TA Document 2000006

AV/C Commands for Management of Asynchronous Serial Bus Connections 1.1

October 24, 2000

Sponsored by:
1394 Trade Association

Accepted for Release by:
1394 Trade Association Board of Directors.

Abstract:
This document describes an AV/C command for management of asynchronous serial bus connections. An asynchronous data-transfer service efficiently transfers data between simple Serial Bus compliant devices. The management command includes subfunctions for establishing, breaking, and monitoring the connection.

Also, extensions to the existing AV/C command are described.

Keywords:
Audio, Video, 1394, Digital, Interface, Asynchronous, Connection, management.

1394 Trade Association Specifications are developed within Working Groups of the 1394 Trade Association, a non-profit industry association devoted to the promotion of and growth of the market for

IEEE 1394-compliant products. Participants in working groups serve voluntarily and without compensation from the Trade Association. Most participants represent member organizations of the 1394 Trade Association. The specifications developed within the working groups represent a consensus of the expertise represented by the participants.

Use of a 1394 Trade Association Specification is wholly voluntary. The existence of a 1394 Trade Association Specification is not meant to imply that there are not other ways to produce, test, measure, purchase, market or provide other goods and services related to the scope of the 1394 Trade Association Specification. Furthermore, the viewpoint expressed at the time a specification is accepted and issued is subject to change brought about through developments in the state of the art and comments received from users of the specification. Users are cautioned to check to determine that they have the latest revision of any 1394 Trade Association Specification.

Comments for revision of 1394 Trade Association Specifications are welcome from any interested party, regardless of membership affiliation with the 1394 Trade Association. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally, questions may arise about the meaning of specifications in relationship to specific applications. When the need for interpretations is brought to the attention of the 1394 Trade Association, the Association will initiate action to prepare appropriate responses.

Comments on specifications and requests for interpretations should be addressed to:

Editor, 1394 Trade Association
Regency Plaza Suite 350
2350 Mission College Blvd.
Santa Clara, Calif. 95054, USA

1394 Trade Association Specifications are adopted by the 1394 Trade Association without regard to patents which may exist on articles, materials or processes or to other proprietary intellectual property which may exist within a specification. Adoption of a specification by the 1394 Trade Association does not assume any liability to any patent owner or any obligation whatsoever to those parties who rely on the specification documents. Readers of this document are advised to make an independent determination regarding the existence of intellectual property rights, which may be infringed by conformance to this specification.

Table of contents

List of figures

List of tables

1. Overview

1.1 Changes from the previous version

This document replaces version 1.0 (Reference [R6]) and differs from it in the following ways:

1) Incorporation of the editorial corrections described in Reference [R7].
2) Clarification of the state machine descriptions in section 7 in order to keep it consistent with the state machines defined in Reference [R8].
3) Modification of the support level of the ASYNCHRONOUS CONNECTION command to be optional, because the enhanced management commands defined in Reference [R9] shall be supported as mandatory. An AV/C command defined in this document may be used to support the existing asynchronous serial bus connections for backward compatibility.

1.2 Preface

This document describes AV/C commands for management of basic asynchronous serial bus connections. The enhanced AV/C management command that supports segment buffer type negotiation and end-to-end connections is defined in Reference [R9].

It is strongly recommended that the enhanced AV/C management command defined in Reference [R9] be implemented if a device supports asynchronous serial bus connections.

If a device is required to support the existing asynchronous serial bus connections management commands, it may support AV/C commands defined in this specification.

The AV/C commands defined in this specification support only the basic segment buffer type defined in Reference [R8] and support only unit-to-unit connections.

1.3 Scope

This document describes an AV/C command for management of asynchronous serial bus connections. An asynchronous data-transfer service efficiently transfers data between simple Serial Bus compliant devices. The scope and purpose of this activity are summarized below:

Scope. The definition of AV/C commands for management of asynchronous connections, where management includes establishing, breaking, and monitoring the connection, and the definition of existing AV/C commands extension for the support of asynchronous connections.

The AV/C management commands assume that the controller, producer, and consumer are attached to the same bus.

Purpose. To provide mechanisms for existing AV/C devices and controllers to easily manage asynchronous connection services.

1.4 Summary

Current AV equipment which supports IEC 61883 uses isochronous channels for real-time data transmission. This document describes how "AV/C Compatible Asynchronous Serial Bus Connections" may be established using the AV/C command set for non-real-time data transmission between AV units. Although asynchronous connections are expected to be established using AV/C commands, other commands can also be used. The connection commands are generated by the controller and are sent to producer and consumer nodes. The controller may be an independent node or may be collocated on the producer-plug or consumer-plug nodes.

An asynchronous connection is designed to survive bus resets. However, asynchronous communications may be temporarily disrupted until the controller has the opportunity to restore the connection. Restoration of the connection involves the notification of new node ID values, since the node ID address of the connected port is sometimes affected by the bus reset.

2. References

The following standards contain provisions, which through reference in this document, constitute provisions of this standard. All the standards listed are normative references. Informative references are given in Annex A. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

[R1] IEEE Std 1394-1995, Standard for a High Performance Serial Bus.

[R2] IEC 61883-1, Consumer audio/video equipment – Digital interface – Part 1: General.

[R3] ISO/IEC 13213: 1994 [ANSI/IEEE Std 1212, 1994 Edition], Information Technology—Microprocessor systems—Control and Status Register (CSR) Architecture for Microcomputer Buses.

[R4] AV/C Digital Interface Command Set General Specification, Version 3.0. TA document number 1998003.

[R5] 1394 Open Host Controller Interface Specification (release 1.00), October 20, 1997

[R6] AV/C commands for management of Asynchronous Serial Bus Connections, Version 1.0. TA document number 1998011

[R7] Editorial Corrections to the Asynchronous Serial Bus Connections, Version 1.0. TA document number 1999010

[R8] AV/C Compatible Asynchronous Serial Bus Connections 2.0. TA document number 2000005

[R9] AV/C Command for Management of Enhanced Asynchronous Serial Bus Connections 1.0, TA document number 1999037

[R10] Enhancements to the AV/C General Specification 3.0 Version 1.0. TA document 1998010

3. Definitions and abbreviations

3.1 Conformance glossary

3.1.1 expected: A key word used to describe the behavior of the hardware or software in the design models *assumed* by this Specification. Other hardware and software design models may also be implemented.

3.1.2 may: A key word that indicates flexibility of choice with *no implied preference*.

3.1.3 shall: A key word indicating a mandatory requirement. Designers are *required* to implement all such mandatory requirements.

3.1.4 should: A key word indicating flexibility of choice with a strongly preferred alternative. Equivalent to the phrase *is recommended*.

3.1.5 reserved fields: A set of bits within a data structure that are defined in this specification as reserved, and are not otherwise used. Implementations of this specification shall zero these fields. Future revisions of this specification, however, may define their usage.

3.1.6 reserved values: A set of values for a field that are defined in this specification as reserved, and are not otherwise used. Implementations of this specification shall not generate these values for the field. Future revisions of this specification, however, may define their usage.

3.2 Technical glossary

3.2.1 asynchronous connection: A logical point-to-point communication path established between producer and consumer ports that supports robust high-bandwidth flow-controlled transfers of one or more data frames.

3.2.2 asynchronous-connection consumer (abbreviated as **consumer**): The node that consumes data frames provided by the asynchronous-connection producer.

3.2.3 asynchronous-connection producer (abbreviated as **producer**): The node that produces data frames for consumption by the asynchronous-connection consumer.

3.2.4 asynchronous plug: A collection of externally visible components (called ports) that can be connected to a subunit for the purposes of sending sequences of variable-length frames.

3.2.5 APR: Asynchronous connection Port Register. One asynchronous plug may have one *iAPR* or more than one up-to 14 *oAPR*. An asynchronous connection is established between *iAPR* on the consumer and *oAPR* on the producer.

3.2.6 input Asynchronous Port Register (abbreviated as ***iAPR***): A consumer-resident register affiliated with a consumer port, that is updated by the producer to indicate how much of data has been written to the segment buffer. This register also has other bits for data flow control purpose.

