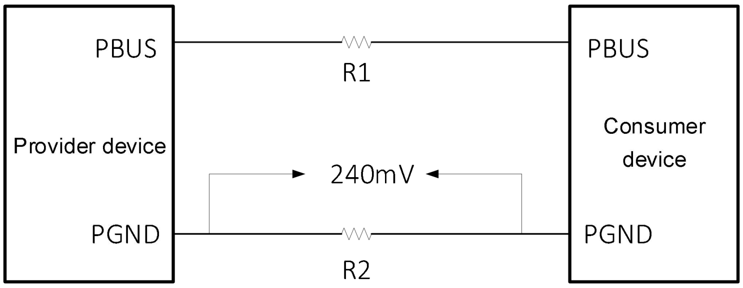
The voltage difference between the two ends of the dual-lane power supply system DGND is required to be less than or equal to 240 mV, and that between the two ends of PGND is required to be less than or equal to 600 mV. R1, R2, R3, and R4 are the equivalent resistances of cables.

Figure 5 Pressure difference requirements at DGND and PGND ends of dual-lane power supply system



The voltage difference between the two ends of the single-lane power supply system PGND is required to be less than or equal to 240 mV, and R1 and R2 are the equivalent resistances of cables.

Figure 6 Pressure difference requirements at PGND end of single-lane power supply system



6 Physical Layer

6.1 Overview

The physical layer specifies the plug-in/pull-out detection mechanism, which detects the levels of the CL pins, to identify and complete single- or dual-lane power supply. The physical layer specifies the auxiliary hot swap detection feature, to support power supply security when the device is connected to or disconnected from the cable in high-power supply scenarios. The physical layer specifies features such as the communication mechanism, data packet format, and message response mechanism, to provide a reliable physical environment for power supply negotiation.

6.2 Plug-in/Pull-out Detection

6.2.1 Description of Plug-in and Pull-out

The schematic diagram of the physical lanes of the dual-lane power supply system in the reverse orientation is as shown in Figure3, and the schematic diagram of the corresponding power supply is as shown in Figure 7. The plug-in/pull-out detection and communication modules of the provider device and the consumer device are connected to the CL signal line through the CL1 pin for plug-in/pull-out detection and communication:

– The plug-in/pull-out detection modules monitor the level change of the CL signal line through the CL1 pin, to determine whether the provider device, consumer device, and cables are mated or unmated.

– The communication module makes use of the CL signal line to complete the communication between the provider device and the consumer device, and between the devices and cable e-markers.

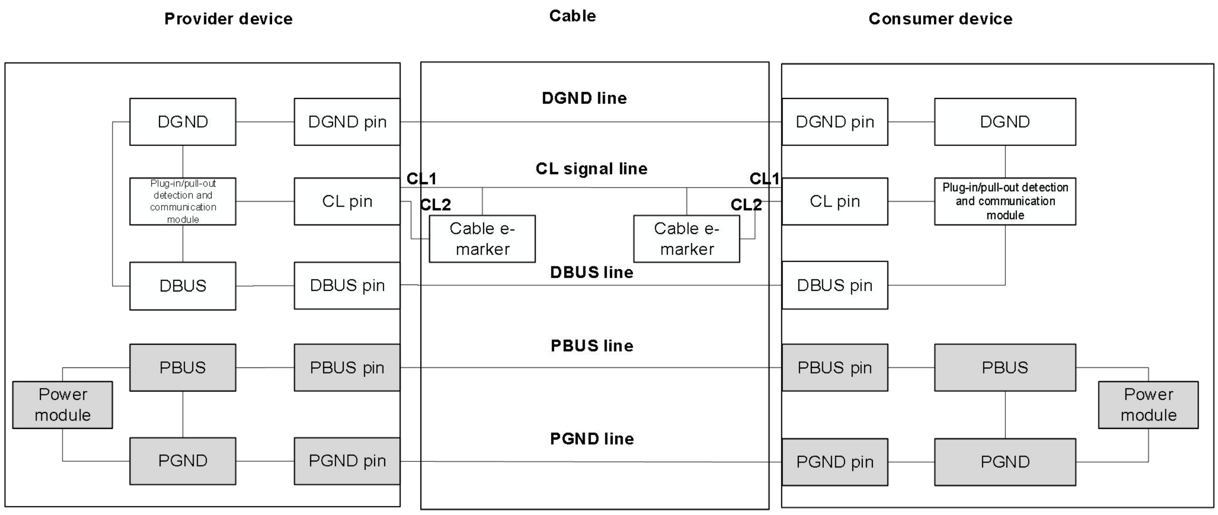
When dual-lane power supply is used, the provider device supplies power to the consumer device through different power modules as shown in Figure 7. The specific process is as follows:

– The DBUS of the provider device supplies power to its low-power components (such as the plug-in/pull-out detection and communication module), and is connected to the DBUS line through the DBUS pin to transmit power to the consumer device. The consumer device is connected to the DBUS line through the DBUS pin to obtain power, and supply power to its low-power components (such as the plug-in/pull-out detection and communication module). The DBUS of the provider device or its plug-in/pull-out detection and communication module, and the plug-in/pull-out detection and communication module of the consumer device form the entire power supply circuit through the DGND return current.

– The PBUS of the provider device supplies power to its high-power components (such as the power module), and is connected to the PBUS line through the PBUS pin to transmit power to the consumer device. The PBUS of the consumer device is connected to the PBUS line through the PBUS pin to obtain power, and supply power to its high-power components (such as the power module). The PBUS or the power module of the provider device and the PBUS or the power module of the consumer device form the entire power supply circuit through the PGND return current.

Note: In Figure 3, when the plug-in/pull-out detection module identifies any cable e-markers in the cable, the power supply connected to the CL2 pin will switch from Vp to VCL to supply power to the cable e-markers.

Figure 7 Schematic diagram of dual-lane power supply



6.2.2 Provider Device End

The provider device monitors the level changes of the CL pins. When it detects that the level of any CL pin drops, the provider device starts to time the plug-in state and continuously monitors the CL level. The plug-in/pull-out detection process at the provider device end is as follows:

(a) When the plug-in/pull-out detection module of the provider device detects that the level of the CL1 pin has been in the range of VRd1 for tDebouncePlugin, the provider device determines that the consumer device supporting single-lane power supply has been plugged in, and powers on the PBUS.

(b) When the plug-in/pull-out detection module of the provider device detects that the level of the CL1 pin has been in the range of VRd2 for tDebouncePlugin, the provider device determines that the consumer device supporting dual-lane power supply has been plugged in, and powers on the DBUS. After the PBUS control instruction is received from the consumer device, the PBUS is powered on as required by the instruction.

(c) When the plug-in/pull-out detection module of the provider device detects that the level of the CL2 pin is in the range of VRa, the provider device determines that any cable e-markers in the cable are detected, and waits for the control instruction of the consumer device before performing the power-on operation.

After the consumer device is plugged in, if the plug-in/pull-out detection module of the provider device detects that the level of CL1 pin changes in the range of VIL ≤ VCL1 < Vpullout, this detection result will not cause any change to the initial plug-in/pull-out detection of the provider device. This change will take effect only after the plug-in/pull-out operation is conducted again.

When the plug-in/pull-out detection module of the provider device detects the rising edge of the CL1 pin and VCL1 is in the range of Vpullout, the provider device starts to time the pull-out state and continuously monitors the level of the CL1 pin. When the provider device detects that the level of the CL1 pin has been within the range of Vpullout for tDebouncePullout, it determines that the consumer device has been pulled out, powers off the DBUS and the PBUS, and switches the CL2 pin to the Vp pull-up path.

In the single-lane power supply scenario, the plug-in/pull-out detection process for the provider device is as shown in Figure 8. In the dual-lane power supply scenario, the plug-in/pull-out detection process for the provider device is as shown in Figure 9. The time thresholds are defined as shown in Table 10.

Figure 8 Plug-in/Pull-out detection for provider device (single-lane consumer device)

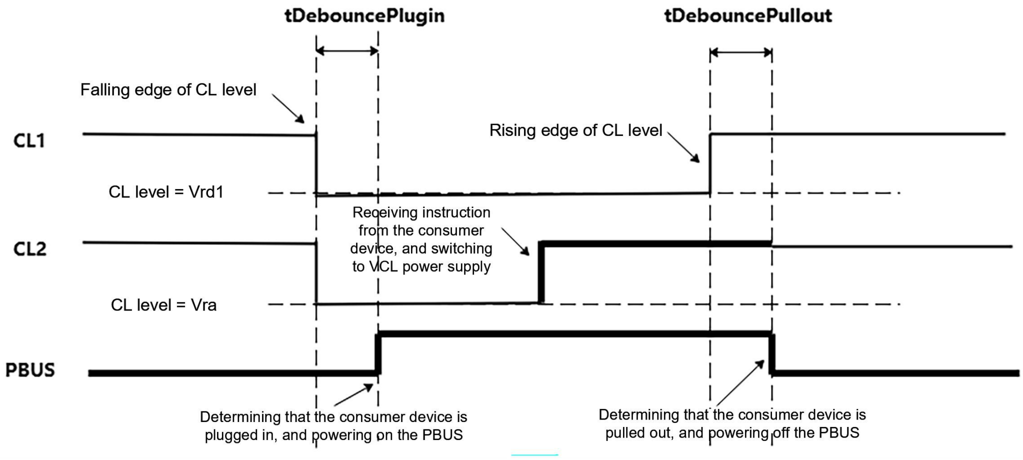


Figure 9 Plug-in/Pull-out detection for dual-lane provider device (dual-lane consumer device)

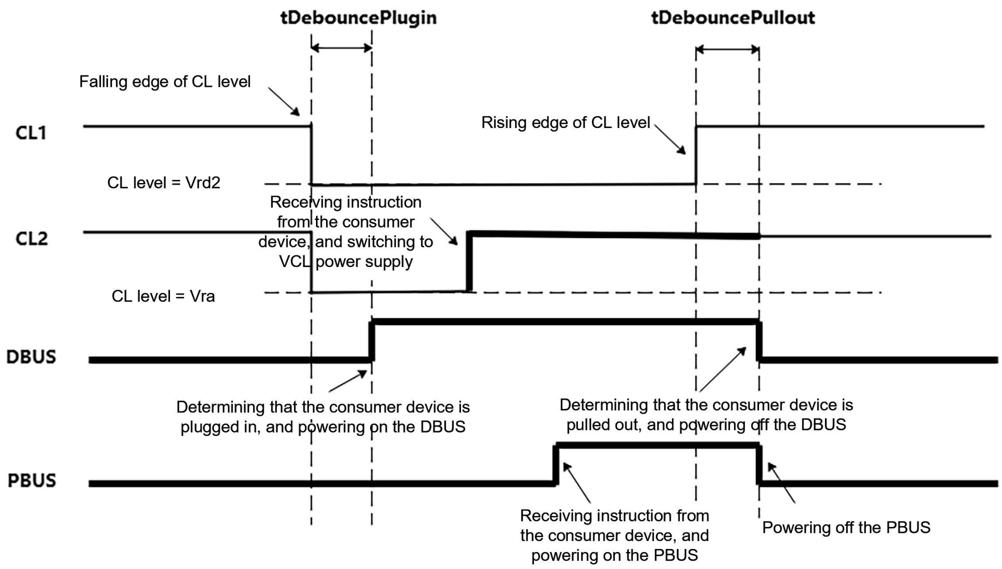


Table 10 Definitions of time thresholds for provider device side

Name	Definition	Minimum Value	Typical Value	Maximum Value
tDebouncePlugin	Debounce time for plug-in	100 ms	—	200 ms
tDebouncePullout	Debounce time for pull-out	10 ms	—	20 ms

6.2.3 Consumer Device End

In the single-lane power supply scenario, the plug-in/pull-out detection process of the consumer device for the provider device is as shown in Figure 10. In the dual-lane power supply scenario, the plug-in/pull-out detection process of the consumer device for the provider device is as shown in Figure 11. The process is as follows:

(a) When the plug-in/pull-out detection module of the consumer device detects that the PBUS pin is powered on and the level on the CL1 pin is in the range of VRd1, the consumer device determines that the single-lane provider device has been plugged in. Otherwise, the consumer device initiates a hard reset.

(b) When the plug-in/pull-out detection module of the consumer device detects that the DBUS pin is powered on and the level on the CL1 pin is in the range of VRd2, the consumer device determines that the dual-lane provider device has been plugged in. Otherwise, the consumer device initiates a hard reset.

(c) After the provider device is plugged in, if the plug-in/pull-out detection module of the consumer device detects that the level of the CL1 pin changes in the range of $0 < VCL1 \leq VIH$, this detection result will not cause any change to the initial plug-in/pull-out detection of the consumer device. This change will take effect only after the plug-in/pull-out operation is conducted again.

(d) When it is detected that the level of the CL1 pin drops to 0 and remains for tPulloutALM, the plug-in/pull-out detection module of the consumer device determines that the provider device is to be disconnected. When it is detected that the level of the CL1 pin drops to 0 and remains for tDebouncePullout or the DBUS/PBUS pin is powered off, the consumer device determines that the provider device has been disconnected.

Figure 10 Plug-in detection for single-lane provider device

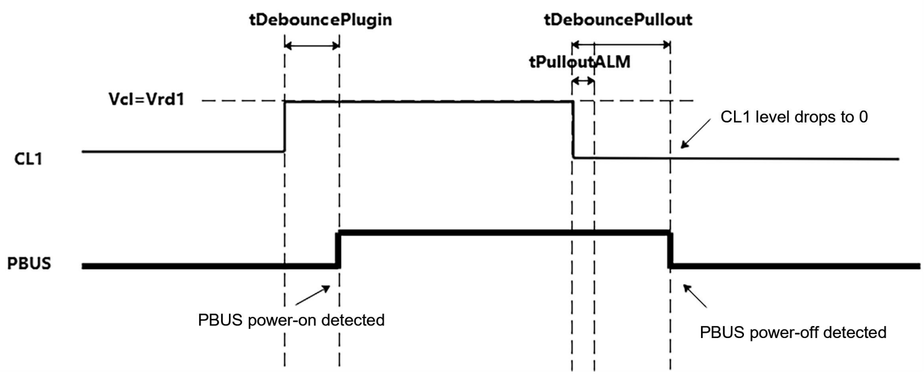
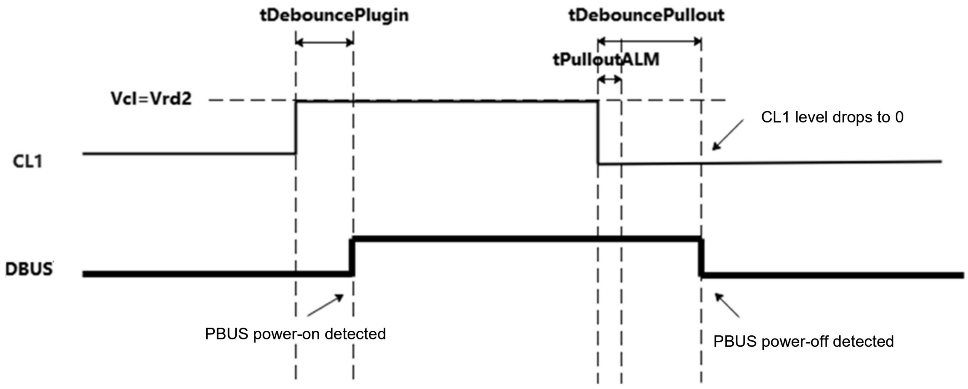


Figure 11 Plug-in detection for dual-lane provider device



The consumer device detects the presence of cable e-markers as follows:

(a) After the consumer device detects that the provider device is plugged in, it starts to detect cable e-markers, opens the Vp pull-up path of the CL2 pin, and closes Rd at the same time.

(b) After the consumer device opens the CL2 pull-up path, if it detects that the level on the CL2 pin has been in the range of VRa for tVRaDebounce, it determines that the near-end cable e-marker chip of the cable is detected. The consumer device closes the Vp pull-up circuit of the CL2 port and switches the CL2 pin to VCL to supply power to the near-end cable e-marker chip.

(c) The consumer device communicates with cable e-marker chips and the provider device, sends an instruction to configure the cable e-marker chips, and sends an instruction to request the VCL and PBUS of the provider device to output corresponding power supply.

(d) The process at the consumer device side is as shown in Figure 12, and the time thresholds are defined as shown in Table 11.

Figure 12 Plug-in/Pull-out detection of consumer device for cable e-markers

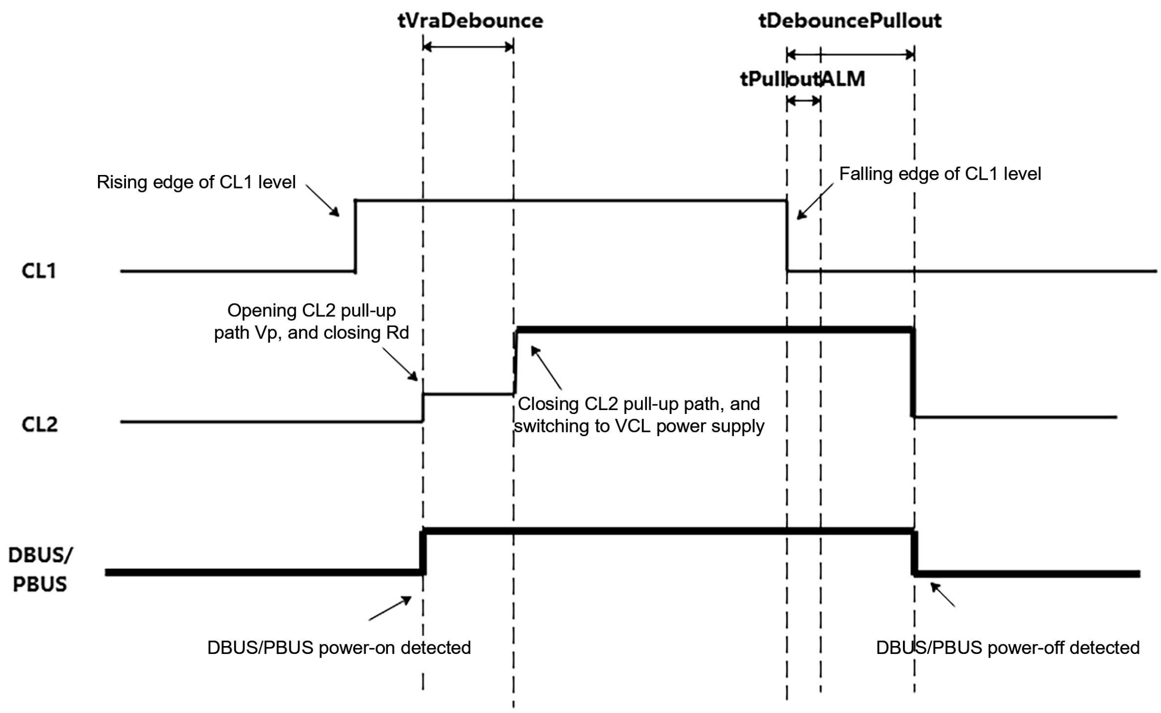


Table 11 Definitions of time thresholds for consumer device side

Name	Definition	Minimum Value	Typical Value	Maximum Value
tVRaDebounce	Debounce time for cable e-marker Ra detection	5 ms	—	10 ms
tPulloutALM	Warning time for pull-out of provider device	800 μs	—	1200 μs
tDebouncePullout	Debounce time for pull-out of provider device	10 ms	—	20 ms

6.2.4 Single- and Dual-lane Device Compatibility

The compatibility of single- and dual-lane devices is as shown in Table 12:

Table 12 Single- and dual-lane device compatibility (initial power-on)

Consumer Device	Provider Device	
	Single-lane Architecture	Dual-lane Architecture
Single-lane architecture	PBUS = 5 V DBUS = 0	PBUS = 5 V DBUS = 0
Dual-lane architecture	—	PBUS = 0

Consumer Device	Provider Device	
	Single-lane Architecture	Dual-lane Architecture
		DBUS = 5 V

6.3 Auxiliary Hot Swap Detection

When the power of system power supply is greater than or equal to 360 W, or the current of power supply is greater than or equal to 6 A, the provider device, the cable, and the consumer device shall support additional auxiliary hot swap function. As shown in Figure 13, P1/P1', P2/P2', P3/P3', and P4/P4' are metal connecting members. After the cable is connected and fixed with the provider device and the consumer device, the corresponding metal members realize the electrical connection between the cable and the device.