3.2.7 output Asynchronous Port Register (abbreviated as ***oAPR***): A producer-resident register affiliated with a producer port on a plug, that is updated by the consumer to indicate how much data can be safely written by the producer. This register also has other bits for data flow control purpose.

3.2.8 AV unit: The physical instantiation of a consumer electronic device, *e.g.*, a camcorder or a VCR, within a Serial Bus node.

3.2.9 AV subunit: An instantiation of a virtual entity that can be identified uniquely within an AV unit and offers a set of coherent functions.

3.2.10 AV/C: Audio/video control, as in the AV/C Digital Interface Command Set

3.2.11 byte: Eight bits of data, used as a synonym for octet.

3.2.12 consumer: (see asynchronous connection consumer).

3.2.13 CompareSwap4: A bus transaction that conditionally stores a *next* value to a specified address and returns the previous data value from that address. The store occurs when the addressed memory value and a second *test* value are equal. In the CSR Architecture, this is called a 4-byte compare_swap transaction.

3.2.14 consumer port: A port that is the sink of data frames and is flow controlled by updates of its externally visible *iAPR*.

3.2.15 CSR Architecture: A abbreviation of the following reference: ISO/IEC 13213 : 1994 [ANSI/IEEE Std 1212, 1994 Edition], Information Technology—Microprocessor systems—Control and Status Register (CSR) Architecture for Microcomputer Buses.

3.2.16 data frame (abbreviated as **frame**): A contiguous group of data bytes sent between producer and consumer.

3.2.17 data segment (abbreviated as **segment**): A largest portion of a data frame that can be written into the segment buffer before updating the consumer's *iAPR* register.

3.2.18 EUI-64: Extended Unique Identifier, 64-bits, as defined by the IEEE. The EUI-64 is a concatenation of the 24-bit company_ID obtained from the IEEE Registration Authority Committee (RAC) and a 40-bit number (typically a silicon serial number) that the vendor identified by company_ID guarantees to be unique for all of its products. The EUI-64 is also known as the node unique ID and is redundantly present in a node's configuration ROM in both the Bus_Info_Block and the Node_Unique_Id leaf.

3.2.19 FCP: Function Control Protocol, as defined by IEC 61883.

3.2.20 frame: (see data frame).

3.2.21 IEEE: The Institute of Electrical and Electronics Engineers, Inc.

3.2.22 isochronous: A term that indicates the essential characteristic of a time-scale or signal, such that the time intervals between consecutive instances either have the same duration or durations that are integral multiples of the shortest duration. In the context of Serial Bus, "isochronous" is taken to mean a bounded worst-case latency for the transmission of data; physical and logical constraints that introduce jitter preclude the exact definition of "isochronous."

3.2.23 LSB: Least significant byte.

3.2.24 lsb: Least significant bit.

3.2.25 MSB: Most significant byte.

3.2.26 msb: Most significant bit.

3.2.27 module: The smallest component of physical management, *i.e.*, a replaceable device.

3.2.28 node: An addressable device attached to Serial Bus with at least the minimum set of control registers defined by IEEE Std 1394-1995.

3.2.29 node ID: A 16-bit number, unique within the context of an interconnected group of Serial Buses. The node ID is used to identify both the source and destination of Serial Bus asynchronous data packets. It can identify one single device within the addressable group of Serial Buses (unicast), or it can identify all devices (broadcast).

3.2.30 plug: A physical or virtual end-point of connection implemented by an AV unit or subunit that may receive or transmit isochronous or other data. Plugs may be Serial Bus isochronous plugs, accessible through the PCR's; they may be asynchronous plugs; they may be external, physical plugs on the AV unit; or they may be internal virtual plugs implemented by the AV subunits.

3.2.31 PCR: Plug Control Register, as defined by IEC 61883, Digital Interface for Consumer Electronic Audio/Video Equipment.

3.2.32 iPCR: Input PCR, as defined by IEC 61883.

3.2.33 oPCR: Output PCR, as defined by IEC 61883.

3.2.34 port: A subcomponent of a plug that supports unidirectional data transfers.

3.2.35 producer: (see asynchronous connection producer).

3.2.36 producer port: A port that is the source of data frames and is flow controlled by updates of its externally visible *oAPR*.

3.2.37 quadlet: Four bytes of data.

3.2.38 segment: (see data segment).

3.2.39 segment buffer: An externally visible address space on a consumer into which data is written by the connected producer.

3.2.40 Serial Bus: The physical interconnects and higher level protocols for the peer-to-peer transport of serial data, as defined by IEEE Std 1394-1995.

3.2.41 quadlet: Four bytes of data.

3.2.42 unit architecture: The formal specification of the format and function of the software-visible resources and behaviors of a class of units. This document, in conjunction with the references above, defines a unit architecture for the class of AV devices.

3.3 Size notation

The Serial Bus description avoids the confusing terms half-word, word, and double-word, which have widely different definitions depending on the processor's word size. In their place the Serial Bus description uses terms established in previous IEEE bus standards, which are independent of the processor. These terms are illustrated in Table 3.1.

Table 3.1 – Size notation examples

Size in bits	16-bit word notation	32-bit word notation	IEEE Std. notation (used in this standard)
8	Byte	Byte	Byte
16	Word	Half-word	Doublet
32	Long-word	Word	Quadlet
64	Quad-word	Double	Octlet

3.4 Numerical notation

Decimal, hexadecimal, and binary numbers are used within this document. For clarity, decimal numbers are generally used to represent counts, hexadecimal numbers are used to represent addresses, and binary numbers are used to describe bit patterns within binary fields.

Decimal numbers are represented in their usual 0, 1, 2, … format. Hexadecimal numbers are represented by a string of one or more hexadecimal (0-9,A-F) digits followed by the subscript 16, except in C++ code contexts, where they are written as `0x123EF2` etc. Binary numbers are represented by a string of one or more binary (0,1) digits, followed by the subscript 2. Thus the decimal number "26" may also be represented as "$1A_{16}$" or "11010_{2}".

3.5 State machine notation

All state machines in this standard use the style shown in Figure 3.1. This is similar to the notation used in the Serial Bus standard, with modifications to more compactly and consistently illustrate state transition actions. To illustrative the functionality of transition-destination labels, the equivalent state machines without transition-destination labels is also illustrated in Figure 3.2. Labels of the form Sxx are state transition labels that signify a destination state. Labels of the form Tnn signify a transition to a tag which performs an action prior to entering the state to which it is attached.