The metal connecting members at one end of the cable include conductive parts P1' and P2' that are electrically connected, and those at the other end of the cable include conductive parts P3 and P4 that are electrically connected. The metal connecting members of the provider device include conductive parts P1 and P2. The metal connecting members of the consumer device include conductive parts P3' and P4'. Among them, P2 and P4' are respectively grounded, and P1 and P3' are respectively connected to the Vp power supply.

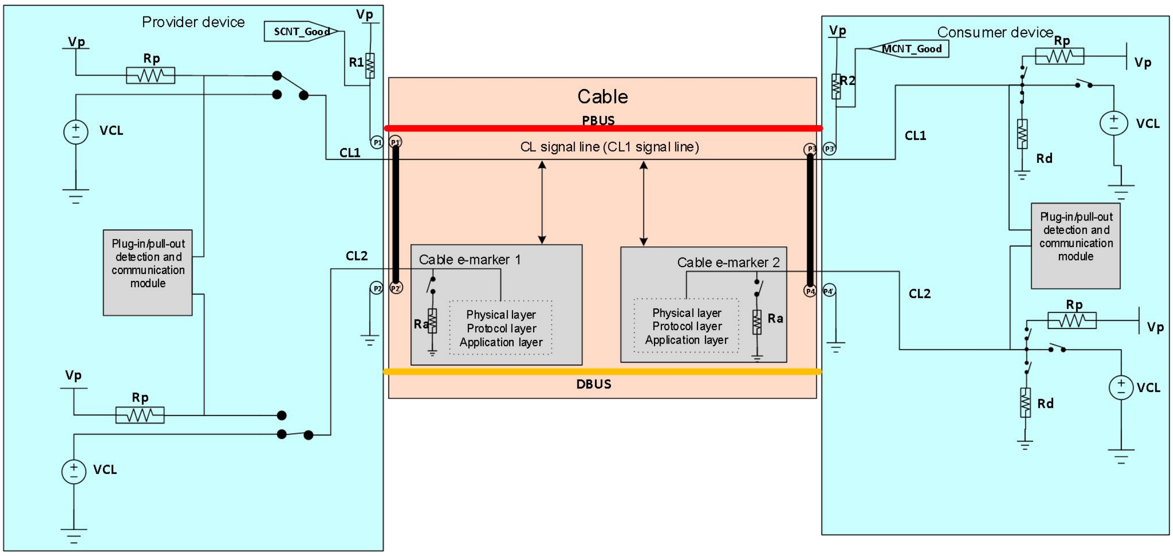
P1'/P2' at one end of the cable cooperates with P1/P2 of the provider device to trigger the SCNT_Good status signal for auxiliary hot swap detection. When the SCNT_Good signal is at a low level, this status signal is a connection signal, indicating that the provider device is connected to the cable. When the SCNT_Good signal is at a high level, this status signal is a disconnection signal, indicating that the provider device is disconnected from the cable.

When P1'/P2' at one end of the cable is connected to P1/P2 of the provider device, P1 and P2 of the provider device are electrically connected, and SCNT_Good is connected to the ground, triggering a low level (triggering the connection signal). When P1'/P2' at one end of the cable is disconnected from P1/P2 of the provider device, P1 and P2 of the provider device are electrically disconnected, and SCNT_Good is pulled up by Vp, triggering a high level (triggering the disconnection signal).

P3/P4 at the other end of the cable cooperates with P3'/P4' of the consumer device to trigger the MCNT_Good status signal for auxiliary hot swap detection. When the MCNT_Good signal is at a low level, this status signal is a connection signal, indicating that the consumer device is connected to the cable. When the MCNT_Good signal is at a high level, this status signal is a disconnection signal, indicating that the consumer device is disconnected from the cable.

When P3/P4 at the other end of the cable is connected to P3'/P4' of the consumer device, P3' and P4' of the consumer device are electrically connected, and MCNT_Good is connected to the ground, triggering a low level (triggering the connection signal). When P3/P4 at one end of the cable is disconnected from P3'/P4' of the consumer device, P3' and P4' of the consumer device are electrically disconnected, and MCNT_Good is pulled up by Vp, triggering a high level (triggering the separation signal).

Figure 13 Schematic diagram of auxiliary hot swap detection



The cable is electrically connected to the provider device and the consumer device through the CL signal line (CL1 signal line) for communication between the provider device and the consumer device, and between the devices and cable e-markers. The cable is electrically connected to the provider device and the consumer device through the CL2 pin, for the devices to supply power to the cable e-markers.

When the plug-in/pull-out detection modules of the provider device and the consumer device detect that the SCNT_Good/MCNT_Good signal is low, this status signal is a connection signal, indicating that the provider device/consumer device is connected to the cable. When they detect that the SCNT_Good/MCNT_Good signal is high, this status signal is a disconnection signal, indicating that the provider device/consumer device is disconnected from the cable. The control and detection process is as follows:

(a) After it is identified that the provider device, the consumer device and the cable are plugged in, the plug-in/pull-out detection and communication module of the consumer device detects whether the MCNT_Good signal is low. If the MCNT_Good signal is not low, high-power transmission will not be carried out. If it is low, a command will be sent through CL1 to inquire whether the SCNT_Good signal at the provider device end is low. If the SCNT_Good signal is not low, high-power transmission will not be carried out. If it is low, the next step of power communication will be carried out.

(b) After the consumer device communicates with the provider device, the provider device provides high-power output to the consumer device. If the plug-in/pull-out detection module of the consumer device detects a change in the MCNT_Good signal, it determines that the provider device is to be disconnected. If the plug-in/pull-out detection module of the provider device detects a change in the SCNT_Good signal, it is required to pull down the CL1 signal for tPulloutALM to notify the consumer device that it is to be disconnected.

(c) When it is required to pull out the device (either from the provider device end or the consumer device), the first step is to manually change the state of the SCNT_Good or MCNT_Good signal from low level to high level (for example, by removing metal screws or pressing physical clips).

(d) After the consumer device detects that the MCNT_Good signal is high or finds that the SCNT_Good signal becomes high through querying the CL1 pin, the plug-in/pull-out detection module and communication module of the consumer device determines that the cable is being hot-pulled out, and sends an instruction to the provider device to turn off the output.

Note: In Figure 13, a "plug-in/pull-out detection and communication module" has both the plug-in/pull-out detection functions and the communication functions. When only the plug-in/pull-out detection related functions are used, it can be referred to as the "plug-in/pull-out detection module". When only the communication related functions are used, it can be referred to as the "communication module". In specific implementation, these modules can be divided into plug-in/pull-out detection modules and communication modules.

6.4 Protocol Handshake Detection

(a) After the plug-in/pull-out detection module of the consumer device detects that the PBUS/DBUS is powered on, it starts handshake detection, and sends a handshake detection signal on the CL1 signal line. After the signal is sent, the consumer device releases the bus. If the consumer device receives the handshake signal as the reply of the provider device in tHandshakeRetry, it determines that the provider device supports this power supply protocol. If the consumer device does not receive the handshake signal as the reply of the provider device in tHandshakeRetry, it can send the handshake signal again. If the handshake detection still fails after the consumer device tries nMsgRetryCount times, it determines that the provider device does not support this power supply protocol.

(b) The provider device starts handshake detection after the PBUS or DBUS is powered on. If it receives the handshake signal from the consumer device in tHandshakeCheck, it determines that the consumer device supports this power supply protocol. When the CL communication line is in the idle state, the provider device replies with a handshake signal. If the handshake signal as the reply of the provider device is consistent with the received handshake signal, the provider device releases the bus after this reply. If the provider device does not receive the handshake signal from the consumer device in tHandshakeCheck, it determines that the consumer device does not support this power supply protocol.

(c) After the consumer device completes the protocol handshake detection successfully, it should send a Ping message to the provider device in tSendPing.

(d) After the provider device completes the protocol handshake detection successfully, if it receives no instructions from the consumer device in tWaitPing, it first sends a consumer device hardware reset command, and then actively resets to the initial state.

Figure 14 Handshake waveform

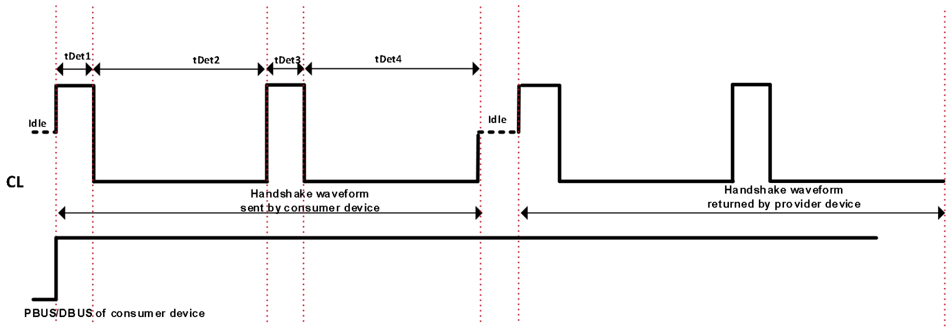


Figure 15 Handshake retry detection

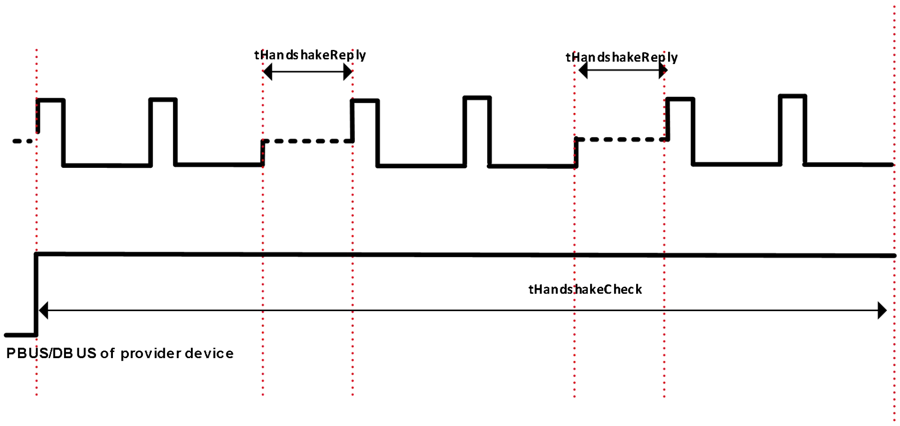


Table 13 Definitions of time thresholds for handshake detection

Name	Definition	Minimum Value	Typical Value	Maximum Value	Unit
tDet1	Duration of 1st handshake detection signal	1.5	2	2.5	ms
tDet2	Duration of 2nd handshake detection signal	6	8	10	ms
tDet3	Duration of 3rd handshake detection signal	1.5	2	2.5	ms
tDet4	Duration of 5th handshake detection signal	6	8	10	ms
tHandshakeRetry	Retry time for handshake detection of the consumer device	-	-	30	ms
tHandshakeCheck	Timeout for the provider device to wait for handshake	-	-	180	ms
tSendping	Time for the consumer device to send a Ping message after successful handshake	-	-	100	ms
tWaitPing	Time for the provider device to wait for a Ping message after successful handshake	110	-	120	ms

Table 14 Definitions of electrical thresholds for handshake detection

Symbol	Parameter	Minimum Value	Typical Value	Maximum Value	Unit
Vp_HS	Handshake detection drive voltage	3.1	3.3	3.5	V

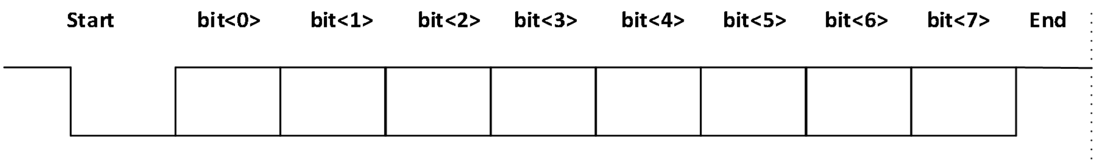
Symbol	Parameter	Minimum Value	Typical Value	Maximum Value	Unit
VOH_HS	Effective output of protocol handshake (high)	3	-	Vp_HS	
VOL_HS	Effective output of protocol handshake (low)	0	-	0.3	V
Io_HS	Output load capability	2	-	-	mA
VIH_HS	Effective intput of protocol handshake (high)	2.5	-	Vp_HS	V
VIL_HS	Effective intput of protocol handshake (low)	-0.3	-	0.6	V
Iin_HS	Input current	-	-	2	mA

6.5 Communication Mechanism

6.5.1 Data Frame Structure

The data frame structure of the physical layer is as shown in Figure 16.

Figure 16 Data frame structure



A data frame contains one start bit, eight data bits, and one end bit.

6.5.2 Idle State

When the bus is in the idle state, the signal line is in the IDLE state, when the level is Vrd, indicating that no information is transmitted on the current line. It is represented as "I" in following figures.

6.5.3 Start Bit

A logic 1 signal and a logic 0 signal are sent to indicate the start of character transmission. It is represented as "S" in following figures.

6.5.4 Data Bits

Every data frame contains 8 bits of logic 0 or 1 signals, and LSB is sent first on the bus, followed by MSB.

6.5.5 End Bit

It is the end mark of the character data, represented by one bit of high level signal. It is represented as "E" in following figures.

6.5.6 Baud Rate

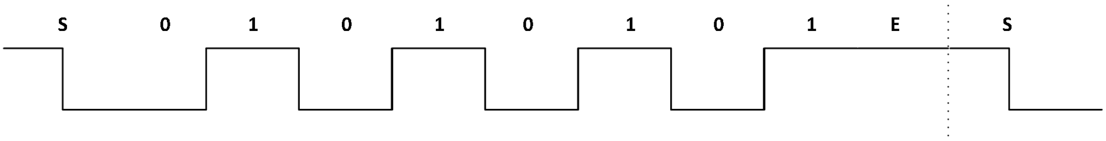
The devices in this document shall support 115,200 bps baud rate as the benchmark level.

When the transmitter sends a data packet, it first sends the training sequence (0xAA) at the set baud rate, as shown in Figure 17. The baud rate error of data transmission shall not exceed ±10% of the benchmark level. In the same data packet, the relative baud rate error shall not exceed ±1%.

Note: The relative baud rate error is calculated by detecting the pulse width of each bit, taking the pulse width of the training bit of the message header as the reference, and calculating the offset of subsequent bits in the current message.

When the receiver receives a data packet, if the baud rate error does not exceed ±15% of the benchmark level, the receiver shall respond as normal; and when the baud rate error exceeds ±15% of the benchmark level, the receiver determines that the baud rate is wrong and will not reply to the current signal.

Figure17 Training character of baud rate



The receiver can obtain the baud rate level of the currently received data packet and the current specific baud rate value by calculating the training character. Before the baud rate level changes again, the current specific baud rate value is used for receiving subsequent data packets, and this baud rate level is used for sending subsequent data packets.

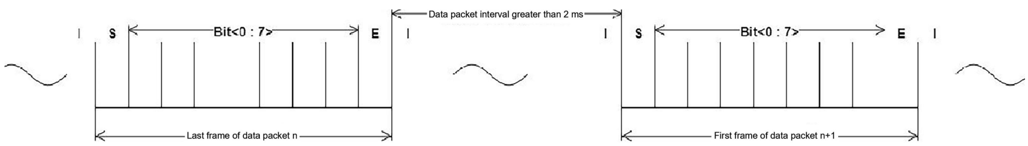
6.5.7 Data Transmission

6.5.7.1 Transmission

In the idle state, the line is at the Vrd level. When the sending instruction is received, the CL line is pulled down by one bit to start communication, and then the data is sent in the sequence from low bits to high bits. After the data is sent, the CL line is pulled up by one bit to stop sending. Then a data frame is sent.

The time of IDLE state between the transmitted data packets shall be greater than or equal to 2 ms, and the timing requirements shall comply with the requirements in Figure 18.

Figure 18 Timing requirements between data packets



6.5.7.2 Receiving

In the idle state, the line is at a high level. When the falling edge (where high level changes to low level) of the line is detected, data is transmitted on the line. The data is received in the sequence from low bits to high bits at the agreed baud rate. After the 8 bits are received, the line is pulled up. Then a data frame is sent.

In order to improve communication reliability, the data frame timeout protection function is added. In a data frame, if the end bit is not received for more than tFrameReceive, the device in the data receiving state should be restored to the idle state to receive new data packets again. Between data frames, if the next data frame is not received in tFrameReceive, the device in the data receiving state should be restored to the idle state to receive new data packets again. The time sequences of intra-frame and inter-frame timeout parameters shall comply with the requirements in Figure 19. For the definitions of the parameters, see Table 15.