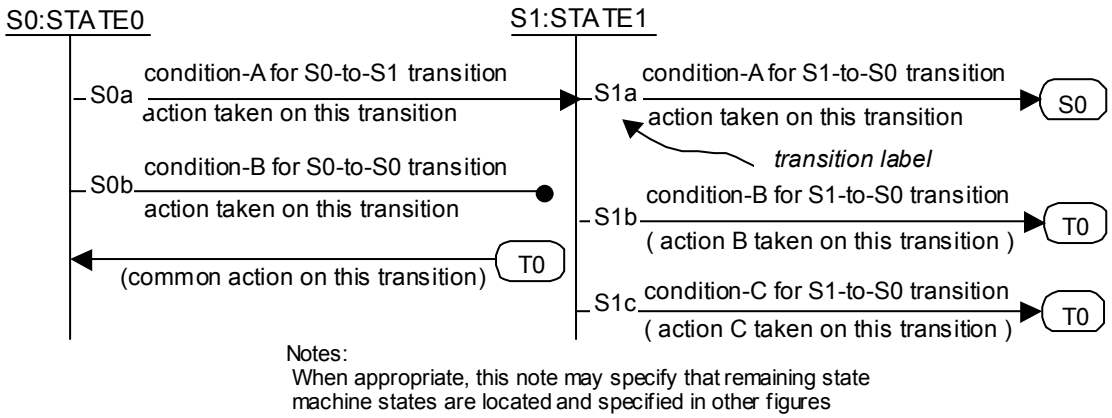


Figure 3.1 – State machine notation

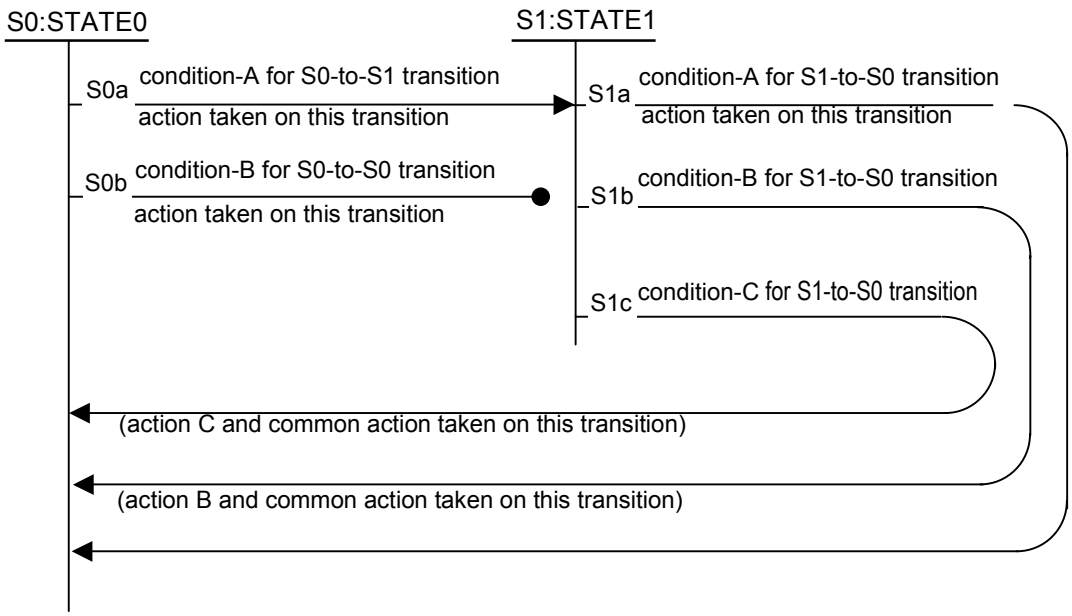


Figure 3.2 – Equivalent state machine

3.6 C++ code notation

The conditions and actions of the state machines are formally defined by C++ code. Since many C++ code operators are non-obvious to the casual reader, their meanings are summarized in Table 3.2.

Table 3.2 – Specific expression summary

Expression	Description
`~I`	Bitwise complement of integer I
`++I`	Pre-increment of integer I (I is incremented, then used in the expression)
`--I`	Pre-decrement of integer I (I is decremented, then used in the expression)
`I ^ J`	Bitwise XOR of integers I and J
`I & J`	Bitwise AND of integer values I and J
`I | J`	Bitwise OR of integer values I and J
`I << J`	Value of I, shifted left by J bits, zero fill
`I >> J`	Value of I, shifted right by J bits, zero fill if I is an unsigned number, sign extension if I is signed
`I == J`	Equality test, true if I is equal to J
`I != J`	Inequality test, true if I is not equal to J
`!B`	Logical negation of boolean variable B
`A && B`	Logical AND of boolean values A and B
`A || B`	Logical OR of boolean values A and B

In addition, the following nonstandard data types (actually, object classes) are supported:

Table 3.3 – Serial Bus data types

Data type	Description
`timer`	real value (units of seconds) that autonomously increments at a defined rate
`boolean`	One bit value where 1 is true and 0 is false

Other, more specific data types are defined in the clauses where they are relevant.

All C++ code is executed as if it takes zero time. Time only elapses when the following function is called:

```
void wait (real time); // wait for "time" to elapse
```

4. Extension for existing AV/C commands

This chapter describes how the existing AV/C commands are extended to support asynchronous connections. Asynchronous connections and asynchronous plugs are handled according to the existing AV/C unit architecture, like isochronous connections and isochronous plugs.

4.1 Plug numbers for asynchronous plug definition

An AV Unit, which supports asynchronous connections, shall have more than one asynchronous plug. To support asynchronous plug, existing plug definitions are extended. Table 9.2-1 in Reference [R4] is changed, as described by Table 4.1 below.

Table 4.1 – Serial Bus and external plug numbers

value	source plug	destination plug
$0 – 1E_{16}$	Serial Bus iPCR[0] – iPCR[30]	Serial Bus oPCR[0] – oPCR[30]
$1F_{16} – 7E_{16}$	Reserved for future specification	Reserved for future specification
$7F_{16}$	Any available Serial Bus plug iPCR[x]	Any available Serial Bus plug oPCR[x]
$80_{16} – 9E_{16}$	External input plug 0 – 30	External output plug 0 – 30
$9F_{16}$	Reserved for future specification	Reserved for future specification
$A0_{16} – BE_{16}$	Serial Bus Asynchronous input plug [0] – [30]	Serial Bus Asynchronous output plug [0] – [30]
BF_{16}	Any available Serial Bus Asynchronous input plug [x]	Any available Serial Bus Asynchronous output plug [x]
$C0_{16} – FC_{16}$	Reserved for future specification	Reserved for future specification
FD_{16}	Reserved for future specification	Multiple plugs
FE_{16}	Invalid	Invalid
FF_{16}	Any available external input plug	Any available external output plug

Table 4.2 below shows the list of AV/C commands in which these new defined values may be used.

Table 4.2 – Existing AV/C commands which handles asynchronous plug

opcode	value
CONNECT	24_{16}
CONNECTIONS	22_{16}
DISCONNECT	25_{16}

4.2 Extended command for asynchronous plug support

The PLUG INFO status command, defined in section 10.8 of Reference [R4], is extended to support asynchronous plugs.

The extended format of PLUG INFO status command is illustrated by Figure 4.1 below.

	msb							lsb
opcode	PLUG INFO (02_{16})							
operand[0]	subfunction							
operand[1]	subfunction dependent fields							
operand[2]								
operand[3]								
operand[4]								

Figure 4.1 – Extended PLUG INFO status command generic format

When the *subfunction* field is set to 00_{16}, the PLUG INFO status command is all the same as defined in [4], which have operand[0] ~ operand[4]. When the *subfunction* field is set to 01_{16}, the PLUG INFO status command format is extended as illustrated by Figure 4.2 below.

	msb							lsb
opcode	PLUG INFO (02_{16})							
operand[0]	01_{16}							
operand[1]	FF_{16}							
operand[2]								
operand[3]								
operand[4]								

Figure 4.2 – Extended PLUG INFO status command format

If the PLUG INFO status command with the *subfunction* field set to 01_{16} was addressed to an AV unit, the response frame returned is illustrated by Figure 4.3 below.

	msb							lsb
opcode	PLUG INFO (02_{16})							
operand[0]	01_{16}							
operand[1]	Serial_Bus_asynchronous_input_plugs							
operand[2]	Serial_Bus_asynchronous_output_plugs							
operand[3]	FF_{16}							
operand[4]								

Figure 4.3 – Extended PLUG INFO status response format from an AV unit

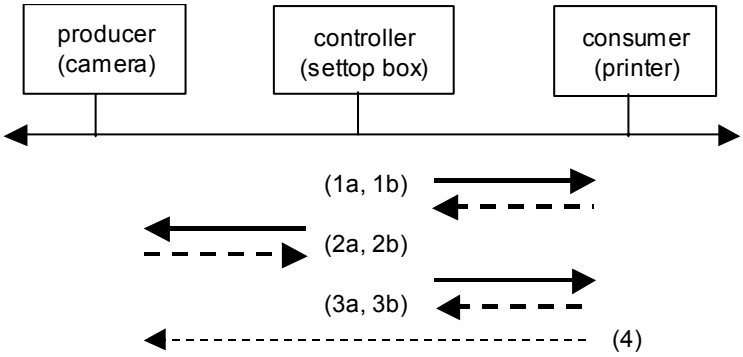
If the PLUG INFO status command is addressed to the AV unit, operand[1] and operand[2] shall indicate the number of Serial Bus Asynchronous input and output plugs, respectively.