Figure 19 Time sequences of intra-frame and inter-frame timeout parameters

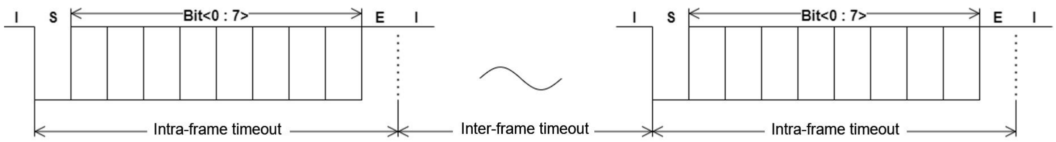


Table 15 Definitions of intra-frame and inter-frame timeout parameters

Name	Definition	Minimum Value	Typical Value	Maximum Value
tFrameReceive	Time of intra-frame and inter-frame reception timeout	500 μs	600 μs	700 μs

6.6 Cyclic Redundancy Check

The transmitter performs CRC on the data of the message header and body to obtain the CRC value of one byte, and adds it to the end of each data packet. The polynomial used is:$x^8 + x^5 + x^3 + 1$ (0x29). For the CRC-8 algorithm, see Appendix A.

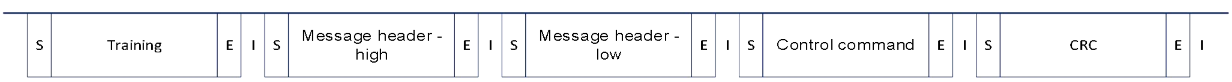
The receiver needs to calculate the CRC value of the received data, and compare it with the CRC byte received in the data packet.

6.7 Data Packet Format

6.7.1 Control Messages

The packet format of control message shall comply with the requirements in Figure 19, and shall be sent in the sequence from high byte to low byte.

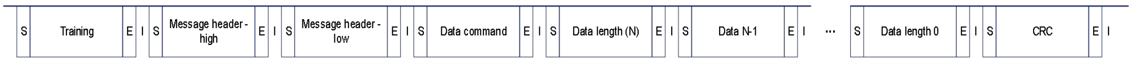
Figure20 Packet format of control message



6.7.2 Data Messages

The format of data message shall comply with the requirements in Figure 20, and shall be sent in the sequence from high byte to low byte.

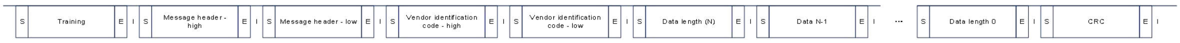
Figure 21 Packet format of data message



6.7.3 Vendor-defined Messages

The format of vendor-defined message shall comply with the requirements in Figure 21, and shall be sent in the sequence from high byte to low byte.

Figure 22 Packet format of vendor-defined message



6.8 Message Response Mechanism

ACK and NCK messages are special control messages as automatic replies after CRC of a received message (non-ACK and non-NCK messages), to notify that the message is received.

The mechanism for replying with ACK/NCK to a received message is as follows:

(a) Verify whether the device type of the message header is that of the receiver, and perform CRC.

(b) Reply with no message if ACK is received, NCK is received, or the device type verification fails.

(c) Send ACK when a non-ACK or non-NCK message is received, the device type verification passes, and the CRC passes.

(d) Send NCK when a non-ACK or non-NCK message is received, the device type verification passes, but the CRC fails.

6.9 Bus Control Right

The bus control process is as follows:

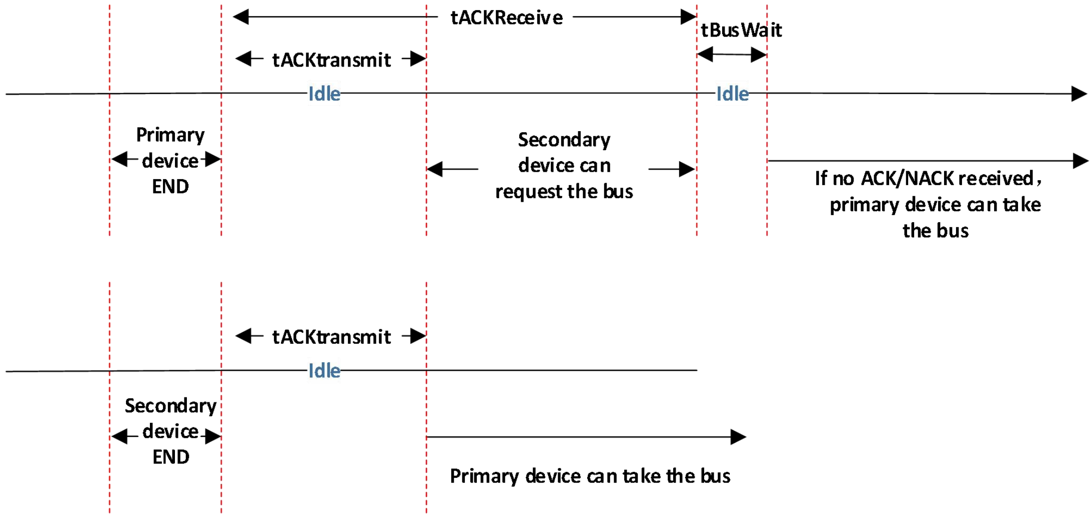
(a) After the primary device sends the end bit, it releases the communication bus and starts the timer ACKReceiveTimer. If neither ACK nor NCK is received in tACKReceive, the primary device can control the communication bus after tBusWait.

After the secondary device receives the last bit of a message, it can control the communication bus after a delay of tACKtransmit, and reply with an ACK or NCK message according to the CRC result.

(b) After the secondary device sends the end bit, it releases the communication bus and starts the timer ACKReceiveTimer. If neither ACK nor NCK is received in tACKReceive, the secondary device can control the communication bus after tBusWait, and send Hard Reset to reset the bus.

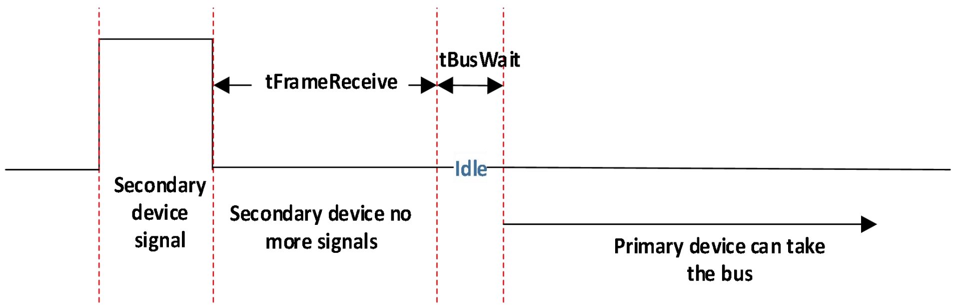
After the primary device receives the last bit of a message, it can control the communication bus after a delay of tACKtransmit, and reply with an ACK or NCK message according to the CRC result.

Figure 23 Sequence diagram of single-bus ACK/NCK signal response



(c) After the primary device receives any communication data bit except the end bit from the secondary device, if the primary device does not receive the end bit after tFrameReceive, it can control the communication bus after tBusWait.

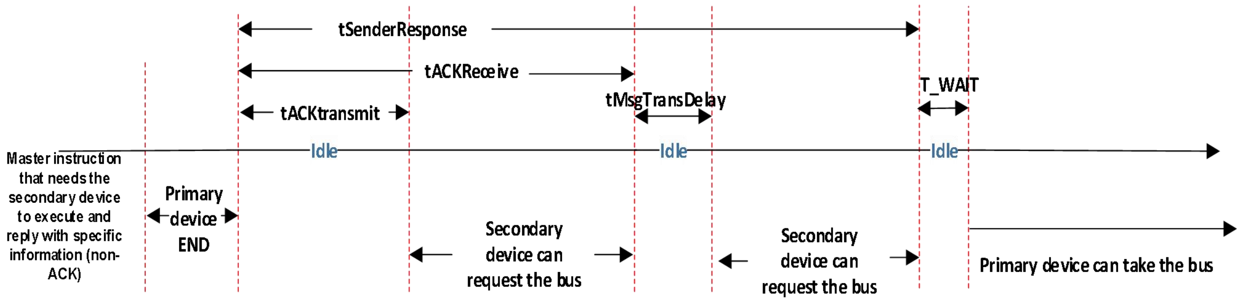
Figure 24 Sequence diagram of single-bus signal transmission exception state



(d) If the message sent by the primary device needs the secondary device to execute and reply with specific information (the message requires a reply in addition to ACK), after the primary device sends the end bit of the message, it releases the communication bus and starts the timer SenderResponseMsg1Timer. The secondary device can control the communication bus in tSenderResponseMsg1. If the primary device does not receive a reply from the opponent in tSenderResponseMsg1, it can control the communication bus after tBusWait.

After the secondary device replies with ACK, it needs to meet the requirements of tMsgTransDelay time (IDLE time between two data packets) when replying with specific information.

Figure 25 Sequence diagram of single-bus single-response signal response



(e) If the message sent by the primary device needs the secondary device to execute and reply with specific information (the message requires two or more messages in addition to ACK), the primary device releases the communication bus and starts the timer SenderResponseMsg2Timer after sending the end bit of the message. The secondary device can control the communication bus in tSenderResponseMsg2. If the primary device does not receive a reply from the opponent in tSenderResponseMsg2, it can control the communication bus after tBusWait.

After the secondary device replies with ACK, it needs to meet the requirements of tMsgTransDelay time (IDLE time between two data packets) when replying with specific information.

Figure 26 Sequence diagram of single-bus multi-response signal response

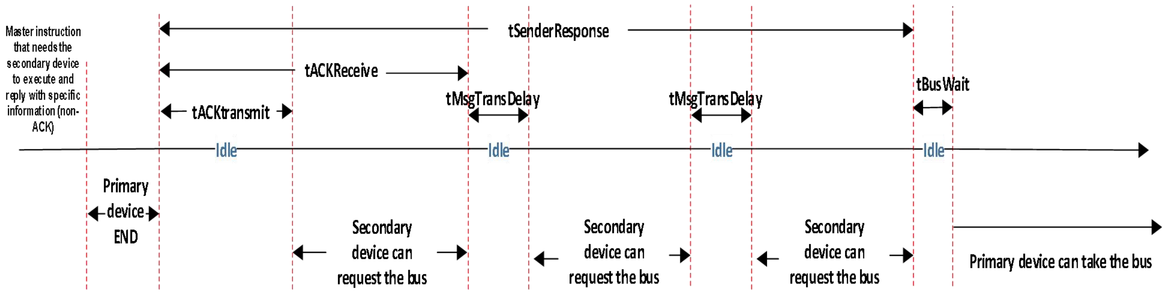


Table 16 Definitions of time thresholds

Name	Definition	Minimum Value	Typical Value	Maximum Value
tFrameReceive	Time of intra-frame and inter-frame reception timeout	500 μs	600 μs	700 μs
tACKReceive	Timeout for the primary device to receive ACK/NCK from the secondary device	—	—	10 ms
tACKtransmit	Delay time for the secondary device to reply with ACK/NCK	100 μs	—	—
tSenderResponseMsg1	Timeout for the secondary device	—	—	50 ms

Name	Definition	Minimum Value	Typical Value	Maximum Value
	to reply with a message in addition to ACK			
tSenderResponseMsg2	Timeout for the secondary device to reply with two messages in addition to ACK	—	—	300 ms
tBusWait	Delay time for the primary device to obtain bus control	100 μs	—	—

6.10 Hardware Reset

A corresponding mechanism is needed to reset the bus and the devices on the bus when an exception occurs to the data bus. For a device to be reset, its data bus shall be pulled down to ground for more than the set time to achieve a hardware reset of the device. When a cable e-marker or the provider device receives the hardware reset command, it shall be reset from the relevant state to the initial state. For the time requirements of hardware reset, see Table 17.

Table 17 Time of hardware reset

Name	Definition	Minimum Value	Typical Value	Maximum Value
tHardReset	Duration of provider device reset signal	2 ms	—	—

7 Protocol layer

7.1 Overview

According to the requirements of devices and information interaction between them, the protocol layer specifies three message types, namely control messages, data messages, and vendor-defined messages, and defines the specific format of each message type. The protocol layer specifies specific messages, the order of message sending, responding, and executing, the processing status and timing of message sending and receiving, and the process of exception handling. The protocol layer provides the application layer with an interface for sending commands and data, and passes the received commands and data to the application layer for processing.

7.2 Messages

7.2.1 Message Format

The message format is as shown in Figure 27.

Figure 27 Message format

Message header (2 bytes)	Message body (1–61 bytes)	CRC (1 byte)

Message header: The message header is used to indicate the message type, the version of the power supply protocol, and for addressing. Its length is 2 bytes.

Message body: The message body stores the specific commands and data of the message. Its length is 1 to 61 bytes.

When a message is sent, the high byte is sent first, followed by the low byte, and in the sequence of the message header, the message body, and CRC. The message header consists of 2 bytes, and is sent in the sequence from high byte (bit 15–8) to low byte (bit 7–0).

CRC: CRC calculation is performed for the data of the message header and the message body. For this purpose, the CRC-8 algorithm is used to obtain the CRC value of one byte. For the CRC-8 algorithm, see Appendix A.

Note: A message is the basic unit of information interaction between the provider device, the consumer device, and cable e-markers.

7.2.2 Message Header

The length of the message header is 2 bytes, and the message header shall comply with the requirements in Table 18.

Table 18 Definition of message header

Bit	Name	Description
15–13	Device address	The bits are used to indicate the receiver of the message, and the device determines whether to receive and process the message according to the bits. 001b: The address of the provider device 010b: The address of the consumer device 011b: The address of the near-end cable e-marker 100b: The address of the far-end cable e-marker 000b: The default address of cable e-marker Others: Reserved
12–9	Message class	The bits are used to distinguish between power supply instructions and non-power supply instructions. Power supply instructions are divided into Class A and Class B. 0000: Non-subclass power supply instruction 0001: Class A power supply instruction 0010: Class B power supply instruction Others: Reserved
8–3	Protocol version number	The bits indicate the protocol version. For example,

Bit	Name	Description
		V1.01 indicates that the corresponding version number is 010001b. To ensure compatibility, the low 2 bits indicate the large version number, namely V1 in this example; the middle 2 bits indicate the medium version number, namely 0 in this example; and the high 2 bits indicate the small version number, namely 1 in this example. 000001b: Initial version 1.0.0 010001b: Version 1.0.1 000010b: Version 2.0.0 Others: Reserved
2–0	Message type	Supported types: 000b: Control message 001b: Data message 010b: Custom message Others: Reserved

7.2.3 Control Messages

7.2.3.1 Overview

The structure of control message is as shown in Figure 28:

Figure 28 Structure of control message

Message header (2 bytes)	Control command (1 byte)	CRC (1 byte)

The message type in the control message header must be 000b, followed by a control command of one byte. For the definitions of control commands, see Table 19.

Table 19 Definitions of control commands

Command No.	Control Command	Transmitter	Receiver	Message Class	Requirements
0x00	Ping	Consumer device	Provider device/Cable e-marker	Non-subclass power supply instruction	Required
0x01	ACK	Provider device/Consumer device/Cable e-marker	Provider device/Consumer device/Cable e-marker	Non-subclass power supply instruction	Required
0x02	NCK	Provider	Provider	Non-subclass	Required

Command No.	Control Command	Transmitter	Receiver	Message Class	Requirements
		device/Consumer device/Cable e-marker	device/Consumer device/Cable e-marker	power supply instruction	
0x03	Accept	Provider device/Cable e-marker	Consumer device	Non-subclass power supply instruction	Required
0x04	Soft_Reset	Consumer device	Provider device/Cable e-marker	Non-subclass power supply instruction	Required
0x05	Power_Ready	Provider device	Consumer device	Subclass power instruction	Required
0x06	Get_Output_Capabilities	Consumer device	Provider device	Subclass power instruction	Required
0x07	Get_Source_TempInfo	Consumer device	Provider device	Non-subclass power supply instruction	Required
0x08	Get_Source_PowerInfo	Consumer device	Provider device	Subclass power instruction	Required
0x09	Get_Cable_Info	Consumer device	Cable e-marker	Non-subclass power supply instruction	Required
0x0A	Get_Cable_Temp	Consumer device	Cable e-marker	Non-subclass power supply instruction	Required
0x0B	Get_Device_Info	Consumer device	Provider device/Consumer device	Non-subclass power supply instruction	Required
0x0C	Get_Error_Info	Consumer device	Provider device/Cable e-marker	Non-subclass power supply instruction	Required
0x0D	Poweron_VCL	Consumer device	Provider device	Non-subclass power supply instruction	Required
0x0E	Poweroff_VCL	Consumer device	Provider device	Non-subclass power supply instruction	Required
0x0F	AddressModifyDone	Cable e-marker	Consumer device	Non-subclass power supply instruction	Required

Command No.	Control Command	Transmitter	Receiver	Message Class	Requirements
0x10	GotoMinVol	Consumer device	Provider device	Subclass power instruction	Required
0x11	PoweroffBUS	Consumer device	Provider device	Subclass power instruction	Required

7.2.3.2 Ping Message

A Ping message is used to detect the presence of a destination device, and can also be used to test whether transmission is normal. After the provider device or a cable e-marker receives a Ping message, if the CRC result shows that no error is detected, it shall reply with an ACK message in tACKReceive. If the CRC result shows that any error is detected, it shall reply with an NCK message in tACKReceive.

The transmitter of a Ping message can resend the message if it does not receive an ACK or NCK message as reply from the opponent in tACKReceive. The number of resends is not limited by the MsgRetryCounter counter.

7.2.3.3 ACK Message

After the provider device, the consumer device, or a cable e-marker receives a message sent to it, it first performs CRC on the message. If the CRC passes, it will reply with an ACK message to the opponent after a delay of tACKtransmit.

The transmitter of a message starts ACKReceiveTimer after it sends the last bit of the message. If it receives ACK in tACKReceive, it determines that the message sent by it has been correctly received by the opponent. and stops ACKReceiveTimer.

When the provider device, the consumer device, or a cable e-marker receives an ACK message with the CRC result showing that no error is detected, it does not need to reply with an ACK message. When the provider device, the consumer device, or a cable e-marker receives an ACK message with the CRC result showing that any error is detected, it does not need to reply with an NCK message.

7.2.3.4 NCK Message

After the provider device, the consumer device, or a cable e-marker receives a message sent to it, it first performs CRC on the message. If the CRC fails, it will reply with an NCK message to the opponent after a delay of tACKtransmit.

The transmitter of a message starts ACKReceiveTimer after it sends the last bit of the message. If it receives NCK in tACKReceive, it determines that the message sent by it has been received by the opponent, but an error occurs in the data. In this case, the transmitter shall resend the message immediately, and reset and restart ACKReceiveTimer after it resends the message.

When the provider device, the consumer device, or a cable e-marker receives an NCK message with the CRC result showing that no error is detected, it does not need to reply with an ACK message. When the provider device, the consumer device, or a cable e-marker receives an NCK message with the CRC result showing that any error is detected, it does not need to reply with an NCK message.

7.2.3.5 Accept Message

The receiver of a message shall reply with an Accept message in the following cases:

(a) The provider device receives a Request message from the consumer device, agrees to the output voltage and current requested by the consumer device, and then adjusts to the output voltage and current requested by the consumer device.

(b) The provider device receives a Config_Watchdog message from the consumer device, and agrees to adjust the watchdog overflow time to the time specified in the message.

(c) The provider device or a cable e-marker receives a Verify_Request message and agrees to perform authentication.

7.2.3.6 Soft_Reset Message

The receiver of a message shall reply with a Soft_Reset message in the following cases:

(a) After the consumer device resends a message nMsgRetryCount times, it does not receive an ACK or NCK message from the opponent still, or it receives an NCK message from the opponent.

(b) After the provider device or a cable e-marker receives a Soft_Reset message, it does not exit from the power supply protocol mode or change the current working state. However, the provider device, the consumer device, or a cable e-marker shall restore the receiving state machine and the sending state machine to their initial states, reset timers and counters, clear the sending and receiving buffers, and terminate unfinished message processing flows.

7.2.3.7 Power_Ready Message

After the provider device receives a Request or PoweronVcl message from the consumer device and accepts this request, it shall reply with an Accept message in tReceiverResponse, and send a Power_Ready message to the consumer device after it adjusts the output voltage, current, or power to the value requested in the Request message.

After the provider device replies with an Accept message, it shall adjust the output voltage, current, or power to the value requested in the Request message in tPowerSupply, and reply with a Power_Ready message to the consumer device.

7.2.3.8 Get_Output_Capabilities Message

After the power supply protocol identification is completed, the consumer device can send a Get_Output_Capabilities message to the provider device to obtain the voltage and current output capabilities of the provider device.

After the provider device receives a Get_Output_Capabilities message, it shall reply with an Output_Capabilities message in tReceiverResponse.

7.2.3.9 Get_Source_TempInfo Message

After the power supply protocol identification is completed, the consumer device can send a Get_Source_TempInfo message to the provider device to obtain the current temperature information of the provider device.

After the provider device receives a Get_Source_TempInfo message, it shall reply with a Source_TempInfo message in tReceiverResponse.

7.2.3.10 Get_Source_PowerInfo Message

After the power supply protocol identification is completed, the consumer device can send a Get_Source_PowerInfo message to the provider device to obtain the current voltage and current information of the provider device.

After the provider device receives a Get_Source_PowerInfo message, it shall reply with a Source_PowerInfo message in tReceiverResponse.

7.2.3.11 Get_Cable_Info Message

After the power supply protocol identification is completed, the consumer device can send Get_Cable_Info messages to cable e-markers to obtain the device information and transmission capacity of the cable, including the impedance, the maximum carrying voltage, and the maximum carrying current of the cable.

After a cable e-marker receives a Get_Cable_Info message, it shall reply with a Cable_Information message in tReceiverResponse.

7.2.3.12 Get_Device_Info Message

After the protocol identification is completed, the consumer device can send requests to the provider device and cable e-markers for their hardware and software information.

The consumer device sends a Get_Device_Info message to the destination device. After the destination device receives the Get_Device_Info message, it shall reply with a Device_Information message in tReceiverResponse.

7.2.3.13 Get_Error_Info Message

After the protocol identification is completed, the consumer device can send requests to the provider device and cable e-markers for their exception state information. The exception state information includes voltage exception, current exception, and temperature exception.

The consumer device sends a Get_Error_Info message to the destination device. After the destination device receives the Get_Error_Info message, it shall reply with a Error_Information message in tReceiverResponse.

The consumer device sends a PowerStepDown message to the provider device. After the provider device receives the PowerStepDown message, it does not need to give any additional reply message except ACK or NCK.

7.2.3.14 PoweronVCL Message

After the protocol identification is completed, when the consumer device completes supplying power to the near-end cable e-marker, it can send a PoweronVCL message to the provider device, to make the provider device to supply power to the far-end cable e-marker.

The consumer device sends a PoweronVCL message to the provider device. After the provider device receives the PoweronVCL message, it shall reply with an Accept message in tReceiverResponse, adjust the output voltage, current, or power to the required value in tPowerSupply, and reply with a Power_Ready message to the consumer device, indicating that the provider device has completed supplying power to cable e-markers.

7.2.3.15 PoweroffVCL Message

After the protocol identification is completed, when the consumer device completes supplying power to the near-end cable e-marker, it can send a PoweronVCL message to the provider device, to make the provider device to supply power to the far-end cable e-marker. The consumer device can send a PoweroffVCL message to the provider device when necessary.

The consumer device sends a PoweroffVCL message to the provider device. After the provider device receives the PoweroffVCL message, it shall reply with an Accept message in tReceiverResponse, and turn off the VCL voltage.

7.2.3.16 AddressModifyDone Message

After the protocol identification is completed, the consumer device will send AddressModify messages to cable e-markers. After a cable e-marker completes modifying its address, it sends a AddressModify_Done message to the consumer device.

7.2.3.17 PoweroffBUS Message

After the protocol identification is completed, when the provider device outputs power on the BUS, it can send a PoweroffBUS message to turn off the power output on the BUS when necessary.

The consumer device sends a PoweroffBUS message to the provider device. After the provider device receives the PoweroffBUS message, it shall reply with an Accept message in tReceiverResponse, and turn off the power supply of the BUS.

7.2.4 Data Messages

7.2.4.1 Overview

The structure of data message is as shown in Figure 29:

Figure 29 Structure of data message

Message header (2 bytes)	Command (1 byte)	Data length (1 byte)	Data (1–59 bytes)	CRC (1 byte)

The message type in the data message header shall be 001b, followed by a command of one byte, to distinguish different data messages. The data length field is set according to the specific length of the subsequent data area. Data message commands shall comply with the requirements in Table 20:

Table 20 Data message commands

Command No.	Command	Transmitter	Receiver	Message Class	Requirements
0x01	Output_Capabilities	Provider device	Consumer device	Subclass power instruction	Required
0x02	Request	Consumer device	Provider device	Subclass power instruction	Required

Command No.	Command	Transmitter	Receiver	Message Class	Requirements
0x03	Source_TempInfo	Provider device	Consumer device	Non-subclass power supply instruction	Required
0x04	Source_PowerInfo	Provider device	Consumer device	Subclass power instruction	Required
0x05	Cable_Information	Cable e-marker	Consumer device	Non-subclass power supply instruction	Required
0x06	Device_Information	Provider device	Consumer device	Non-subclass power supply instruction	Required
0x07	Error_Information	Provider device/Cable e-marker	Consumer device	Non-subclass power supply instruction	Required
0x08	Config_Watchdog	Consumer device	Provider device/Cable e-marker	Non-subclass power supply instruction	Required
0x09	Refuse	Provider device/Cable e-marker	Consumer device	Non-subclass power supply instruction	Required
0x0A	Verify_Request	Consumer device	Cable e-marker/Provider device	Non-subclass power supply instruction	Optional
0x0B	Verify_Response	Cable e-marker/Provider device	Consumer device	Non-subclass power supply instruction	Optional
0x0C	AddressModify	Consumer device	Cable e-marker	Non-subclass power supply instruction	Required
0x0D	PowerStepUp	Consumer device	Provider device	Subclass power instruction	Required
0x0E	PowerStepDown	Consumer device	Provider device	Subclass power instruction	Required
0x0F	ExtDeviceRegWrite	Consumer device	Cable e-marker	Non-subclass power supply instruction	Optional
0x10	ExtDeviceRegRed	Consumer device	Cable e-marker	Non-subclass power supply	Optional

Command No.	Command	Transmitter	Receiver	Message Class	Requirements
				instruction	
0x11	Cable_TempInfo	Cable e-marker	Consumer device	Non-subclass power supply instruction	Required
0x12	Test_Request	Test device	Provider device/Consumer device/Cable e-marker	Non-subclass power supply instruction	Required

7.2.4.2 Output_Capabilities Message

7.2.4.2.1 Message Structure

The structure of Output_Capabilities message is as shown in Figure 30:

Figure 30 Structure of Output_Capabilities Message

Message header (2 bytes)	Command (Output_Capabilities)	Data length (1 byte)	Output mode 1 (8 bytes)	Output mode 2 (8 bytes)	...	Output mode n (1 ≤ n ≤ 7) (8 bytes)	CRC (1 byte)

Command: The number corresponding to the command set as an Output_Capabilities message.

Data length: An Output_Capabilities message has at least one output mode, and can include up to 7 output modes. The value of the data length field is calculated based on the number of output modes. Each output mode consists of 8 bytes, so that the total length is 8 x n bytes for n output modes, where n ≤ 7.

Output mode: The output mode is used to indicate the power output mode of the provider device. In the programmable output mode, the output voltage of the provider device is configured as a range (including the upper and lower limits of the output voltage). The output current of the provider device is also configured as a range (including the upper and lower limits of the output current). In addition, the voltage and current regulation steps supported must be selected for the provider device. In the fixed voltage output mode, the output voltage of the provider device is configured as a fixed value. The output current of the provider device can be set to a fixed value or as a range (including the upper and lower limits of the output current). When the current is configured as a range, the current regulation step supported must be selected for the provider device.

The provider device shall support at least one output mode, and can support up to 7 output modes. For the definition of output mode, see Table 21. The output mode number is used to number the one or more output modes in the Output_Capabilities message. The number of the first output mode after the data length field in the Output_Capabilities message is 1, and the subsequent output modes are numbered in ascending order with increments of 1. When an Output_Capabilities message is sent, the output modes are sent in the sequence from 1 to n.

Table 21 Definition of output mode

Bit	Description
63–60	Output mode number
59–58	Current regulation step: 000b: 10 mA 001b: 20 mA 010b: 30 mA 011b: 40 mA 100b: 50 mA 111b: The current is not adjustable (which is valid only in the fixed voltage output mode) Others: Reserved
57–56	Voltage regulation step: 00b: 10 mV 01b: 20 mV
55–40	Maximum output voltage, in 10 mV
39–24	Minimum output voltage, in 10 mV
23–8	Maximum output current, in 10 mA
7–0	Minimum output current, in 10 mA

7.2.4.2.2 Fixed Voltage Output Mode

When the maximum output voltage and the minimum output voltage in an output mode are set to the same voltage value, the output mode is with a fixed voltage output.

In the fixed voltage output mode, if the current regulation step is set to 111b, no request can be made to adjust the maximum output current of the fixed voltage output mode. In the working scenario with this fixed voltage output mode, the current output by the provider device shall not exceed the maximum output current value indicated in the output mode. In this case, the voltage regulation step and minimum output current fields in the output mode will be invalid, and can be set to 0 by default. For example, if a fixed voltage output mode of the provider device is 10 V and 5 A, the output mode is configured as follows:

Table 22 An example of fixed voltage output mode (10 V and 5 A)

Bit	Description
63–60	Output mode number
59–57	Current regulation step: 111b
56	Voltage regulation step: 0b
55–40	Maximum output voltage: 10 V

Bit	Description
39–24	Minimum output voltage: 10 V
23–8	Maximum output current: 5 A
7–0	Minimum output current: 0 A

In the fixed voltage output mode, if the current regulation step is set to any of the five valid values from 000b to 100b as defined in Table 21, a request can be made to adjust the maximum output current of this fixed voltage output mode. In this way, the minimum output current and the maximum output current constitute the constant current capacity interval of the provider device. The consumer device can send a Request message to request a provider device to set its constant current point to a certain value in the constant current capacity range. The actual output current of the provider device will not exceed this requested constant current value. In this case, the voltage regulation step field in the output mode will be invalid, and can be set to 0 by default. For example, if a fixed voltage output mode of the provider device is 10 V (2–5 A) and the current regulation step is 40 mA, the output mode is configured as follows:

T**able 23** Example of a fixed voltage output mode (10 V 2–5 A)

Bit	Description
63–60	Output mode number
59–57	Current regulation step: 011b
56	Voltage regulation step: 0b
55–40	Maximum output voltage: 10 V
39–24	Minimum output voltage: 10 V
23–8	Maximum output current: 5 A
7–0	Minimum output current: 2 A

7.2.4.2.3 Programmable Output Mode

When the maximum output voltage and the minimum output voltage in an output mode are set to different voltage values, the output mode represents the programmable output mode.

In the programmable output mode, the maximum output voltage shall be greater than the minimum output voltage, and the maximum output current shall be greater than or equal to the minimum output current. A provider device sets the current regulation step and voltage regulation step according to its capability.

For example, a certain programmable output mode of a provider device is voltage 5.5–11 V, current 0.5–5 A, current regulation step 30 mA, and voltage regulation step 20 mV. The following is the configuration of this output mode.

Table 24 Example of a programmable output mode

Bit	Description
63–60	Output mode number
59–57	Current regulation step: 010b
56	Voltage regulation step: 1b
55–40	Maximum output voltage: 11 V
39–24	Minimum output voltage: 5 V
23–8	Maximum output current: 5 A
7–0	Minimum output current: 0.5 A

7.2.4.2.4 Output Mode Setting Requirements

When there are both fixed voltage output modes and programmable output modes in the Output_Capabilities message, all fixed voltage output modes shall be placed before all programmable output modes.

When there are multiple fixed voltage output modes, these output modes shall be arranged according to the size of the output voltage in the Output_Capabilities message. The fixed output mode with a lower output voltage comes first, followed by the fixed output mode with a higher output voltage, and the output mode numbers are assigned in sequence.

When there are multiple programmable output modes, these output modes shall be arranged according to the maximum output voltage in the Output_Capabilities message. The programmable output mode with a lower maximum output voltage comes first, followed by the programmable output mode with a higher maximum output voltage, and the output mode numbers are assigned in sequence.

When there are multiple programmable output modes, the minimum output voltage of programmable output mode n ($7 \geq n > 1$) shall be equal to the maximum output voltage of programmable output mode n–1. The voltage output ranges of all programmable output modes of a provider device must form a continuous voltage output range to represent the entire programmable output voltage range that the provider device can provide. For example, if a provider device has only two adjacent programmable output modes 1 and 2, and their output voltage ranges are 3.4–5.5 V and 5.5–11 V respectively, then the complete programmable output voltage range of the provider device is 3.4–11 V. If the output voltage ranges of these two programmable output modes are 3.4–5 V and 5.5–11 V respectively, the minimum output voltage of programmable output mode 2 is not equal to the maximum output voltage of programmable output mode 1, resulting in failure to form a continuous voltage output range. This situation is not allowed.

The definition and division for the entire programmable output voltage range of a provider device must comply with the requirements in Table 45. According to the rated power of a provider device, Table 45 is checked for the voltage levels that must be supported and those that may optionally be supported by the provider device. The entire programmable output voltage range of the provider device is then determined based on its actual voltage and current output capabilities. After the entire programmable output voltage range is determined, the range is divided into one or more programmable output modes according to the differences in current output capabilities of the provider device across different voltage ranges. A programmable output mode can be used to represent multiple voltage levels. A voltage level can also be divided into one to three programmable output modes.

Example 1:

The rated power of the provider device is 20 W. According to Table 45, the device shall support a 5 V programmable voltage level. Within the voltage range of a 5 V programmable level, the provider device has a maximum output current of 3 A and a minimum output current of 0.5 A. Then, the provider device only sets one programmable output mode, and the following arrangement shows the output mode of the Output_Capabilities message.

Figure 31 Example of a programmable output mode (power 20 W)

Output mode number: 1
Current regulation step: 010b
Voltage regulation step: 1b
Maximum output voltage: 5.5 V
Minimum output voltage: 3.4 V
Maximum output current: 3 A
Minimum output current: 0.5 A

Example 2:

The rated power of the provider device is 33 W. According to Table 45, the device must support a 10 V programmable voltage level. In addition, the provider device optionally supports a 5 V programmable level in the range of 5–5.5 V. Then, the entire programmable output voltage range of the provider device is 5–11 V.

(a) If the provider device has a maximum output current of 3 A throughout its programmable output voltage range (5–11 V), then the device can be represented by only one programmable output mode, and the following arrangement shows the output mode of the Output_Capabilities message.

Figure 32 Example of a programmable output mode (power 33 W, maximum output current at level 1)

Output mode number: 1
Current regulation step: 010b
Voltage regulation step: 1b
Maximum output voltage: 11 V
Minimum output voltage: 5 V
Maximum output current: 3 A
Minimum output current: 0.5 A

(b) If the provider device has different maximum output current capabilities within different voltage ranges, such as 4 A within 5–5.5 V and 3 A within 5.5–11 V, then the device needs to be represented by two programmable output modes, and the following arrangement shows the output mode of the Output_Capabilities message.

Figure 33 Example of programmable output modes (power 33 W, maximum output current at level 2)

Output mode number: 1 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 5.5 V Minimum output voltage: 5 V Maximum output current: 4 A Minimum output current: 0.5 A	Output mode number: 2 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 11 V Minimum output voltage: 5.5 V Maximum output current: 3 A Minimum output current: 0.5 A

Example 3:

The rated power of the provider device is 80 W. According to Table 45, the device shall support a 10 V programmable voltage level. In addition, the provider device optionally supports a 5 V programmable level and a 20 V programmable level in the range of 11–20 V. Then, the entire programmable output voltage range of the provider device is 3.4–20 V.

(a) If the provider device has a maximum output current of 6 A within the voltage range of 3.4–5.5 V, 5 A within the range of 5.5–11 V and 4 A within the range of 11–20 V, then the device needs to be represented by three programmable output modes, and the following arrangement shows the output mode of the Output_Capabilities message.

Figure 34 Example of programmable output modes (power 80 W, maximum output current at level 3)

Output mode number: 1 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 5.5 V Minimum output voltage: 3.4 V Maximum output current: 6 A Minimum output current: 0.5 A	Output mode number: 2 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 11 V Minimum output voltage: 5.5 V Maximum output current: 5 A Minimum output current: 0.5 A	Output mode number: 3 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 20 V Minimum output voltage: 11 V Maximum output current: 4 A Minimum output current: 0.5 A

(b) The provider device can further subdivide the entire programmable output voltage range according to its current output capabilities. For example, the maximum output current is 6 A within the voltage range of 3.4–5.5 V, 5.5 A within the range of 5.5–8 V, 5 A within the range of 8–12 V, 4.5 A within the range of 12–15 V, and 4 A within the range of 15–20 V, then the device needs to be represented by five programmable output modes, and the following arrangement shows the output mode of the Output_Capabilities message.