5. AV/C connection sequences

This chapter describes an overview of asynchronous connection management. Since the AV/C command that manages the asynchronous connection has only one common frame format, the *subfunction* field value specifies the action to request the target. In this chapter, these subfunctions are described just as "command". The detail of AV/C management command (ASYNCHRONOUS CONNECTION) is described in Chapter 6.

5.1 Establishing an asynchronous connection

An asynchronous connection is established by a controller, which sends an ALLOCATE command to the consumer node, as illustrated by Figure 5.1. The consumer port is effectively locked from other changes, including connection overlays, between the processing of the initial ALLOCATE and final ATTACH command.



1a) ALLOCATE command frame
1b) ALLOCATE response frame
2a) ALLOCATE_ATTACH command frame
2b) ALLOCATE_ATTACH response frame
3a) ATTACH command frame
3b) ATTACH response frame, ++connection count == 1
4) Asynchronous connection transport starts
oAPR register update

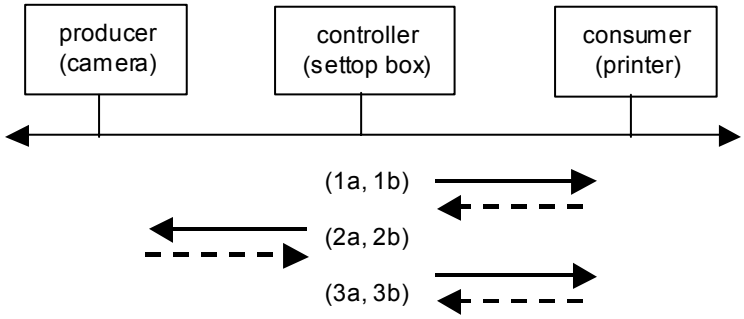
Figure 5.1 – Controller managed connection

The ALLOCATE command (1a,1b) allocates the port resources and returns the address of the consumer port to the controller. The following ALLOCATE_ATTACH (2a,2b) command is responsible for allocating and connecting the producer port resources; the final ATTACH (3a,3b) command is responsible for connecting the consumer port, resulting its connection count value incremented to be one. The producer port remains inactive until the consumer updates the producer-resident *oAPR* register (4), thereby activating the producer port.

Note − There are timeout constraints between (1b)~(3a) and (2b)~(4) to avoid unnecessary idle states. If the next request is not observed within 5 seconds, the port detects a timeout. See Chapter 7 for details.

5.2 Breaking an asynchronous connection

The disconnection of asynchronous ports is initiated by a controller, which sends a DETACH command to the consumer node, as illustrated by Figure 5.2.



1a) DETACH command frame
1b) DETACH response frame, --connection count == 0
2a) DETACH_RELEASE command frame
2b) DETACH_RELEASE response frame
3a) RELEASE command frame
3b) RELEASE response frame

Figure 5.2 – Connection break sequence

The DETACH command (1a,1b) decrements its connection count value. If the connection count value which is returned by the DETACH response (1b) is zero, it indicates that the consumer entered the successful disconnection sequence. If the returned connection count value is not zero, it indicates that the consumer port still has more than one connection. In such a case, the controller should not issue the DETACH_RELEASE command (2a,2b) to the producer, which would break the connection. For detailed description of this case, please refer to Section 5.5.

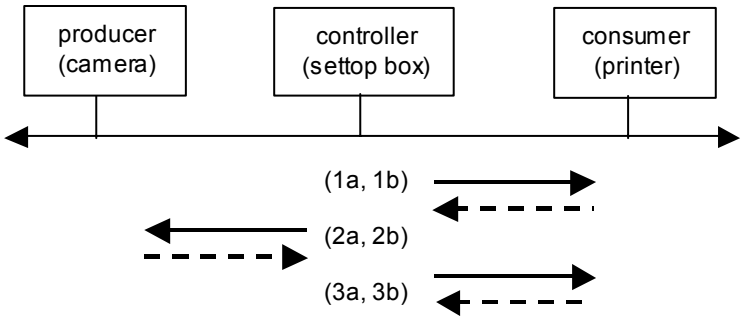
If the connection count value is zero, the consumer-port resource is left in an inactive state. While inactive, the consumer-plug resource accepts register updates and segment buffer writes from the producer, while inhibiting the generation of producer-port updates and segment buffer writes.

The subsequent DETACH_RELEASE command (2a,2b) disconnects the producer-port. If the producer holds multicast connections, and if the disconnected producer-port is also the last-connected producer-plug port, the producer-plug resources is also released. The final RELEASE command (3a,3b) disconnects the consumer-port and releases its resources.

Note – There are timeout constraints between (1b)~(3a) to avoid unnecessary idle states. If the next request is not observed within 5 seconds, the port detects a timeout. See Chapter 7 for details.

5.3 Failure of establishing an asynchronous connection

The controller's connection sequence may fail if the affiliated producer-port connection attempt is rejected. In this case, the controller is responsible for releasing the prepared consumer-port resource, as illustrated in Figure 5.3.



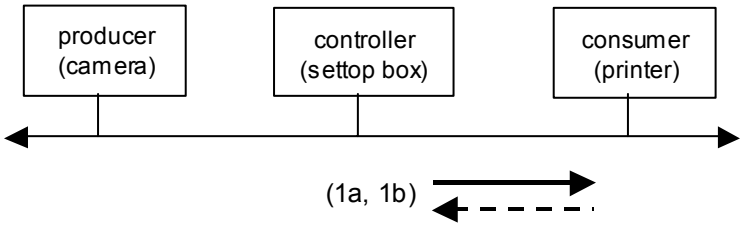
1a) ALLOCATE command frame
1b) ALLOCATE response frame
2a) ALLOCATE_ATTACH command frame
2b) ALLOCATE_ATTACH REJECTED response frame
3a) RELEASE command frame
3b) RELEASE response frame

Figure 5.3 – Producer-plug connection failure

Note − There are timeout constraints between (1b)~(3a) to avoid unnecessary idle states. If the next request is not observed within 5 seconds, the port detects a timeout. See Chapter 7 for details.

5.4 Overlaying an asynchronous connection

An asynchronous connection supports overlay of existing connection as optional, because existing isochronous connections defined in Reference [R2] support overlay and an asynchronous connection may be used together with an isochronous connection. The overlaid connection can not be broken while the connection count value is greater than one because there would be other controllers who are working with this connection. After one connection has been established, the existing connection can be overlaid by the same controller or other controllers, as illustrated by Figure 5.4.



1a) ADD_OVERLAY command frame
1b) ADD_OVERLAY response frame, ++connection count

Figure 5.4 – Connecting an overlaid plug

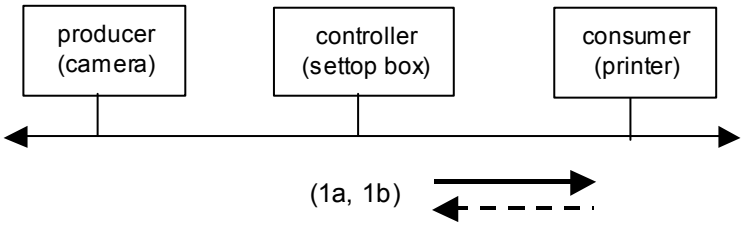
Note that connection count information is the property of the consumer port. The overlay command shall be issued to the consumer only. When overlaying the existing connection, the following conditions shall be met at the consumer port:

1) Same producer. The node ID of the to-be-connected producer is the same as the node ID of the currently connected producer.

2) Same plug and port. The plug ID and port ID on the to-be-connected producer matches the plug ID and port ID of the currently connected producer.

5.5 Breaking an overlaid connection

When more than one overlaid connection has been established, the disconnection of an overlaid port using the same command as with a normal disconnect operation is more efficient, as illustrated by Figure 5.5.