Figure 35 Example of programmable output modes (power 80 W, maximum output current at level 5)

Output mode number: 1 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 5.5 V Minimum output voltage: 3.4 V Maximum output current: 6 A Minimum output current: 0.5 A	Output mode number: 2 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 8 V Minimum output voltage: 5.5 V Maximum output current: 5.5 A Minimum output current: 0.5 A	Output mode number: 3 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 12 V Minimum output voltage: 8 V Maximum output current: 5 A Minimum output current: 0.5 A	Output mode number: 4 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 15 V Minimum output voltage: 12 V Maximum output current: 4.5 A Minimum output current: 0.5 A	Output mode number: 5 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 20 V Minimum output voltage: 15 V Maximum output current: 4 A Minimum output current: 0.5 A

(c) If two fixed voltage output modes, 9 V 5 A and 15 V (1–4 A), are added to the five existing programmable output modes in (b), the following arrangement shows the output mode of the Output_Capabilities message.

Figure 36 Example of programmable output modes (power 80 W, maximum output current at level 7)

Output mode number: 1 Current regulation step: 111b Voltage regulation step: 0b Maximum output voltage: 9 V Minimum output voltage: 9 V Maximum output current: 5 A Minimum output current: 0 A	Output mode number: 2 Current regulation step: 010b Voltage regulation step: 0b Maximum output voltage: 15 V Minimum output voltage: 15 V Maximum output current: 4 A Minimum output current: 1 A	Output mode number: 3 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 5.5 V Minimum output voltage: 3.4 V Maximum output current: 6 A Minimum output current: 0.5 A	Output mode number: 4 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 8 V Minimum output voltage: 5.5 V Maximum output current: 5.5 A Minimum output current: 0.5 A	Output mode number: 5 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 12 V Minimum output voltage: 8 V Maximum output current: 5 A Minimum output current: 0.5 A	Output mode number: 6 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 15 V Minimum output voltage: 12 V Maximum output current: 4.5 A Minimum output current: 0.5 A	Output mode number: 7 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 20 V Minimum output voltage: 15 V Maximum output current: 4 A Minimum output current: 0.5 A

7.2.4.3 Request Message

The structure of a Request message is shown in Figure 37.

Figure 37 Structure of a Request message

Message header (2 bytes)	Command (Request)	Data length (1 byte)	Requested data (5 bytes)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the Request message.

Data length: The request data of the Request message contains only 5 bytes, so the data length is set to 5.

The structure of request data is shown in Table 25.

Table 25 Structure of request data

Bit	Description
39–36	Reserved
35–32	Output mode number (1–7)
31–16	Requested output voltage, unit: 10 mV
15–0	Requested output current, unit: 10 mA

In the structure of the request data, the output mode number indicates which output mode in the Output_Capabilities message is requested for the provider device to use.

If a fixed voltage output mode is requested, the request output voltage field is filled with the maximum output voltage value of that fixed mode. If the current regulation step of that fixed mode is 111b, the request output current field is filled with the maximum output current value in the fixed voltage output mode. If the current regulation step of that fixed mode is a valid value other than 111b defined in the output mode, the request output current field can be set to a value between the maximum and minimum output current (inclusive).

If a programmable output mode is requested, request the provider device to output a certain voltage value between the maximum and minimum output voltage (inclusive) of the programmable output mode, and request the provider device to output a certain current value between the maximum and minimum output current (inclusive) of the mode.

The voltage and current requested by the consumer device from the provider device shall not exceed the voltage and current ranges identified in the corresponding output mode in the Output_Capabilities message of the provider device, nor shall they exceed the carrying capacity of the cable. The carrying capacity of the cable is determined by the maximum carrying voltage and maximum carrying current in the Cable_Information message replied by the cable e-marker.

For example, the following shows the output mode of the Output_Capabilities message sent by the provider device.

Figure 38 Example of a Request message of a provider device

Output mode number: 1 Current regulation step: 111b Voltage regulation step: 0b Maximum output voltage: 9 V Minimum output voltage: 9 V Maximum output current: 5 A Minimum output current: 0 A	Output mode number: 2 Current regulation step: 010b Voltage regulation step: 0b Maximum output voltage: 15 V Minimum output voltage: 15 V Maximum output current: 4 A Minimum output current: 1 A	Output mode number: 3 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 5.5 V Minimum output voltage: 3.4 V Maximum output current: 6 A Minimum output current: 0.5 A	Output mode number: 4 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 11 V Minimum output voltage: 5.5 V Maximum output current: 5 A Minimum output current: 0.5 A	Output mode number: 5 Current regulation step: 010b Voltage regulation step: 1b Maximum output voltage: 20 V Minimum output voltage: 11 V Maximum output current: 4 A Minimum output current: 0.5 A

(a) If a consumer device requests a provider device to output a fixed voltage of 9 V and a limited maximum output current of 5 A according to the output mode 1, the following shows the request data format of the consumer device's Request message.

Figure 39 Example of a Request message of a consumer device (output mode 1)

Output mode number: 1 ... Requested output voltage: 9 V Requested output current: 5 A

(b) If a consumer device requests a provider device to output a fixed voltage of 15 V and a limited maximum output current of 3.5 A according to the output mode 2, the following shows the request data format of the consumer device's Request message.

Figure 40 Example of a Request message of a consumer device (output mode 2)

Output mode number: 2 ... Requested output voltage: 15 V Requested output current: 3.5 A

(c) If a consumer device requests a provider device to output programmable voltage and programmable current (voltage 5.1 V and current 3 A) according to the output mode 3, the following shows the request data format of the consumer device’s Request message.

Figure 41 Example of a Request message of a consumer device (output mode 3)

Output mode number: 3
...
Requested output voltage: 5.1 V
Requested output current: 3 A

7.2.4.4 Source_TempInfo Message

The structure of a Source_TempInfo message is shown in Figure 42.

Figure 42 Structure of a Source_TempInfo message

Message header (2 bytes)	Command (Source_TempInfo)	Data length (1 byte)	Requested data (2 bytes)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the Source_TempInfo message.

Data length: The status information of the Source_TempInfo message contains 2 bytes, so the data length is set to 2.

The structure of request data is shown in Table 26.

Table 26 Structure of Source_TempInfo request data

Bit	Description
15–8	Current internal temperature of the provider device, in °C Bit 15–8 = 00000000, marking that the provider device has no internal temperature data
7–0	Current output port temperature of the provider device, in °C Bit 7–0 = 00000000, marking that the provider device has no temperature data for the output port

7.2.4.5 Source_PowerInfo Message

The structure of a Source_PowerInfo message is shown in Figure 43.

Figure 43 Structure of a Source_PowerInfo message

Message header (2 bytes)	Command (Source_PowerInfo)	Data length (1 byte)	Requested data (4 bytes)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the Source_PowerInfo message.

Data length: The status information of the Source_PowerInfo message contains 4 bytes, so the data length is set to 4.

The structure of request data is shown in Table 27.

Table 27 Structure of Source_PowerInfo request data

Bit	Description
31–16	Current output voltage, in 10 mV
15–0	Current output current, in 10 mA

7.2.4.6 Cable_Information Message

The structure of a Cable_Information message is shown in Figure 44.

Figure 44 Structure of a Cable_Information message

Message header (2 bytes)	Command (Cable_Information)	Data length (1 byte)	Requested data (28 bytes)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the Cable_Information message.

Data length: The cable information of the Cable_Information message contains 24 bytes, so the data length is set to 24.

The structure of request data is shown in Table 28.

Table 28 Structure of Cable_Information request data

Bit	Type	Description
192–190	Basic information	Reserved
189		RSV3/RSV4 pin support, 0: not supported, 1: supported (Type-B shall use RSV3/RSV4 as DBUS.)
188		RSV1/RSV2 pin support, 0: not supported, 1: supported
187–184		Version number of the Cable_Information structure (not the version number of the power supply protocol document) 0000b: reserved 0001b: version 1.0 0001b–1111b: reserved
183–176		Vendor ID: uniformly assigned by the organization
175–168		Product ID: assigned by the vendor

<table>
<tr><th>Bit</th><th>Type</th><th>Description</th></tr>
<tr><td>167–160</td><td rowspan="7"></td><td>Device hardware version number, assigned by the vendor</td></tr>
<tr><td>159–152</td><td>Device software version number, assigned by the vendor</td></tr>
<tr><td>151–150</td><td>Cable type
00: passive cable
01: active cable
Others: reserved</td></tr>
<tr><td>149–147</td><td>Two-piece connector of the cable
001b: Type-B male connector to Type-B male connector
Others: reserved</td></tr>
<tr><td>146</td><td>Reserved</td></tr>
<tr><td>145–144</td><td>Number of cable e-markers, 01: 1 pc, 10: 2 pcs, others: reserved</td></tr>
<tr><td>143–136</td><td>Maximum operating temperature of cable, in °C</td></tr>
<tr><td>135–132</td><td rowspan="3">Communication information</td><td>Reserved</td></tr>
<tr><td>131–128</td><td>Maximum communication rate
0000b: reserved
0001b: HS1 2 Gbps 010b: HS1 4 Gbps 011b: HS2 6 Gbps
0100b: HS2 8 Gbps 101b: HS3 10 Gbps 0110b: HS3 12 Gbps
0111b: HS3 16 Gbps 000b: HS4 20 Gbps 1001b: HS4 24 Gbps
1011b–1110b: reserved 111b: other modes</td></tr>
<tr><td>127–124</td><td>Cable length (cable delay)
0000b: 0.8 m (< 10 ns)
0001b: 1.5 m ([10 ns, 15 ns))
0010b: 2 m ([10 ns, 20 ns))
0011b: 3 m ([20 ns, 30 ns))
0100b: 4 m ([30 ns, 40 ns))
0101b: 5 m ([40 ns, 50 ns))
0110b: 10 m ([90 ns, 100 ns))
0111b: 15 m ([140 ns, 150 ns))
1000b: 20 m ([190 ns, 200 ns))
1001b–1111b: reserved</td></tr>
<tr><td>123–122</td><td rowspan="2">Communication information</td><td>Number of main link lanes
00b: 4
01b: 8
10b–11b: reserved</td></tr>
<tr><td>121</td><td>Whether to support USB 2.0 communication
0b: USB 2.0 not supported</td></tr>
</table>

Bit	Type	Description
		1b: USB 2.0 supported
120		Whether to support fast training 0: not supported 1: supported
119–112		Fast training IL-2 Gbps Value range: [0, 255]. 1 unit represents 0.2 dB. Accuracy: 0.2 dB. Range: 0 dB to 51 dB
111–104		Fast training IL-4 Gbps Value range: [0, 255]. 1 unit represents 0.2 dB. Accuracy: 0.2 dB. Range: 0 dB to 51 dB
103–96		Fast training IL-6 Gbps Value range: [0, 255]. 1 unit represents 0.2 dB. Accuracy: 0.2 dB. Range: 0 dB to 51 dB
95–88		Fast training IL-8 Gbps Value range: [0, 255]. 1 unit represents 0.2 dB. Accuracy: 0.2 dB. Range: 0 dB to 51 dB
87–80		Fast training IL-10 Gbps Value range: [0, 255]. 1 unit represents 0.2 dB. Accuracy: 0.2 dB. Range: 0 dB to 51 dB
79–72		Fast training IL-12 Gbps Value range: [0, 255]. 1 unit represents 0.2 dB. Accuracy: 0.2 dB. Range: 0 dB to 51 dB
71–64		Fast training IL-16 Gbps Value range: [0, 255]. 1 unit represents 0.2 dB. Accuracy: 0.2 dB. Range: 0 dB to 51 dB
63–56		Fast training IL-20 Gbps Value range: [0, 255]. 1 unit represents 0.2 dB. Accuracy: 0.2 dB. Range: 0 dB to 51 dB
55–48		Fast training IL-24 Gbps Value range: [0, 255]. 1 unit represents 0.2 dB. Accuracy: 0.2 dB. Range: 0 dB to 51 dB
47–40	Power supply information	Cable DBUS ground loop impedance, in 5 mΩ
39–32		Cable PBUS ground loop impedance, in 5 mΩ
31–24		DBUS maximum operating voltage, in 1 V
23–16		DBUS maximum operating current, in 0.5 A
15–8		PBUS maximum operating voltage, in 1 V
7–0		PBUS maximum operating current, in 0.5 A

7.2.4.7 Device_Information Message

The structure of a Device_Information message is shown in Figure 45.

Figure 45 Structure of a Device_Information message

Message header (2 bytes)	Command (Device_Information)	Data length (1 byte)	Requested data (8 bytes)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the Device_Information message.

Data length: The device information of the Device_Information message contains 8 bytes, so the data length is set to 8.

The structure of request data is shown in Table 29. The vendor identification code must be filled with the identification code of the vendor corresponding to the brand of the provider device or consumer device. The vendor-defined identification code can be filled with the manufacturer identification code of the provider device or consumer device, the vendor identification code of the scheme or main control chip, or other relevant vendor identification codes to assist in further identifying and distinguishing devices. The vendor corresponding to the brand of the provider device or consumer device determines the content of the vendor-defined identification code by itself, and the content can be filled with the default value 0x0000. The device hardware version number and software version number are in a format defined by the device vendor. If not filled in, the default value 0 is used. When sending device information, send the high byte first and then the low byte.

Table 29 Structure of Device_Information request data

Bit	Description
63–48	Vendor identification code
47–32	Vendor-defined identification code
31–16	Device hardware version number
15–0	Device software version number

7.2.4.8 Error_Information Message

The structure of an Error_Information message is shown in Figure 46.

Figure 46 Structure of an Error_Information message

Message header (2 bytes)	Command (Error_Information)	Data length (1 byte)	Requested data (4 bytes)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the Error_Information message.

Data length: The error information of the Error_Information message contains 4 bytes, so the data length is set to 4.

The structure of request data is shown in Table 30.

Table 30 Structure of Error_Information request data

Bit	Description
15–4	Reserved
3	0: normal; 1: OTP
2	0: normal; 1: PBUSOVP
1	0: normal; 1: DBUSOVP
0	0: normal; 1: CLOVP

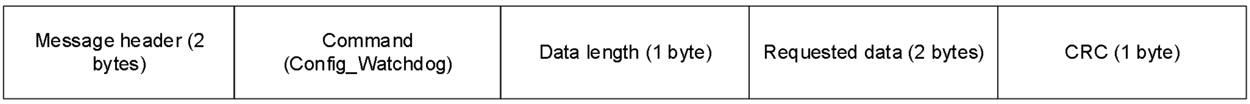
When a provider device encounters an error in the table, it shall set the relevant bits of the error information to 1.

A consumer device can obtain the error state information of a provider device by sending a Get_Error_Info message. After receiving the Get_Error_Info message, the provider device shall reply with an Error_Information message within tReceiverResponse time.

7.2.4.9 Config_Watchdog Message

The structure of a Config_Watchdog message is shown in Figure 47.

Figure 47 Structure of a Config_Information message



Command: It is set to the number corresponding to the command of the Config_Watchdog message.

Data length: The configuration information of the Config_Watchdog message contains 2 bytes, so the data length is set to 2.

The structure of request data is shown in Table 31.

Table 31 Structure of Config_Watchdog request data

Bit	Description
15–0	Watchdog timer overflow time, in ms

The watchdog timer overflow time of a provider device is 1s by default. A consumer device can configure the watchdog overflow time of the provider device through the Config_watchdog message. If the watchdog timer overflow time configured in the message is 0, the watchdog function is turned off.

The watchdog is started after the successful protocol identification between the provider device and the consumer device. The provider device shall reset the watchdog every time it receives a message from the consumer device. If the provider device needs to reply to a received message (except for replying to an ACK message), the watchdog shall be suspended from the time when the message is received until the reply message is sent. After sending the reply message, restart the watchdog. For example, when a provider device receives a Request message from a consumer device, it immediately resets the watchdog and suspends the watchdog. After the Power_Ready message is sent, it restarts the watchdog.

After the watchdog timer of a provider device overflows, the hardware reset of the provider device is triggered to return to the initial state.

7.2.4.10 Refuse Message

The structure of a Refuse message is shown in Figure 48.

Figure 48 Structure of a Refuse message

Message header (2 bytes)	Command (Refuse)	Data length (1 byte)	Feedback information (2 bytes)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the Refuse message.

Data length: The feedback information of the Refuse message contains 2 bytes, so the data length is set to 2.

The structure of request data is shown in Table 32.

Table 32 Structure of Refuse message request data

Bit	Description
15–11	Reserved
10–8	Message type: For the message type rejected by the Refuse message, see the three message types defined in Table 18.
7–0	Reasons for rejection: 0x01 -> unrecognized command or data 0x02 -> unsupported command or data 0x03 -> device busy, unable to respond temporarily 0x04 -> out-of-range output voltage, current, or power requested by a consumer device 0x05 -> other reasons

After receiving a message, if a provider device, a consumer device, or a cable e-marker cannot respond to or execute the action requested by the message due to a reason listed in Table 32, it shall reply to the sender with a Refuse message within the tReceiverResponse time. The Refuse message is filled with the message type of the rejected message and the reason for rejection.

When a provider device, a consumer device, or a cable e-marker receives a correct CRC message, and the following situations occur in the message, the rejection reason in the Refuse message is 0x01 (unrecognized command or data):

(a) The message type in the message header is incorrect. For example, the message type identification is 011, which is undefined in Table 16.

(b) According to the message type in the header, the message length is found to be incorrect during message parsing. For example, according to the definition of the Source_Information message, the status information field of the message is 8 bytes long. If the status information field of the received Source_Information message is not 8 bytes long, the message is considered incorrect.

When a provider device, a consumer device, or a cable e-marker receives a correct CRC message, and the following situations occur in the message, the rejection reason in the Refuse message is 0x02 (unsupported command or data):

(a) The command read from the message, based on the message type in the header, is not intended for a receiver of the type of the device that received the message. For example, the provider device receives the Get_Sink_Info message.

(b) In a data message and a vendor-defined message, certain data has a range requirement, but the received data exceeds the required range. For example, a key number in a received Verify_Request message is not within the key number range of the receiver.

(c) When the output mode number, requested output voltage, and requested output current of the Request message are out of range, the rejection reason is 0x04.

(d) The command read from the message, based on the message type in the header, is not defined in Table 19 and Table 20, nor in the command list of vendor-defined messages. For example, the command number 0x2A of a received control message is not defined in Table 19.

(e) The received message is correct, and the command and data in the message are defined, but the device cannot perform the functions corresponding to the command. For example, the provider device and the consumer device receive messages such as the Detect_Cable_Info message, Verify_Request message, and Start_Cable_Detect message, but the devices do not support these functions.

7.2.4.11 Verify_Request Message

The structure of a Verify_Request message is shown in Figure 49.

Figure 49 Structure of a Verify_Request message

Message header (2 bytes)	Command (Verify_Request)	Data length (1 byte)	Key number (1 byte)	Random data (16 bytes)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the Verify_Request message.

Data length: The data includes two parts, the key number and random data, totaling 17 bytes, so the data length is set to 17.