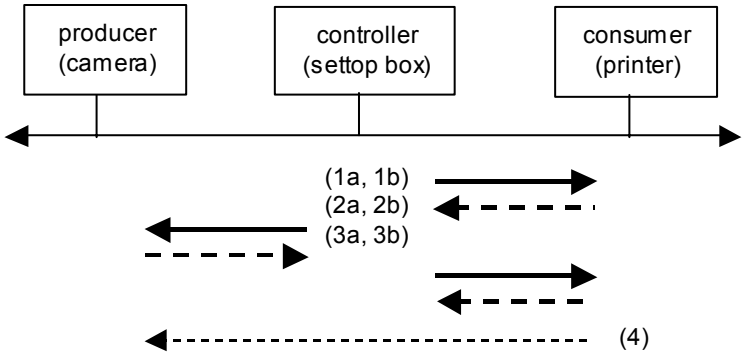
1a) DETACH command
1b) DETACH response frame, --connection count != 0

Figure 5.5 – Disconnecting an overlaid plug

If the DETACH response frame (1b) includes the *connection count* field set to zero, this indicates that the consumer has no connection. In such a case, the controller is responsible to break the connection by issuing the DETATCH_RELEASE command and RELEASE command, as described "5.2 Breaking an asynchronous connection".

5.6 Establish multicast connections

Since asynchronous connections optionally supports a multicast connection capability, one producer plug can be connected up to 14 consumer nodes using 14 ports inside. After one connection has been established, the controller can establish the connection between the current producer plug (with a different port) and another consumer port (if the producer plug supports multicast connections), as illustrated by Figure 5.6.



1a) ALLOCATE command frame
1b) ALLOCATE response frame
2a) ALLOCATE_ATTACH command frame
2b) ALLOCATE_ATTACH response frame
3a) ATTACH command frame
3b) ATTACH response frame
4) Asynchronous connection transport starts
oAPR register update

Figure 5.6 – Establishing multicast connections

Multicast connection can be established if the following conditions are met when the ALLOCATE_ATTACH control command frame (2a) is processed at the producer port:

1) Same producer. The to-be-connected producer is the same as currently connected producer.

2) Same plug. The plug ID on the to-be-connected producer matches the plug ID of the currently connected producer.

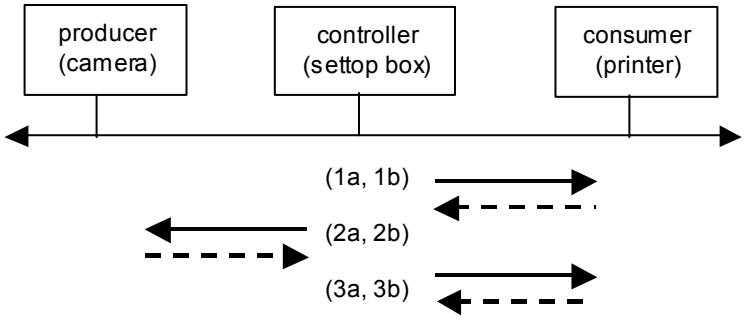
3) Different port. The port ID on the to-be-connected producer shall be different from the port ID of currently connected producer. The controller may specify the port by using “any available port” value in the ALLOCATE_ATTACH (2a) command frame to get the available port ID value, which may be assigned by the producer, returned by the response frame.

4) Different consumer plug. The plug ID of the to-be-connected consumer is different from any of the already-connected consumers.

Note − There are timeout constraints between (1b)~(3a) and (2b)~(4) to avoid unnecessary idle states. If the next request is not observed within 5 seconds, the port detects a timeout. See Chapter 7 for details.

5.7 Breaking multicast connections

After multicast connections have been established, one of these connections can be broken, as illustrated by Figure 5.7.



1a) DETACH command frame
1b) DETACH response frame
2a) DETACH_RELEASE command frame
2b) DETACH_RELEASE response frame
3a) RELEASE command frame
3b) RELEASE response frame

Figure 5.7 – Breaking multicast connections

Note that DETACH_RELEASE (2a,2b) command frame should specify the producer port ID to which the consumer port is connected. If more than one connection has been established on the plug, the DETACH_RELEASE (2a,2b) command only breaks the specified connection. On the other hand, the other connections which the producer plug holds would still remain.

Note − There are timeout constraints between (1b)~(3a) to avoid unnecessary idle states. If the next request is not observed within 5 seconds, the port detects a timeout. See Chapter 7 for details.

5.8 Reconnect procedures after bus reset

5.8.1 AV/C reconnect timing

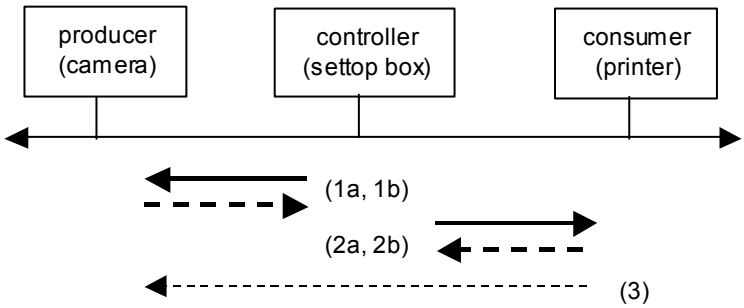
Asynchronous connections are affected by bus resets, since the node ID portions of their connected ports may have changed. The controller is responsible for resuming the connections (providing each port with a revised node ID of the other) after the bus reset.

To keep the consistency with RESERVE control command, the resumption of asynchronous connections shall complete within 10 seconds by the controller that established the connection. A previously active producer or consumer rejects all connection and disconnection commands during these first 10 seconds, accepting only its expected resumption commands. After the 10-second delay, commands to resume are rejected, because the targets have returned to their initial states; the connection and disconnection commands are accepted in the normal fashion. A previously inactive producer or consumer accepts connection and disconnection commands, with no distinction between the commands that are received in the first 10 seconds and those commands that follow.

5.8.2 AV/C reconnect commands

The RESTORE_PORT command is used to re-establish the connection. The use of distinct reconnection commands allows reconnections and new connections to proceed concurrently, while providing the

consumer port with sufficient information to distinguish between the two operations, as illustrated by Figure 5.8. A new asynchronous connection in the first 10 seconds is also allowed, as described in section 5.1.



1a) RESTORE_PORT command frame
1b) RESTORE_PORT response frame
2a) RESTORE_PORT command frame
2b) RESTORE_PORT response frame
3) Asynchronous connection transport starts
oAPR register update

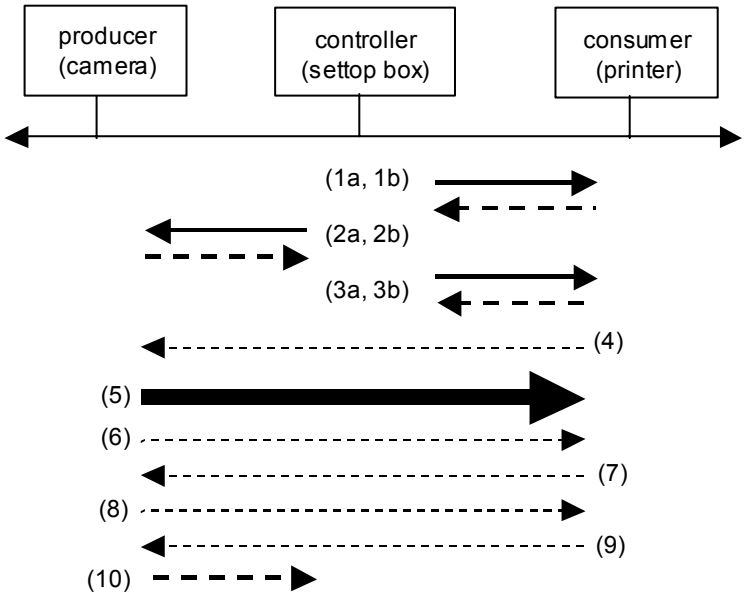
Figure 5.8 – Reconnecting asynchronous plugs

Note − There are timeout constraints between (1b)~(3) to avoid unnecessary idle states. If the next request is not observed within 5 seconds, the port detects a timeout. See Chapter 7 for details.

5.9 Automatic disconnection

The controller can direct the producer node to break the connection automatically after a single frame has been transmitted, using the ALLOCATE_ATTACH_FRAME subfunction. If this subfunction is used in the command frame, the target shall return an INTERIM response, followed by an ACCEPTED or REJECTED response after a single frame transmission.

A controller can request the automatic disconnection to the producer node, as illustrated by Figure 5.9 below.



1a) ALLOCATE command frame
1b) ALLOCATE response frame
2a) ALLOCATE_ATTACH_FRAME command frame
2b) ALLOCATE_ATTACH_FRAME interim response frame (INTERIM)
3a) ATTACH command frame
3b) ATTACH response frame
4) Asynchronous connection transport starts
oAPR register update
5) A single frame transmission
6) iAPR register update, *EndOfFrame* indication
7) oAPR = SEND
8) iAPR = FREE (disconnect indication)
9) oAPR = FREE (disconnect confirmation)
10) ALLOCATE_ATTACH_FRAME final response

Figure 5.9 – Producer initiated disconnection

The ALLOCATE command (1a, 1b) allocates the port resources and returns the address of the consumer port to the controller. The subsequent ALLOCATE_ATTACH_FRAME (2a,2b) command is responsible for allocating and connecting the producer port resources; the final ATTACH (3a,3b) command is responsible for connecting the consumer port. The port remains inactive until the consumer updates the producer-resident *oAPR* register (4), thereby activating the producer port.

After the ALLOCATE_ATTACH_FRAME (2a) command has been sent, the target (producer) shall return an INTERIM response frame (2b), which shall include the port information (i.e., address of the producer port, port bits, etc.). The controller shall use these information when the subsequent ATTACH command (3a) is issued. The ATTACH command (3a,3b) connects the consumer port to the producer port, resulting the start of asynchronous connection transport by updating the *oAPR* register (4).

After a single frame data has been transmitted (5), the producer indicates the *EndOfFrame* by updating the consumer-resident *iAPR* register's ***mode*** value to LAST, LESS, JUNK or LOST (6). Then the consumer

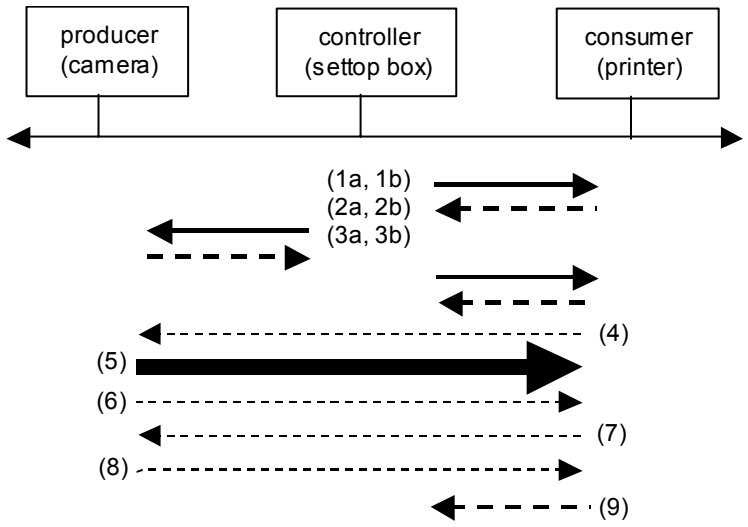
requests the producer to send next frame by updating the producer-resident *oAPR* register with *mode* value set to SEND (7).

As the producer has been requested to disconnect automatically, the producer requests disconnection by updating the *iAPR.mode* with FREE value (8), then the consumer confirms disconnection by updating the *oAPR.mode* with FREE value (9).

After successful disconnection (*iAPR* register's ***mode*** value was LAST), the producer returns an ACCEPTED response for ALLOCATE_ATTACH_FRAME command (10). If an error condition occurs during a single frame transmission (i.e., the iAPR register's mode value was LESS, JUNK or LOST) and the connection may have been broken, the producer returns a REJECTED response for ALLOCATE_ATTACH_FRAME command (10) with error code value stored in *status* field.

Note − There are timeout constraints between (1b)~(3a) and (2b)~(4) to avoid unnecessary idle states. If the next request is not observed within 5 seconds, the port detects a timeout. See Chapter 7 for details.

Also, a controller can request the automatic disconnection to the consumer node, as illustrated by Figure 5.10 below.



1a) ALLOCATE command frame
1b) ALLOCATE response frame
2a) ALLOCATE_ATTACH command frame
2b) ALLOCATE_ATTACH response frame
3a) ATTACH_FRAME command frame
3b) ATTACH_FRAME interim response frame (INTERIM)
4) Asynchronous connection transport starts
oAPR register update
5) A single frame transmission
6) *iAPR* register update, *EndOfFrame* indication
7) *oAPR* = FREE (disconnect indication)
8) *iAPR* = FREE (disconnect confirmation)
9) ATTACH_FRAME final response

Figure 5.10 – Consumer initiated disconnection

The ALLOCATE command (1a, 1b) allocates the port resources and returns the address of the consumer port to the controller. The subsequent ALLOCATE_ATTACH (2a,2b) command is responsible for

allocating and connecting the producer port resources; the final ATTACH_FRAME (3a,3b) command is responsible for connecting the consumer port. The consumer returns an INTERIM response frame (3b) to the controller, then starts an asynchronous connection transport by updating the *oAPR* register (4). The producer port remains inactive until the consumer updates the producer-resident *oAPR* register, thereby activating the producer port.

After a single frame data has been transmitted (5), the producer indicates the *EndOfFrame* by updating the consumer-resident *iAPR* register's ***mode*** value to LAST, LESS, JUNK or LOST (6).

As the consumer has been requested to disconnect automatically, the consumer requests disconnection by updating the *oAPR.mode* with FREE value (7), then the producer confirms disconnection by updating the *iAPR.mode* with FREE value (8).

After successful disconnection (*iAPR* register's ***mode*** value was LAST), the consumer returns an ACCEPTED response for the ATTACH_FRAME command (9). If an error condition occurs during a single frame transmission (*iAPR* register's ***mode*** value was LESS, JUNK or LOST) and the connection may have been broken, the consumer returns a REJECTED response for the ATTACH_FRAME command with error code value stored in *status* field (9).

Note – There are timeout constraints between (1b)~(3a) and (2b)~(4) to avoid unnecessary idle states. If the next request is not observed within 5 seconds, the port detects a timeout. See Chapter 7 for details.

6. Asynchronous Connection management command

6.1 Overview

A controller establishes an asynchronous connection between the Producer Node and the Consumer Node by using AV/C commands. After the connection has been established, asynchronous data frames are transmitted between the nodes.

Although the AV/C command which is addressed to the AV/C subunit might be the trigger to start the transmission, this kind of definition is a subunit design dependent issue and is out of scope of this document.

The AV/C command defined in this specification, which is used for management of asynchronous connections, has only one opcode and common frame format. Support level of asynchronous connection command is defined in Table 6.1 below.

Note that an AV/C unit can have asynchronous plugs, this management command is a unit command.

A target node that has one or more asynchronous plug may support the ASYNCHRONOUS CONNECTION command according to the following table.

Table 6.1 – Support level of asynchronous connection management command

Opcode	Value	Support level (by *ctype*)			Comments
		C	S	N	
ASYNCHRONOUS CONNECTION	26_{16}	*	M	-	Manage asynchronous connections

Note – * The support level of ASYNCHRONOUS CONNECTION control command is dependent on its subfunctions and described in Section 6.2.

Note – The ASYNCHRONOUS CONNECTION STATUS command is only Mandatory within the context of implementing this specification. It is Optional for implementations of asynchronous connections in general.

6.2 Common frame format

The common frame format for the ASYNCHRONOUS CONNECTION command (both CONTROL and STATUS commands) and response, which provides the Asynchronous Connection and Asynchronous Plug management functionality, is illustrated by the Figure 6.1 below.

	msb							lsb
Opcode	ASYNCHRONOUS CONNECTION (26_{16})							
operand[0]	subfunction							
operand[1]	status							
operand[2]	plug ID							
operand[3]	(msb) plug offset							
operand[4]								
operand[5]								
operand[6]								
operand[7]								
operand[8]	(lsb)		port ID				port bits	
operand[9]	connected node ID							
operand[10]								
operand[11]	(msb) connected plug offset							
operand[12]								
operand[13]								
operand[14]								
operand[15]								
operand[16]	(lsb)		connected port ID				connected port bits	
operand[17]	connected plug ID							
operand[18]	ex	res	connection count					
operand[19]	write interval				retry count			
operand[20]	reserved							

Figure 6.1 – ASYNCHRONOUS CONNECTION common frame format

subfunction: The ***subfunction*** field indicates the action to be taken by the target. When it is used in a CONTROL command, it has one of the values in Table 6.2 below.