Key number: Multiple sets of keys can be pre-stored in a provider device, a consumer device, or a cable e-marker. When sending the Verify_Request message, the sender shall specify which set of keys is used for encryption.

Random data: The sender of the Verify_Request message generates 16 bytes of random data.

7.2.4.12 Verify_Response Message

The structure of a Verify_Response message is shown in Figure 50.

Figure 50 Structure of a Verify_Response message

Message header (2 bytes)	Command (Verify_Response)	Data length (1 byte)	Encrypted data (32 bytes)	Random data (16 bytes)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the Verify_Response message.

Data length: The data includes encrypted data of 32 bytes and random data of 16 bytes, totaling 48 bytes, so the data length is set to 48.

Encrypted data: After receiving the Verify_Request message, a provider device, a consumer device, or a cable e-marker encrypts the data with the key specified in the Verify_Request message, obtaining encrypted data of 32 bytes. The encryption process and algorithms are determined by the terminal vendor.

Random data: After receiving the Verify_Request message, a provider device, a consumer device, or a cable e-marker generates a 16-byte random number before executing the encryption algorithm. This random number needs to be sent back in the Verify_Response message.

7.2.4.13 AddressModify Message

AddressModify is used to modify the address of a cable e-marker. After receiving the AddressModify message, the cable e-marker replaces its original address with the updated address in Table 33.

The structure of an AddressModify message is shown in Figure 51.

Figure 51 Structure of an AddressModify message

Message header (2 bytes)	Command (AddressModify)	Data length (1 byte)	Requested data (1 byte)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the AddressModify message.

Data length: The feedback information of the AddressModify message contains 1 byte, so the data length is set to 1.

The structure of request data is shown in Table 33.

Table 33 Structure of AddressModify request data

Bit	Description
7–4	Original address
3–0	Updated address

7.2.4.14 PowerStepUp Message

After the protocol identification is completed, a consumer device can send a PowerStepUp message to a provider device to increase the voltage of the provider device by n minimum step voltage amplitudes.

The consumer device sends a PowerStepUp message to the provider device. After the provider device receives the PowerStepUp message, no additional reply message is required except ACK or NCK.

The structure of a PowerStepUp message is shown in Figure 52.

Figure 52 Structure of a PowerStepUp message

Message header (2 bytes)	Command (PowerStepUp)	Data length (1 byte)	Requested data (1 byte)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the PowerStepUp message.

Data length: The feedback information of the PowerStepUp message contains 1 byte, so the data length is set to 1.

The structure of PowerStepUp request data is shown in Table 34.

Table 34 Structure of PowerStepUp request data

Bit	Description
7–0	Voltage regulation amplitude, in units of the minimum step voltage amplitude

7.2.4.15 PowerStepDown Message

After the protocol identification is completed, a consumer device can send a PowerStepDown message to a provider device to reduce the voltage of the provider device by n minimum step voltage amplitudes.

The consumer device sends a PowerStepDown message to the provider device. After the provider device receives the PowerStepDown message, it does not need to give any additional reply message except ACK or NCK.

The structure of a PowerStepDown message is shown in Figure 53.

Figure 53 Structure of a PowerStepUp message

Message header (2 bytes)	Command (PowerStepDown)	Data length (1 byte)	Requested data (1 byte)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the PowerStepDown message.

Data length: The feedback information of the PowerStepDown message contains 1 byte, so the data length is set to 1.

The structure of PowerStepDown request data is shown in Table 35.

Table 35 Structure of PowerStepDown request data

Bit	Description
7–0	Voltage regulation amplitude, in units of the minimum step voltage amplitude

7.2.4.16 ExtDeviceRegWrite Message

After the protocol identification is completed, a consumer device can send an ExtDeviceRegWrite message to a cable e-marker, instructing the cable e-marker to perform a register write operation on an external device.

The consumer device sends an ExtDeviceRegWrite message to the cable e-marker. After the cable e-marker receives the ExtDeviceRegWrite message, no additional reply message is required except ACK or NCK.

The structure of an ExtDeviceRegWrite message is shown in Figure 54.

Figure 54 Structure of an ExtDeviceRegWrite message

Message header (2 bytes)	Command (ExtDeviceRegWrite)	Data length (1 byte)	External device 12C address (1 byte)	External device register address (1 byte)	Value written in register (1 byte)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the ExtDeviceRegWrite message.

Data length: The feedback information of the ExtDeviceRegWrite message contains 3 bytes, so the data length is set to 3.

7.2.4.17 ExtDeviceRegRead Message

After the protocol identification is completed, a consumer device can send an ExtDeviceRegRead message to a cable e-marker, instructing the cable e-marker to perform a register read operation on an external device.

The consumer device sends an ExtDeviceRegRead message to the cable e-marker. After the cable e-marker receives the ExtDeviceRegRead message, no additional reply message is required except ACK or NCK.

The structure of an ExtDeviceRegRead message is shown in Figure 55.

Figure 55 Structure of an ExtDeviceRegRead message

Message header (2 bytes)	Command (ExtDeviceRegRead)	Data length (1 byte)	External device 12C address (1 byte)	External device register address (1 byte)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the ExtDeviceRegRead message.

Data length: The feedback information of the ExtDeviceRegRead message contains 2 bytes, so the data length is set to 2.

7.2.4.18 Cable_TempInfo Message

The structure of a Cable_TempInfo message is shown in Figure 56.

Figure 56 Structure of a Cable_TempInfo message

Message header (2 bytes)	Command (Cable_TempInfo)	Data length (1 byte)	Requested data (1 byte)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the Cable_TempInfo message.

Data length: The status information of the Cable_TempInfo message contains 1 byte, so the data length is set to 1.

The structure of Cable_TempInfo request data is shown in Table 36.

Table 36 Structure of Cable_TempInfo request data

Bit	Description
7–0	Current cable port temperature, in °C Bit 7–0 = 00000000, marking that the provider device has no temperature data for the output port.

7.2.4.19 Test_Request Message

The structure of a Test_Request message is shown in Figure 57.

Figure 57 Structure of a Test_Request message

Message header (2 bytes)	Command (Test_Request)	Data length (1 byte)	Requested data (2 bytes)	CRC (1 byte)

Command: It is set to the number corresponding to the command of the Test_Request message.

Data length: The test content of the Test_Request message contains 2 bytes, so the data length is set to 2.

The structure of the test content is shown in Table 37. When sending test content, send the high byte first and then the low byte.

Table 37 Structure of test content

Bit	Description
15	1: test mode enabled. The device under test works in test mode 0: test mode disabled. The device under test works in normal mode
14	1: voltage accuracy test mode enabled (the output current can be 10% higher than the set value, valid only in programmable output mode) 0: voltage accuracy test mode disabled
13–11	Device address
10–8	Message type
7–0	Command No.

The device addresses and message types are defined above. The command number is the number of each command defined in Table 19 and Table 20. If a message is a vendor-defined message, the number is defined by the vendor. After receiving a Test_Request message, a provider device, a consumer device, or a cable e-marker parses the test content in the message and sends the message specified in the test content to the test device. The device address field in the header of the message is filled with the device address specified in the test content.

If the test content is only used to enable or disable the voltage accuracy test mode, or only to enable or disable the test mode, rather than to command the device under test to send a certain message, bit0 to bit13 of the test content shall all be set to 1. In this case, the device under test only needs to reply with an ACK message.

7.2.5 Vendor-defined Message

The structure of a vendor-defined message is shown in Figure 58.

Figure 58 Structure of a vendor-defined message

Message header (2 bytes)	Vendor identification code (2 bytes)	Data length (1 byte)	Data (1–58 bytes)	CRC (1 byte)

The data in the messages is defined by each vendor. A provider device and a consumer device shall reply with an ACK message when they receive a vendor-defined message with correct CRC. A provider device and a consumer device shall reply with an NCK message when they receive a vendor-defined message with incorrect CRC. After receiving the vendor-defined message that cannot be responded to and processed, the provider device and the consumer device shall reply with a Refuse message after replying with an ACK message. The reason for rejection is 0x02.

7.3 Timer

7.3.1 ACKReceiveTimer

The sender of the message uses the ACKReceiveTimer to determine whether the message is correctly received by the receiver. After sending the last bit of a message, the sender immediately starts the ACKReceiveTimer if the Rx signal line is idle. Otherwise, the sender waits until the Rx signal line becomes idle and then starts the timer. If the receiver's ACK is received within the tACKReceive time, the message is concluded to have been correctly received by the receiver. If the receiver's NCK is received within the tACKReceive time, or neither ACK nor NCK is received within the tACKReceive time, the message is concluded to have not been correctly received by the receiver, and the sender initiates the retransmission or error-handling mechanism. If the retransmission condition is met, the sender shall resend the message within the tRetry time after determining that the message has not been correctly received by the receiver.

The receiver of the message, after receiving the last bit of a message, delays the tACKtransmit time and replies with an ACK or NCK message based on the result of the CRC check.

7.3.2 SenderResponseTimer

If a message requires the receiver to further reply with the corresponding response message after replying with an ACK message (for example, reply with the Source_Information message after receiving the Get_Device_Info message), the sender, after sending the last bit of that message, immediately starts the SenderResponseTimer if the Rx signal line is idle. Otherwise, the sender waits until the Rx signal line becomes idle and then starts the SenderResponseTimer. The sender of the message shall receive a response message from the receiver within the tSenderResponse time. If the sender does not receive a response from the receiver within the tSenderResponse time, the retransmission and error-handling mechanisms are initiated. If the retransmission condition is met, the sender shall resend the message within the tRetry time after determining that the message has not been correctly received by the receiver.

After replying with an ACK message, the receiver of the message delays the tMsgTransDelay time and sends a response message that requires a reply. Moreover, after receiving the message, the receiver must reply to the sender with a response message within the tReceiverResponse time.

7.3.3 PowerSupplyTimer

When a consumer device sends a Request message to a provider device and receives an Accept message from the provider device, the consumer device starts the PowerSupplyTimer. After replying with the Accept message, the provider device shall adjust the output to the voltage and current values requested in the Request message within the tPowerSupply time, and reply to the consumer device with a Power_Ready message If the consumer device does not receive the Power_Ready message within the tPowerSupply time, the consumer device shall send a hardware reset command to the provider device to reset its hardware.

7.3.4 MsgTransDelayTimer

After sending a message, a provider device, a consumer device, or a cable e-marker starts the MsgTransDelayTimer to avoid sending the next message within the tMsgTransDelay time.

For the value setting of tMsgTransDelay, the response time requirements for certain messages shall be taken into account to avoid exceeding the time thresholds of other timers, such as tACKReceive and tSenderResponse.

When tACKtransmit and tMsgTransDelay conflict, tMsgTransDelay takes priority.

7.3.5 VerifyResponseTimer

The provider device or the consumer device sends a Verify_Request message to the other device to request authentication. The VerifyResponseTimer is started after the Accept message from the other device is received. If no VerifyResponse message is received from the other device within the tVerifyResponse time, the authentication process is exited and the authentication is deemed failed.

7.3.6 Timers and Their Time Thresholds

The definition of each time threshold is shown in Table 38.

Table 38 Definitions of time thresholds

Time Threshold	Minimum Value	Maximum Value
tACKReceive	—	10 ms
tACKtransmit	100 μs	—
tRetry	—	500 μs
tSenderResponse	—	50 ms
tReceiverResponse	—	40 ms
tPowerSupply	—	550 ms
tMsgTransDelay	2 ms	—
tVerifyResponse	—	1000 ms

The relationships between timers and time thresholds are shown in Table 39.

Table 39 Relationships between timers and time thresholds

Timer	Time Threshold
ACKReceiveTimer	tACKReceive
SenderResponseTimer	tSenderResponse
PowerSupplyTimer	tPowerSupply
MsgTransDelayTimer	tMsgTransDelay
VerifyResponseTimer	tVerifyResponse

7.4 Counter

7.4.1 MsgRetryCounter

To ensure the reliability of message transmission, the sender of the message must establish a message retransmission mechanism. If the message sender receives an NCK message after sending a message, or if neither an ACK message nor an NCK message is received from the receiver within tACKReceive time, the transmission is considered ailed, and the message retransmission mechanism is initiated. When sending a new message, the sender resets the MsgRetryCounter and increases it by 1 for each retransmission. If the message is retransmitted nMsgRetryCount times without receiving an ACK message, the current message transmission is considered failed.

7.4.2 Counter and Its Counting Threshold

The definition of each counting threshold is shown in Table 40.

Table 40 Definition of the counting threshold

Counting Threshold	Value
nMsgRetryCount	3

The relationship between the counter and the counting threshold is shown in Table 41.

Table 41 Relationship between the counter and counting threshold

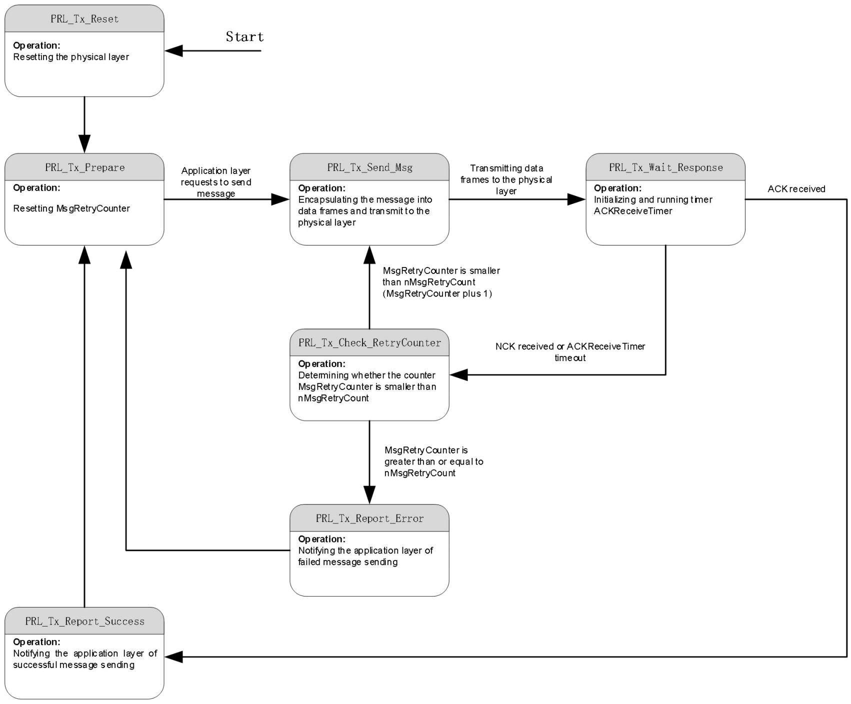
Counter	Counting Threshold
MsgRetryCounter	nMsgRetryCount

7.5 State Machine

7.5.1 Message Sending State Machine

The definition of a message sending state machine is shown in Figure 59.

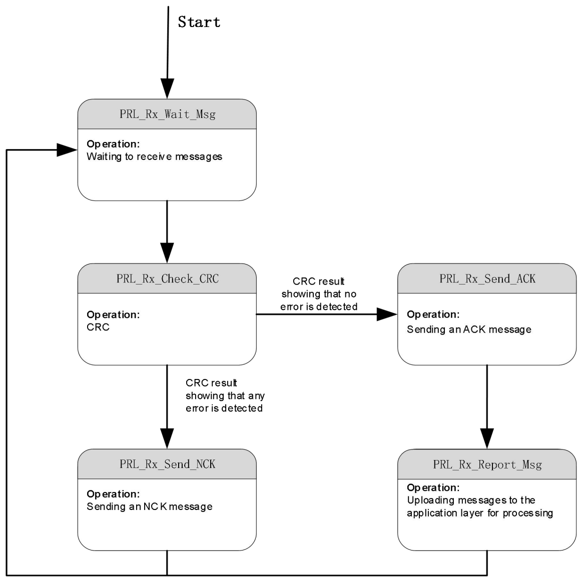
Figure 59 Definition of a message sending state machine



7.5.2 Message Receiving State Machine

The definition of a message receiving state machine is shown in Figure 60.

Figure 60 Definition of a message receiving state machine



7.6 Protocol Upgrade and Compatibility Requirements

The first version of the General Purpose Multimedia Interface Power Supply Protocol released is 1.0. Subsequent modifications and upgrades to the protocol shall ensure backward compatibility. That is, higher versions of the protocol shall be compatible with lower versions. After the consumer device and the provider device complete the protocol handshake, the consumer device sends a ping message to the provider device. In the ping message, the consumer device fills in the "protocol version number" field of the message header with the latest power supply protocol version number the device supports. After receiving this ping message, the provider device extracts the protocol version number in the header and compares it with the latest protocol version number supported by the provider device. Actions are taken according to the following three situations:

(a) If the protocol version number of the provider device is the same as that of the consumer device, the same protocol version number is filled in the header of the replied ACK message by the provider device.

(b) If the protocol version number of the provider device is lower than that of the consumer device, the latest protocol version number supported by the provider device is filled in the header of the replied ACK message.

(c) If the protocol version number of the provider device is higher than that of the consumer device, the provider device runs the same old protocol version as the consumer device, and fills the protocol version number supported by the consumer device in the header of the replied ACK message.

After the ACK message for the first ping message from the provider device is received by the consumer device, actions are taken according to the following two situations:

(a) If the protocol version number in the ACK message of the provider device is consistent with the number filled in the ping message header by the consumer device, the consumer device operates according to the protocol version.

(b) If the protocol version number in the ACK message of the provider device is lower than the number filled in the ping message header by the consumer device, the consumer device operates according to the protocol version specified in the ACK message.

8 Application Layer

8.1 Overview

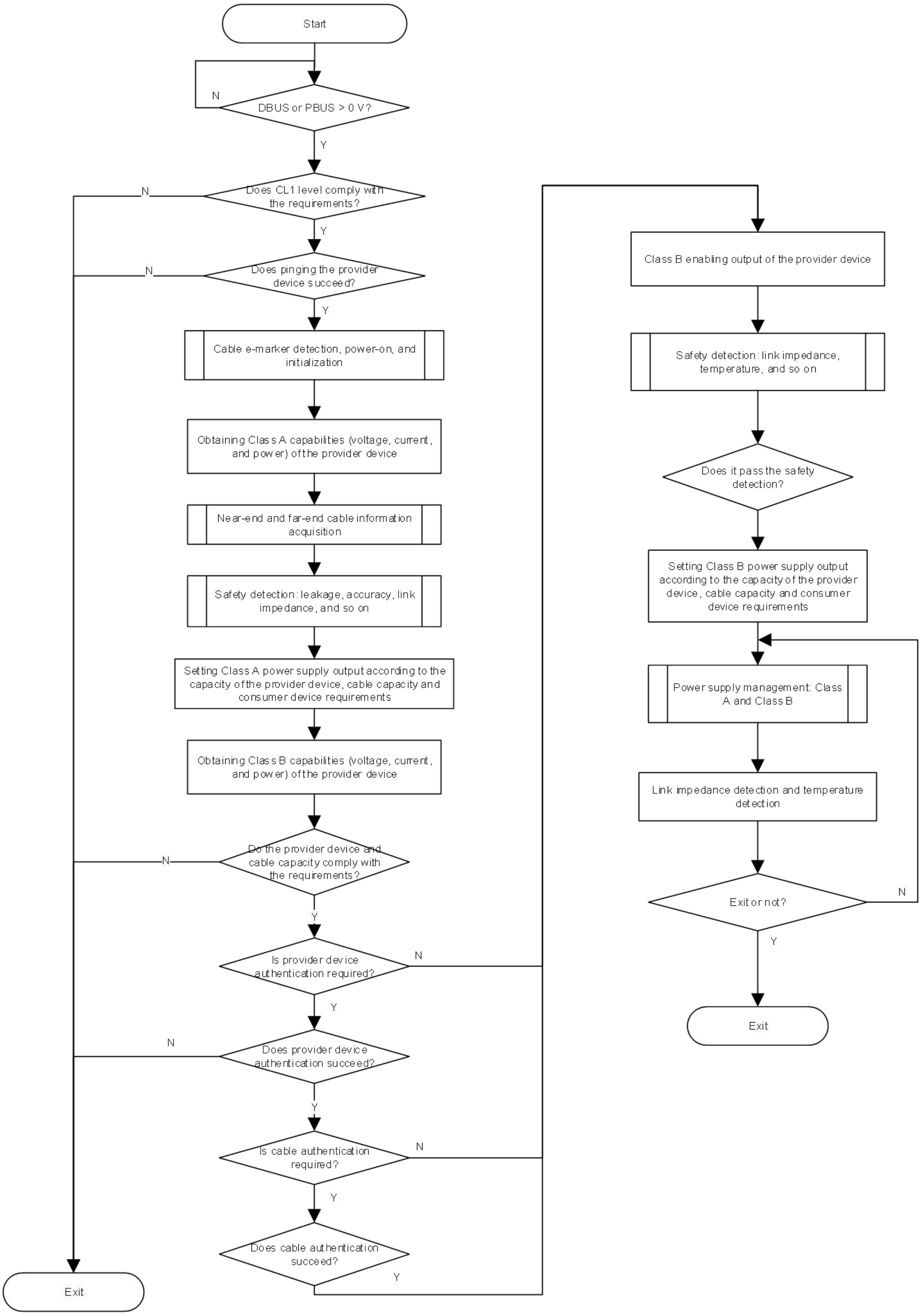
The application layer includes policy control of consumer devices, authentication, protection of provider devices, and safety detection. The application layer describes the protocol identification mechanism, protocol application strategy, and power supply security management of consumer devices and provider devices in different scenarios to achieve information synchronization between the two parties.

8.2 Policy Control of Consumer Devices

8.2.1 Policy Control of the Consumer Device System

The policy control of a consumer device mainly describes the power supply protocol identification of consumer devices, vendor-defined authentication for provider devices, cable identification of consumer devices, communication wake-up, and power supply management. The overall process of the policy control of a consumer device is shown in Figure 61.

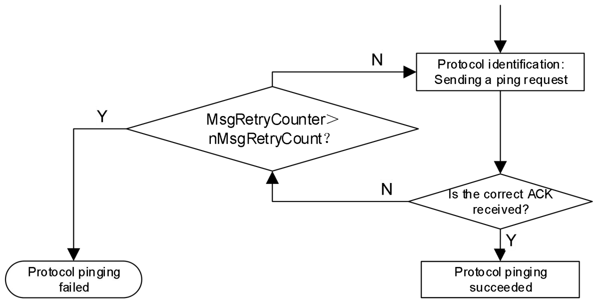
Figure 61 Policy control of a dual-channel consumer device



8.2.2 Protocol Identification of Consumer Devices

Protocol ping initialization

Figure 62 Protocol ping initialization



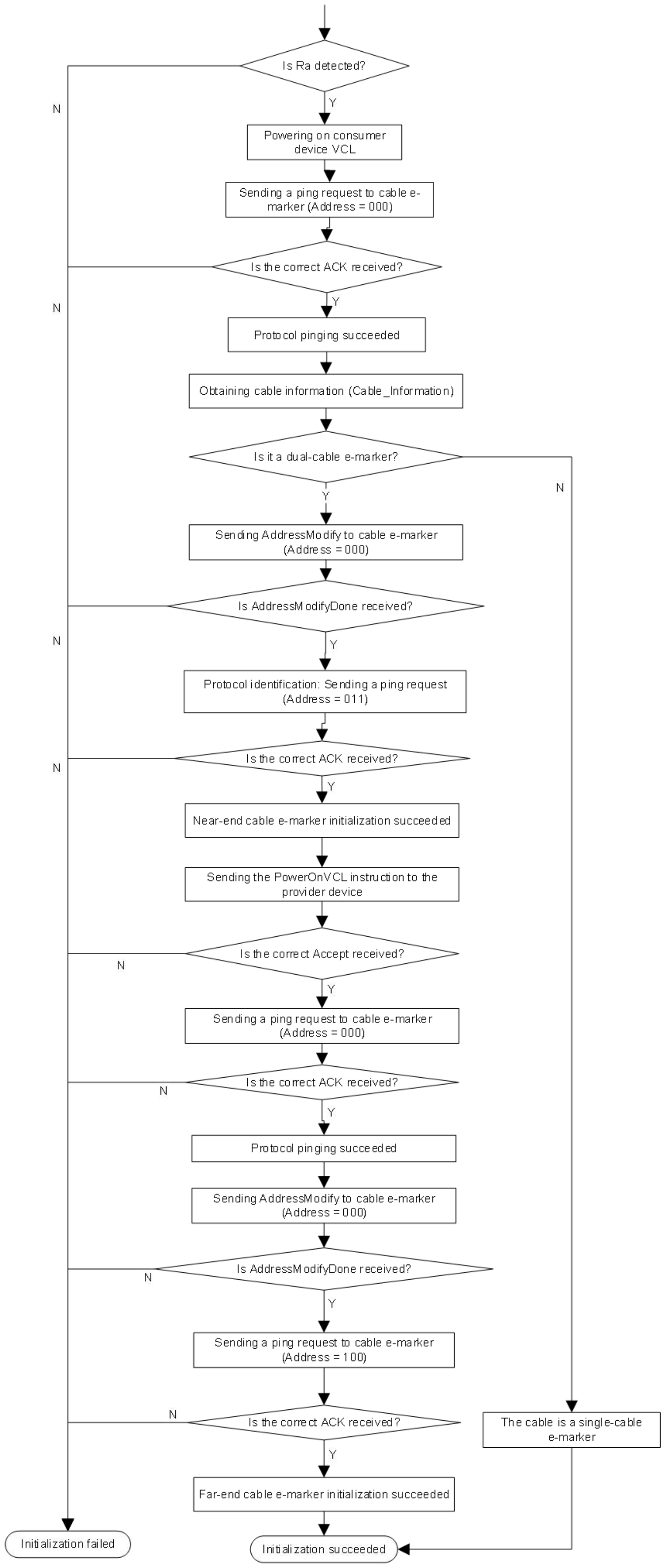
8.2.3 Cable E-Marker Initialization

This section describes the process for a consumer device to modify the address of a cable e-marker through an AddressModify message (replace the original address with the updated address in Table 33) to facilitate the identification of the near-end (consumer device side) and far-end (provider device side) cable e-markers.

As shown in Table 18, the original address of the cable e-marker is 000b. For cables with dual-cable e-markers, after the consumer device completes the modification of the cable e-marker address, the near-end cable e-marker address is modified to 011b, and the far-end address is modified to 100b.

In Figure 63, a successful protocol ping indicates that the consumer device and the cable e-marker communicate normally.

Figure 63 Cable e-marker initialization



Note: Basic retry procedures are not in the Figure.

8.3 Authentication

8.3.1 Authentication of Provider Devices

The authentication of a provider device is initiated by a consumer device. Only after passing the vendor authentication is the provider device allowed to work at the set threshold power. The specific threshold depends on a consumer device and is determined by the terminal vendor.

8.3.2 Cable Authentication

The authentication of a cable is initiated by a consumer device. Only after passing the vendor authentication is the cable device allowed to work at the set threshold power. The specific threshold depends on the consumer device and is determined by the terminal vendor.

8.4 Protection of Provider Devices

When abnormal protection occurs in a provider device, the protocol status and electrical characteristics change. To ensure that a provider device and a consumer device can be restored to the initial state of the protocol at the same time in the protection scenario, achieving the purpose of re-entering the protocol identification, the protection action and restoration action of the provider device need to be specified. See Table 42 for details.

Table 42 Protection Actions and Restoration Actions for Provider Devices

No.	Protection Function	Protective Action	Restoration Action	Remarks
1	PBUS/DBUS output overvoltage	1. PBUS and DBUS disconnect outputs; 2. When the fault persists, PBUS and DBUS output in hiccup mode at the default voltage, with a hiccup period > 1s.	1. PBUS and DBUS output at the default voltage; 2. CL1/CL2 returns to the initial state and waits for the next handshake of this power supply protocol.	The default voltage is 5.0 V in Class A mode and 0 V in Class B mode.
2	PBUS/DBUS output short circuit	PBUS and DBUS disconnect outputs.	1. PBUS and DBUS output at the default voltage; 2. CL1/CL2 returns to the initial state and waits for the next handshake of this power supply protocol.	—
3	PBUS/DBUS output overcurrent	1. PBUS and DBUS disconnect outputs; 2. When the fault persists, PBUS and DBUS output in hiccup mode at the default voltage, with a hiccup period > 1s.	1. PBUS and DBUS output at the default voltage; 2. CL1/CL2 returns to the initial state and waits for the next handshake of this power supply protocol.	The upper limit of the UVP value of the provider device is set to 55% of the CV value.

No.	Protection Function	Protective Action	Restoration Action	Remarks
4	PBUS/DBUS output undervoltage	1. PBUS and DBUS disconnect outputs; 2. When the fault persists, PBUS and DBUS output in hiccup mode at the default voltage, with a hiccup period > 1s.	1. PBUS and DBUS output at the default voltage; 2. CL1/CL2 returns to the initial state and waits for the next handshake of this power supply protocol.	—
5	Overtemperature	1. The duration of PBUS and DBUS output disconnection is > 1s; 2. A hardware reset is issued to the consumer device.	1. PBUS and DBUS output at the default voltage; 2. CL1/CL2 returns to the initial state and waits for the next handshake of this power supply protocol.	—
6	CL1/CL2 overvoltage	1. PBUS and DBUS disconnect outputs; 2. When the fault persists, PBUS and DBUS output in hiccup mode at the default voltage, with a hiccup period > 10s.	1. PBUS and DBUS output at the default voltage; 2. CL1/CL2 returns to the initial state and waits for the next handshake of this power supply protocol.	—
7	Hardware Reset	The duration of PBUS and DBUS output disconnection is > 1s.	1. PBUS and DBUS output at the default voltage; 2. CL1/CL2 returns to the initial state and waits for the next handshake of this power supply protocol.	Hardware reset protection is equivalent to power disconnection.
8	Communication timeout protection function	1. The duration of PBUS and DBUS output disconnection is > 1s; 2. A hardware reset is issued to the consumer device.	1. PBUS and DBUS output at the default voltage; 2. CL1/CL2 returns to the initial state and waits for the next handshake of this power supply protocol.	—
9	Softreset	1. PBUS and DBUS maintain the current voltage output; 2. The protocol status returns to idle; 3. Wait for instructions from the consumer device.	—	If a hardware reset is received, it is executed in accordance with the hardware reset protection rules.

8.5 Safety Detection and Requirements

8.5.1 Detection of Cable Port Temperature

To ensure safe operation, after the output of the Class B power supply, the cable port temperature shall be detected periodically, with a detection period ≤ 2 minutes.

8.5.2 Detection of Link Leakage Current

To ensure safe operation, when the Class B power supply is turned on, turn off all power circuits and detect the output current of the provider device. If the current exceeds the preset threshold, the load circuits shall not be enabled.

8.5.3 Channel Impedance Detection and Treatment Requirements

To ensure safe operation and not be affected by external factors, when the input current of a consumer device is greater than 3 A, the channel impedance shall be detected periodically, with a detection period ≤ 2 minutes.

9 Power Input and Output Requirements

9.1 Basic Requirements

The power supply protocol specified in this document divides the power into two subcategories:

——Class A is a data-power subclass with a maximum current of 3 A and is suitable for low-power power supply scenarios such as supplying power to SOCs. There are two power modes on Class A, namely the discrete voltage regulation mode and the continuous voltage regulation mode.

——Class B is a high-power subclass with a maximum current of 15 A and is suitable for high-power power supply scenarios, such as supplying power to speakers and LEDs. Class B is in continuous voltage regulation mode.

9.2 Device Power

9.2.1 Power of Provider Devices

Power devices are divided into two types: single-channel and dual-channel. When a provider device supplies power to a single-channel consumer device, PBUS shall support both Class A and Class B. When a provider device supplies power to a dual-channel consumer device, PBUS only supports Class B, while DBUS only supports Class A.

A provider device with output power ≥ 360 W or current ≥ 6 A shall support dual-channel power supply and the hot-plug auxiliary detection function, while a device with power < 360 W and current < 6 A only supports single-channel power supply.

9.2.2 Power of Consumer Devices

Consumer devices are divided into two types: single-channel and dual-channel. A single-channel device is only allowed to transmit power on PBUS. A consumer device with input power ≥ 360 W or current ≥ 6 A shall support dual-channel operation and the hot-plug auxiliary detection function, while the device with power < 360 W and current < 6A only supports single-channel operation.

9.2.3 Cable Power

Cables shall support dual-channel power supply.

The relationship between current in cables and cable e-markers needs to meet the following requirements:

(1) If the current > 6 A, two cable e-markers shall be used, and the hot-plug auxiliary detection function shall be supported.

(2) If the current > 3 A, at least one cable e-marker is required.

(3) If the current ≤ 3 A, cable e-markers are not required.

9.2.4 Device Compatibility Requirements

The compatibility requirements for provider devices, consumer devices, and cables are shown in Table 43:

Table 43 Compatibility requirements for provider devices, consumer devices, and cables

Provider Device	**Single Channel**				**Dual Channel**			
Consumer Device	**Single Channel**		**Dual Channel**		**Single Channel**		**Dual Channel**	
Cable	Single-cable e-marker	Double-cable e-marker	Single-cable e-marker	Double-cable e-marker	Single-cable e-marker	Double-cable e-marker	Single-cable e-marker	Double-cable e-marker
Compatible or Not	Yes	Yes	No	No	Yes	Yes	Yes	Yes

9.3 Class A Power Requirements

9.3.1 Range of Output Power

Class A has two power modes: mode 1 and mode 2. Mode 1 is a discrete voltage regulation mode, and the supported voltage output levels are 5 V, 9 V, 12 V, 15 V, and 20 V. Mode 2 is a continuous voltage regulation mode, and the supported programmable output voltage levels are 5 V, 10 V, and 20 V. For devices that support Class A, Class A shall support mode 1, and mode 2 is optional.

After a provider device supporting Class A is powered on, the default power specification requirements are shown in Table 44.

Table 44 Default power specifications of the provider device

Default Specifications	**Minimum Value**	**Typical Value**	**Maximum Value**	**Remarks**
Output Voltage	4.75 V	5 V	5.5 V	Measure under the no-load state.

Default Specifications	Minimum Value	Typical Value	Maximum Value	Remarks
Output Current	2.00 A	2.20 A	3.00 A	See Appendix B for cable compensation.
Note: Cable compensation is present in default voltage and discrete voltage regulation mode, and is absent in continuous voltage regulation mode.				

The output power requirements of Class A are shown in Table 45. When the rated power of a provider device meets a certain power value or range in the first column of Table 45, the corresponding row lists the voltage levels that must be supported, the voltage levels that can be optionally supported, and the voltage levels that are not recommended to be supported. The table also indicates the requirements of each voltage level for the current output capability.

Table 45 Output power of Class A mode 1

Voltage Level Rated Power (P)	5 V	9 V	12 V	15 V	20 V
P ≤ 15 W	I(M) ≤ 3 A	—	—	—	—
15 W < P ≤ 27 W	3 A	I(M) ≤ 3 A	—	—	—
27 W < P ≤ 36 W	3 A	3 A	I(M) ≤ 3 A	—	—
36 W < P ≤ 45 W	3 A	3 A	3 A	I(M) ≤ 3 A	—
45 W < P ≤ 60 W	3 A	3 A	3 A	3 A	I(M) ≤ 3 A
Note 1: The (M) marked after the current symbol I in the table indicates the corresponding voltage level and current size requirements, which must be supported. Note 2: The "—" marked in the table indicates that it is not recommended to support the corresponding voltage level.					

Table 46 Output power of Class A mode 2

Voltage Level Rated Power (P)	5 V Programmable (3.3–5.5 V)	10 V Programmable (5.5–11 V)	20 V Programmable (11–20 V)
P ≤ 15 W	I(M) ≤ 3 A	—	—
15 W < P ≤ 27 W	I(M) = 3 A	I(M) ≤ 3 A	—
27 W < P ≤ 36 W	I(M) = 3 A	I(M) ≤ 3 A	I(M) ≤ 3 A
36 W < P ≤ 45 W	I(M) = 3 A	I(M) ≤ 3 A	I(M) ≤ 3 A
45 W < P ≤ 60 W	I(M) = 3 A	I(M) ≤ 3 A	I(M) ≤ 3 A

9.3.2 Requirements for Dynamic Regulation of Output Power

Dynamic regulation of output power refers to the power regulation action that a provider device starts to perform after receiving a power regulation instruction issued by a consumer device. The requirements have two parts: electrical parameters and regulation timing. The electrical parameter requirements are shown in Table 47, and the timing parameter requirements are shown in Table 48.