Table 6.2 – *subfunction* field definitions

Symbol	value	meaning
ALLOCATE	01_{16}	Allocate the consumer port resource
ATTACH	02_{16}	Connect the consumer port to the producer port
ALLOCATE_ATTACH	03_{16}	Allocate the producer port resource and connect it to the consumer port
RELEASE	05_{16}	Release the port resource
DETACH	06_{16}	Disconnect the consumer port
DETACH_RELEASE	07_{16}	Disconnect and release the producer port resource
ADD_OVERLAY	$0A_{16}$	Add the overlaid connection to the consumer port
SUSPEND_PORT	10_{16}	Suspend the consumer port
RESUME_PORT	20_{16}	Resume the consumer port
RESTORE_PORT	40_{16}	Restore the connection after a bus reset
ATTACH_FRAME	82_{16}	Connect the consumer port to the producer port and disconnect it after the transmission of a frame
ALLOCATE_ATTACH_FRAME	83_{16}	Allocate the producer port resource and connect it to the consumer port and disconnect and release it after the transmission of a frame
RESTORE_PORT_FRAME	$C0_{16}$	Restore the port resource that is allocated by the ALLOCATE_ATTACH_FRAME or ATTACH_FRAME subfunction command after a bus reset
-	other values	Reserved

When it is used in a STATUS command, this field shall be set to FF_{16}.

When the value of *subfunction* is ATTACH_FRAME, ALLOCATE_ATTACH_FRAME, or RESTORE_PORT_FRAME, an INTERIM response may be used as the first response and, for other subfunctions, an INTERIM response should not be used.

As the msb of the *subfunction* field indicates the "disconnect request", the subfunction can be described as follows:

```
#define dr_flag          0x80  // disconnect request bit.
                               // if set to one, disconnect after a
                               // single frame transmission.
#define ATTACH_FRAME           dr_flag|ATTACH
#define ALLOCATE_ATTACH_FRAME  dr_flag|ALLOCATE_ATTACH
#define RESTORE_PORT_FRAME     dr_flag|RESTORE_PORT
```

The detailed descriptions of these subfunctions are described in the following sections.

Table 6.3 below shows the support level of these subfunctions. In the table, "M" means "Mandatory", "O" means "Optional", and "-" means "Not used".

Table 6.3 – Support level of subfunctions

symbol	producer	consumer
ALLOCATE	-	M
ATTACH	-	M
ALLOCATE_ATTACH	M	-
RELEASE	-	M
DETACH	-	M
DETACH_RELEASE	M	-
ADD_OVERLAY	-	O
SUSPEND_PORT	-	O
RESUME_PORT	-	O
RESTORE_PORT	M	M
ATTACH_FRAME	-	O
ALLOCATE_ATTACH _FRAME	O	-
RESTORE_PORT_ FRAME	O	O

Note – The use of Mandatory and Optional above is limited in scope to this specification.

status: The ***status*** field indicates the states of the asynchronous port or the result of command execution. The states of the asynchronous port are defined in Chapter 7.

In case of the CONTROL command, this field indicates the result of command execution or the status of asynchronous port. Table 6.4 below shows the *status* field values of the response frame in case of CONTROL command.

Table 6.4 – *status* field values for CONTROL command response frame

value	symbol	*response* code of AV/C frame	meaning
01_{16}	FREE	ACCEPTED	the specified port is in a FREE state
02_{16}	FIXED	ACCEPTED	the specified port is in a FIXED state
03_{16}	ACTIVE	ACCEPTED	the specified port is in a ACTIVE state
04_{16}	INACTIVE	ACCEPTED	the specified port is in a INACTIVE state
05_{16}	WAIT	ACCEPTED	the specified port is in a WAIT state
06_{16}	SUSPENDED	ACCEPTED	the specified port is in a SUSPENDED state
80_{16}	NO_PLUG	REJECTED	no plug is available now
81_{16}	NO_PORT	REJECTED	no port of the specified plug is available now
82_{16}	PLUG_BUSY	REJECTED	the specified plug is not available now
83_{16}	PORT_BUSY	REJECTED	the specified port is not available now
84_{16}	INVALID_OFFSET	REJECTED	the invalid offset address value passed
85_{16}	NO_CONNECTION	REJECTED	no connection to break no connection to add overlay
86_{16}	CONNECTED_ NODE_ERROR	REJECTED	connected port not responding
87_{16}	BROKEN	REJECTED	disconnected by the connected port
88_{16}	MAX_OVERLAY	REJECTED	connection count is already maximum value
89_{16}	FRAME_ERROR	REJECTED	frame transmission failure. The frame did not end with *iAPR.mode* = LAST
FE_{16}	ANY_OTHER_ERR	REJECTED	other internal errors
other values	-	-	reserved

Note − If the msb of returned *status* value was set to one, this field indicates the error code. Note that in case of command frame (both CONTROL and STATUS), this field shall be set to FF_{16}, and the *status* value is returned in a response frame from the target.

Table 6.5 below shows the *status* field values of the response frame in case of STATUS command.

Table 6.5 – *status* field values for STATUS command response frame

value	symbol	*response* code of AV/C frame	meaning
01_{16}	FREE	STABLE	the specified port is in a FREE state
02_{16}	FIXED	STABLE	the specified port is in a FIXED state
03_{16}	ACTIVE	STABLE	the specified port is in a ACTIVE state
04_{16}	INACTIVE	STABLE	the specified port is in a INACTIVE state
05_{16}	WAIT	STABLE	the specified port is in a WAIT state
06_{16}	SUSPENDED	STABLE	the specified port is in a SUSPENDED state
other values	-	-	reserved

plug ID: The ***plug ID*** field indicates the plug identifier of the target and this field should include the values defined in Table 6.6.

Table 6.6 – *plug ID* supported values

value	meaning
$A0_{16}$	asynchronous plug [0]
:	:
BE_{16}	asynchronous plug [30]
BF_{16}	any available asynchronous Plug

The value of BF_{16} (any available asynchronous plug) may be used to indicate that the controller has no preference and that the plug number may be assigned by the target.

plug offset: The ***plug offset*** field is 42 bits in length and indicates the base offset address of the plug of the target.

port ID: The ***port ID*** field specifies which port of the plug is selected, as specified below:

Table 6.7 – *port ID* definitions

value	Meaning
0_{16}	consumer port
1_{16}	producer port [1]
:	:
E_{16}	producer port[14]
F_{16}	any available producer port

When setting up the connection with the producer plug, the controller should use F_{16} as ***port ID***. After bus reset, the controller should use the allocated *port ID* value to restore the port.

The ***plug offset*** and ***port ID*** indicates the 48-bit offset address of the port of the target node, as calculated below:

```
(offset address of the port) = (plug offset) << 6 | (port ID) << 2;
```

port bits: The ***port bits*** field indicates the constraints and capabilities of specified port. The meaning of this field depends on the type of the port. If the port is the consumer port, this field indicates constraints it has. If the port is the producer port, this field indicates the capability of it. See Reference [R8], "4.3.4 Consumer port address" and "4.3.5 Producer port address" for details. Table 6.8 below shows the meaning of this field.