Table 47 Requirements for electrical parameters of a provider device

Tag Number	Unit	Description	Requirements
Starting V	mV	Initial voltage value of the regulation action	—
vSetNew (Typical)	mV	Reference voltage value of the regulation action	—
vRealNew (Max)	mV	Maximum actual voltage value after the reference voltage takes effect	See the specifications in Table 49.
vRealNew (Min)	mV	Minimum actual voltage value after the reference voltage takes effect	See the specifications in Table 49.
vRealValid (Max)	mV	The overshoot of the maximum actual voltage value after the reference voltage takes effect	≤ 1.05 vSetNew
vRealValid (Min)	mV	The undershoot of the minimum actual voltage value after the reference voltage takes effect	≥ 0.95 vSetNew

Table 48 Requirements for timing parameters of a provider device

Tag Number	Unit	Description	Requirements
T_{Delay}	ms	Delay time from receiving the instruction to replying	< 10 ms
t_{ACK}	ms	Time point of ACK response	—
t_{Accept}	ms	Time point of Accept response	—
t_0	ms	Starting time point of voltage regulation	—
$T_{PowSettle}$	ms	Execution time of power regulation	If 11 V < vSetNew or Starting V ≤ 20 V Requirement: ≤ 250 ms; Otherwise, if vSetNew ≤ 11 V and Starting V ≤ 11 V Requirement: ≤ 100 ms; When the above conditions are met, the following also needs to be met: |vSetNew – Starting V| ≤ 1 V Requirement: ≤ 50 ms;

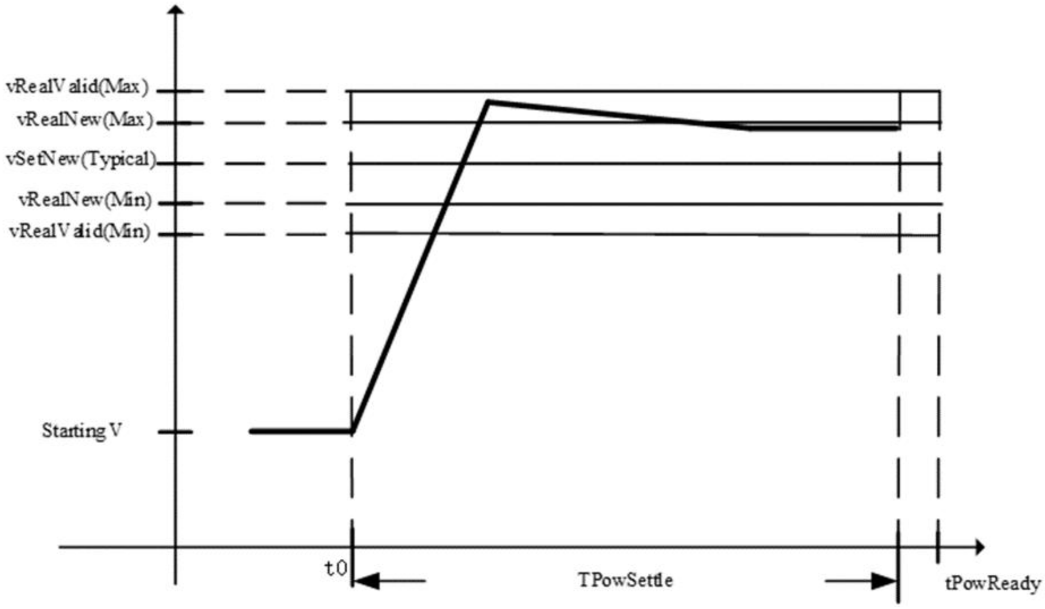
Tag Number	Unit	Description	Requirements
$t_{PowReady}$	ms	Completion time point of voltage regulation (Including the time of $T_{PowSettle}$)	If 11 V < vSetNew or Starting V ≤ 20 V Requirement: ≤ 275 ms; Otherwise, if vSetNew and Starting V ≤ 11V Requirement: ≤ 125 ms; When the above conditions are met, the following also needs to be met: |vSetNew – Starting V| ≤ 1 V Requirement: ≤ 70 ms;

9.3.2.1 Electrical Requirements for Output Power Regulation

9.3.2.1.1 Electrical Requirements for Output Power Increase

After a provider device receives the power increase instruction issued by a consumer device, the power regulation action of the provider device is shown in Figure 64.

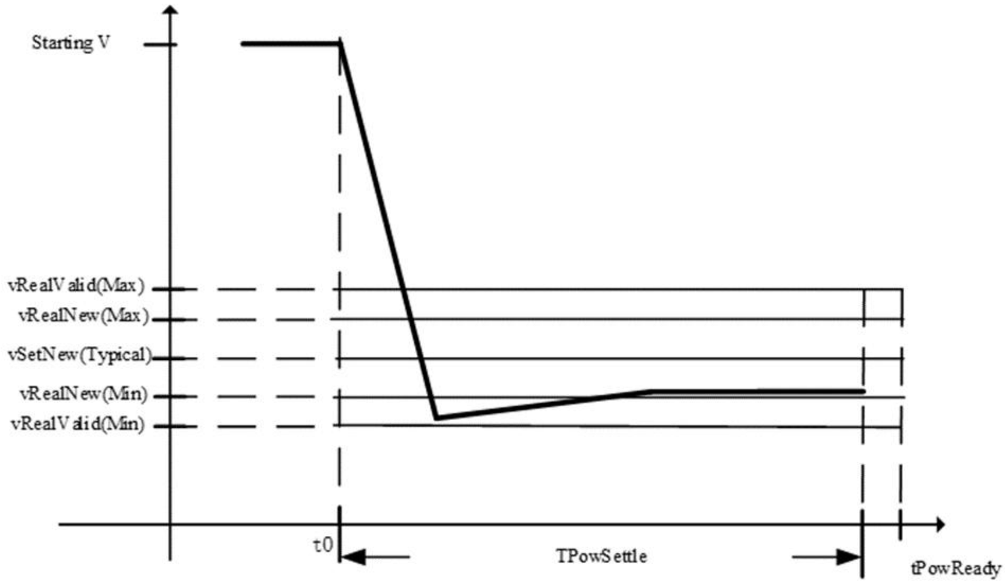
Figure 64 Schematic diagram of electrical requirements for a power increase of a provider device



9.3.2.1.2 Electrical Requirements for Output Power Reduction

After a provider device receives the power reduction instruction issued by a consumer device, the power regulation action of the provider device is shown in Figure 65.

Figure 65 Schematic diagram of electrical requirements for a power reduction of a provider device

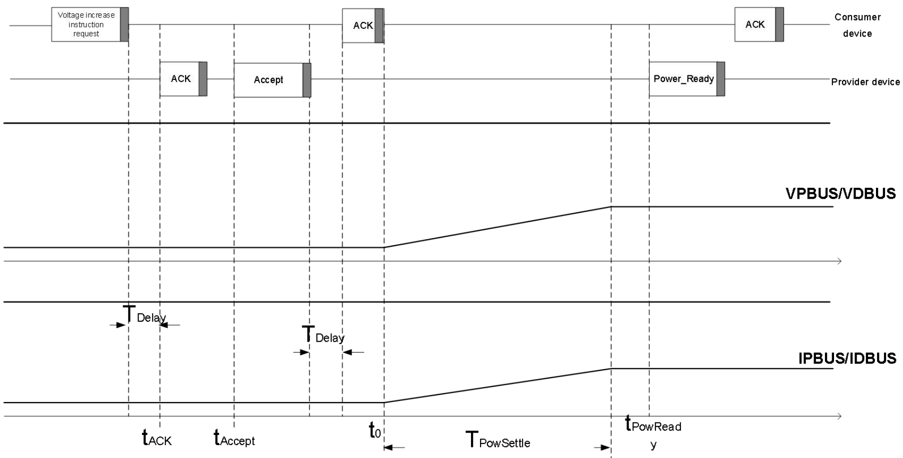


9.3.2.2 Timing Requirements for Output Power Regulation

9.3.2.2.1 Timing Requirements for Output Power Increase

After a provider device receives the power increase instruction issued by a consumer device, the power regulation timing of the provider device is shown in Figure 66.

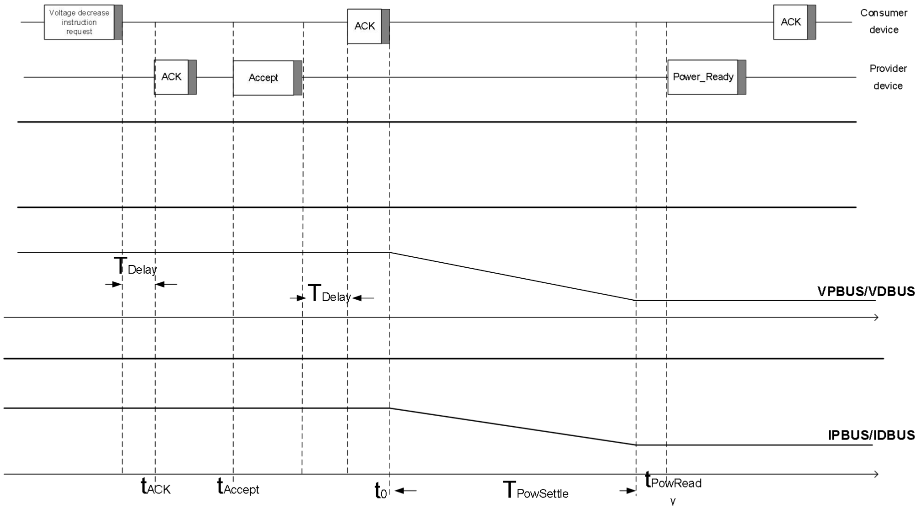
Figure 66 Schematic diagram of timing requirements for a power increase of a provider device



9.3.2.2.2 Timing Requirements for Output Power Reduction

After a provider device receives the power reduction instruction issued by a consumer device, the power regulation timing of the provider device is shown in Figure 67.

Figure 67 Schematic diagram of timing requirements for a power reduction of a provider device



9.3.2.3 Requirements for Output Power Step Regulation

The requirements for output power step regulation are as follows:

(a) Output voltage regulation step: 20 mV/step, with an allowable error of ±1 step, that is ±20 mV.

(b) Output current regulation step: 20 mA/step, with an allowable error of ±1 step, that is ±20 mA.

9.3.3 Requirements for Output Power Steady-State Accuracy

The steady-state output power mainly refers to the values of output voltage and output current. The requirements for power accuracy in steady state are shown in Table 49.

Table 49 Requirements for voltage accuracy of a provider device in steady state

Output Mode	Voltage Value	Calculation Method	Accuracy Requirements
1	5 V, 9 V, 12 V, 15 V, and 20 V	|Actual value-reference value|	5%
2	5 V, 10 V, and 20 V	|Actual value-reference value|	3%
Note: For plate end measurement, the test ambient temperature is –10°C to +35°C			

Table 50 Requirements for current accuracy of a provider device in steady state

Output Mode	Output Current Range I	Calculation Method	Accuracy Requirements
1	0 A < I < 3 A	Actual value-reference value	±300 mA
2	0 A < I < 3 A	Actual value-reference value	±300 mA
Note: The test ambient temperature is 25°C to 35°C			

9.4 Class B Power Requirements

9.4.1 Requirements for Output Power Range

Class B is in continuous fast voltage regulation mode, and the supported programmable output voltage levels are 18 V, 24 V, 36 V, 48 V, and 60 V. A provider device that only supports Class B has a default voltage of 0 V after power-on. After receiving the voltage and current regulation command, the device outputs power.

The output power requirements of Class B are shown in Table 51. When the rated power of Class B meets a certain power value or range in the first column of Table 51, the corresponding row lists the voltage levels that must be supported, the voltage levels that can be optionally supported, and the voltage levels that are not recommended to be supported. The table also indicates the requirements of each voltage level for the current output capability.

Table 51 Output power of Class B

Voltage Level **Rated Power (P)**	**18 V Programmable** **(14–20 V)**	**24 V Programmable** **(22–30 V)**	**36 V Programmable** **(30–40 V)**	**48 V Programmable** **(42–51 V)**	**60 V Programmable** **(52–60 V)**
P ≤ 240 W	3 A ≤ I(O) ≤ 15 A	3 A ≤ I(O)	3 A ≤ I(O)	3 A ≤ I(O)	3 A ≤ I(O)
240 W < P < 480 W	4 A ≤ I(O) ≤ 15 A	4 A ≤ I(O)	3 A ≤ I(O)	3 A ≤ I(O)	2 A ≤ I(O)
480 W ≤ P ≤ 900 W	5 A ≤ I(O) ≤ 15 A	5 A ≤ I(O) ≤ 15 A	4 A ≤ I(O) ≤ 15 A	4 A ≤ I(O)	3 A ≤ I(O)
P > 900 W	-	-	-	-	-
Note 1: The (O) marked after the current symbol I in the table indicates that the corresponding voltage level of the current can be optionally supported. If this voltage level is supported, the specified current size must be met. Note 2: The "-" marked in the table indicates that it is not recommended to support the corresponding voltage level.					

9.4.2 Requirements for Dynamic Regulation of Output Power

Dynamic regulation of output power refers to the power regulation action that a provider device starts to perform after receiving a power regulation instruction issued by a consumer device. The requirements have two parts: electrical parameters and regulation timing. The electrical parameter requirements are shown in Table 52, and the timing parameter requirements are shown in Table 53.

Table 52 Requirements for electrical parameters of a provider device

Tag Number	Unit	Description	Requirements
Starting V	mV	Initial voltage value of the regulation action	—
vSetNew (Typical)	mV	Reference voltage value of the regulation action	—
vRealNew (Max)	mV	Maximum actual voltage value after the reference voltage takes effect	See Table 54 for the specifications.
vRealNew (Min)	mV	Minimum actual voltage value after the reference voltage takes effect	See Table 54 for the specifications.
vRealValid (Max)	mV	The overshoot of the maximum actual voltage value after the reference voltage takes effect	Levels: 18 V, 24 V, 36 V, and 48 V, and requirement: ≤ 1.1 vSetNew; Level: 60 V, and requirement: ≤ 1.05 vSetNew;
vRealValid (Min)	mV	The undershoot of the minimum actual voltage value after the reference voltage takes effect	Levels: 18 V, 24 V, 36 V, and 48 V, and requirement: ≥ 0.9 vSetNew; Level: 60 V, and requirement: ≥ 0.95 vSetNew;

Table 53 Requirements for timing parameters of a provider device

Tag Number	Unit	Description	Requirements
T_{Delay}	ms	Delay time from receiving the instruction to replying	—
t_{ACK}	ms	Time point of ACK response	—
t_{Accept}	ms	Time point of Accept response	—
t_0	ms	Starting time point of voltage regulation	—
$T_{PowSettle}$	ms	Execution time of power regulation	0 V ≤ vSetNew — Starting V ≤ 42 V, and requirement: ≤ 200 ms; 42 V < vSetNew — Starting V ≤ 60 V, and requirement: ≤ 300 ms;
$t_{PowReady}$	ms	Completion time point of voltage regulation (Including the time of $T_{PowSettle}$)	0 V ≤ vSetNew — Starting V ≤ 42 V, and requirement: ≤ 225 ms; 42 V < vSetNew — Starting V ≤ 60 V, and requirement: ≤ 325 ms;

$T_{PowSettle\_setpup}$	ms	Completion time for PBUS step-up voltage regulation	Number of single regulation steps Nstep ≤ 10, and requirement: ≤ 2.5 ms; 10 < Nstep ≤ 100, and requirement: ≤ 50 ms; 100 < Nstep ≤ 256, and requirement: ≤ 100 ms;
$T_{PowSettle\_setpdown}$	ms	Completion time for PBUS step-down voltage regulation	Number of single regulation steps Nstep ≤ 10, and requirement: ≤ 2.5 ms; 10 < Nstep ≤ 100, and requirement: ≤ 70 ms; 100 < Nstep ≤ 256, and requirement: ≤ 140 ms;

9.4.2.1 Electrical Requirements for Output Power Regulation

9.4.2.1.1 Electrical Requirements for Output Power Increase

After a provider device receives the power increase instruction issued by a consumer device, the power regulation action of the provider device is shown in Figure 64.

9.4.2.1.2 Electrical Requirements for Output Power Reduction

After a provider device receives the power reduction instruction issued by a consumer device, the power regulation action of the provider device is shown in Figure 65.

9.4.2.2 Timing Requirements for Output Power Regulation

9.4.2.2.1 Timing Requirements for Output Power Increase

After a provider device receives the power increase instruction issued by a consumer device, the power regulation timing of the provider device is shown in Figure 66.

9.4.2.2.2 Timing Requirements for Output Power Reduction

After a provider device receives the power reduction instruction issued by a consumer device, the power regulation timing of the provider device is shown in Figure 67.

9.4.2.3 Requirements for Output Power Step Regulation

The requirements for output power step regulation are as follows:

(a) Output voltage regulation step: 20 mV/step, with an allowable error of ±1 step, that is ±20 mV.

(b) Output current regulation step: 20 mA/step, with an allowable error of ±1 step, that is ±20 mA.

9.4.3 Requirements for Output Power Steady-State Accuracy

The steady-state output power mainly refers to the values of output voltage and output current. The requirements for power accuracy in steady state are shown in Table 54 and Table 55.

Table 54 Requirements for voltage accuracy of a provider device in steady state

Output Voltage Range	Calculation Method	Accuracy Requirements
Levels: 18 V and 24 V	|Actual value-reference value|	5%
Levels: 36 V, 48 V, and 60 V	|Actual value-reference value|	3%
Note: For plate end measurement, the test ambient temperature is –10°C to +35°C		

Table 55 Requirements for current accuracy of a provider device in steady state

Output Current Range	Calculation Method	Accuracy Requirements
I < 1 A	|Actual value-reference value|	300 mA
1A ≤ I ≤ 15A	|Actual value-reference value|	500 mA
15 A < I	|Actual value-reference value|	600 mA
Note: The test ambient temperature is 25°C to 35°C		

Appendix A
(Normative)
Description of CRC-8 Algorithm

CRC-8 algorithm description and the reference code:

This document uses CRC-8 check, and the polynomial used in the algorithm is $x^8 + x^5 + x^3 + 1$. The reference code of the algorithm is as follows:

```
#define CRC_8_POLYNOMIAL       0x29       //X8 + X5 + X3 + 1
unsigned char CRC8_Calculate（unsigned char *pData, unsigned char Size）
{
    unsigned char i;
    unsigned char rCRC = 0;

     while（Size--）
     {
         rCRC ^= *pData++;
         for （i = 8; i > 0; --i）
         {
             if （rCRC & 0x80）
                 rCRC = （rCRC << 1） ^ CRC_8_POLYNOMIAL;
             else
                 rCRC = （rCRC << 1）;
         }
     }

     return（rCRC）;
}
```

Appendix B
(Normative)
Requirements for Cable Voltage Compensation

Cable compensation is based on Class A power requirements, and this section takes PBUS as an example.

Cable compensation requirements:

$$\mathrm{PBUS} = \mathrm{PBUS'} + \mathrm{I} * \mathrm{Rcable} \quad \text{(B.1)}$$

In the formula:

——PBUS: output voltage after cable compensation, in V;

——PBUS': output voltage before cable compensation, in V;

——I: actual output current, in A;

——Rcable: actual cable impedance. For example, the impedance is 100 mΩ, that is to say, 1 A compensates 100 mV.

See Figure B.1.

Figure B.1 Cable Compensation Requirements