Table 6.8 – *port bits* field definitions

port ID Value	port bits value	symbol	meaning
0_{16}	$X1_2$	ct == 1	The consumer port supports the concurrent writes
	$X0_2$	ct == 0	The consumer port supports only the sequential writes
	$1X_2$	m == 1	The consumer port supports multicast connections
	$0X_2$	m == 0	The consumer port does not support multicast connections
1_{16}~E_{16}	00_2	FIXED	Segment buffer size shall never change for this port
	01_2	FRAME	Segment buffer size may change at the next frame boundary for this port
	10_2	SEGMENT	Segment buffer size may change at the next segment boundary for this port
	11_2	-	Reserved

connected node ID: The ***connected node ID*** field indicates the node identifier which the target is (going to be) connected with.

connected plug offset: The ***connected plug offset*** field is 42 bits in length and indicates the base offset address of the plug to which the target plug is (going to be) connected with.

connected port ID: The ***connected port ID*** field indicates the port identifier or the port to which the target plug is (going to be) connected with and this field has values defined as Table 6.7.

The ***connected node ID***, ***connected plug offset*** and ***connected port ID*** indicates the 64-bit Serial Bus Address of the connected port, as calculated below:

```
(address of connected port)
      = (connected node ID) << 48 | (plug offset) << 6 | (port ID) << 2;
```

connected port bits: The ***connected port bits*** field indicates constraints and capabilities of specified port. The meaning of this field depends on the type of the port. If the port is the consumer port, this field indicates the constraints it has. If the port is the producer port, this field indicates the capability of it. Table 6.8 shows the meaning of this field.

connected plug ID: The ***connected plug ID*** field indicates the plug identifier of the target and has values defined by Table 6.6.

connection count: The ***connection count*** field indicates the number of overlaid connections the consumer node holds. This means how many controllers concern for this connection. If the consumer port is not connected to any other producer port, this field is zero. After the consumer port is connected to the producer port, this field would be incremented, up to 63 ($3F_{16}$). Note that the value of $3F_{16}$ shall be used for the command frame and the response frame may include the current value. As the producer port does not hold this information, this field shall be always $3F_{16}$ for the producer port.

ex (exclusive): The ***ex*** bit specifies whether the other controllers are expected to be excluded from this plug or not. If the target has accepted a control command where the ***ex*** bit is one, the target shall check the following control command addressed to the plug for whether the node ID of the controller is same as the previous one. If the node ID of the controller is different from the previous one, the target shall reject the requested control commands. If this bit is set to zero, the target may accept the control commands addressed to the specified plug from other controllers.

Note that ***ex***=1 may be accepted if one of the following conditions had been met:

— The specified plug is the consumer plug.

— The specified producer plug is not used.

— The controller, that already holds the exclusive access to the producer plug, is going to add a new (multicast) connection on it.

If a port is used using ***ex***=1, the subsequent ASYNCHRONOUS CONNECTION CONTROL command with ***ex***=1 should be used by the owner.

When the ***subfunction*** field specifies ATTACH_FRAME, ALLOCATE_ATTACH_FRAME, or RESTORE_PORT_ FRAME, the ***ex*** bit shall be set to one.

res: The ***res*** field is reserved for the future extension and shall be zero.

write interval: If the *ct* bit of the consumer port is one, ***write interval*** indicates the required interval of Serial Bus Write request (TR_DATA.req) that would be issued to the consumer port, to avoid a number of "ack_busy" returning.

If the *ct* bit of the consumer port is zero, this field indicates the required interval from failed transaction (TR_DATA.conf with "Request status = RETRY LIMIT") to the next write request retry (TR_DATA.req).

Interval time of write transactions request can be calculated as follows:

$$(\text{Interval Time}) = (\text{NOMINAL\_CYCLE\_TIME}) \times 2^{(\textit{write interval})}$$

The detailed definitions of "TR_DATA.req" and "TR_DATA.conf" are described in section 7.1.2 of Reference [R1].

retry count: ***retry count*** indicates the required retry count for Serial Bus Transactions failure issued to the consumer port.

Note − The values of write interval and retry count are provided by the consumer node by using a RESPONSE frame. The controller shall pass these values to the producer node. The producer node is recommended to pace the generation of Serial Bus Transactions according to provided values. Otherwise, if the producer node ignored these values and generated Serial Bus Transactions at its own pace, these transactions may fail and the producer node may receive ack_busy.

6.3 CONTROL commands

This section describes the format of the ASYNCHRONOUS CONNECTION CONTROL command.

For the CONTROL command, the target returns a NOT IMPLEMENTED response when any fields, except for *plug offset*, *connected node ID* and *connected plug offset* field, includes the unsupported values. It is recommended that the target return a REJECTED response when the *plug offset*, *connected node ID* and *connected plug offset* fields contain unsupported values.

Note that all fields shall be the same as the command frame in an NOT IMPLEMENTED response frame.

6.3.1 ALLOCATE subfunction

The ALLOCATE subfunction is used to retrieve the offset address of the specified or available consumer port from the target, and temporarily reserve the port from other changes before the ATTACH subfunction. The controller can specify the plug ID of the target, or allow the consumer to assign the available plug with using "*any available plug*" value.

When this subfunction is used with "*any available plug*" value for the *plug ID* field and the consumer has an available plug, its plug ID and its offset address are returned in the ACCEPTED response frame.

Table 6.9 illustrates the value of each field in the CONTROL command frame and ACCEPTED response frame of the ALLOCATE subfunction.

Table 6.9 – Command and ACCEPTED response frame of ALLOCATE

field	CONTROL command frame	ACCEPTED response frame
subfunction	ALLOCATE (01_{16})	
status	not used (FF_{16})	FIXED (02_{16})
plug ID	specified plug ID or any available plug (BF_{16})	specified plug ID or allocated plug ID
plug Offset	not used (3 FF FF FF FF FF_{16})	Offset address of the plug
port ID	consumer port (0_{16})	←
port bits	not used (11_2)	supported value
connected node ID	not used (FF FF_{16})	←
connected plug offset	not used (3 FF FF FF FF FF_{16})	←
connected port ID	not used (F_{16})	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	00_{16} (current value)
write interval	not used (F_{16})	required write interval value
retry count	not used (F_{16})	required retry count value

Note – "←" means "same as the command frame"

Note that the ALLOCATE subfunction can be used by only the consumer, so the *port ID* field shall be always zero.

If the target cannot allocate the requested plug resource or any error conditions occurs, the target returns a REJECTED response.

Table 6.10 illustrates the value of each field in the CONTROL command frame and the REJECTED response frame of the ALLOCATE subfunction.

Table 6.10 – Command and REJECTED response frame of ALLOCATE

field	CONTROL command frame	REJECTED response frame
subfunction	ALLOCATE (01_{16})	
status	not used (FF_{16})	error code
plug ID	specified plug ID or any available plug (BF_{16})	←
plug Offset	not used (3 FF FF FF FF FF_{16})	←
port ID	consumer port (0_{16})	←
port bits	not used (11_2)	←
connected node ID	not used (FF FF_{16})	←
connected plug offset	not used (3 FF FF FF FF FF_{16})	←
connected port ID	not used (F_{16})	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the command frame"

In a REJECTED response frame, the *status* field includes the error code as defined in Table 6.4.

6.3.2 ALLOCATE_ATTACH subfunction

The ALLOCATE_ATTACH subfunction is used by the producer to retrieve the offset address of the specified or available producer plug and/or port from the target and to inform the producer node about the consumer port information for establishing a connection.

Furthermore, the ALLOCATE_ATTACH subfunction is used by the producer to establish the multicast connection. When adding a new connection to the already-used plug (multicast), the plug ID value may be retrieved by using the STATUS command before issuing this subfunction. Also, the controller may use the "any available port" value for the *port ID* field of this command to allow the producer plug to allocate a new port.

A controller may specify a plug ID or it may allow the target to allocate any available plug when the controller has no preference and the plug number may be assigned by the producer.

Also, the controller shall specify the to-be-connected port that has been retrieved from the consumer node by an ALLOCATE response frame.

When this subfunction is used with the "*any available plug*" value for the *plug ID* field and the producer has an available plug, its plug ID and its offset address would be returned in an ACCEPTED response frame.

Table 6.11 illustrates the value of each field in the CONTROL command frame and the ACCEPTED response frame for the ALLOCATE_ATTACH subfunction.

Table 6.11 – Command and ACCEPTED response frame of ALLOCATE_ATTACH

field	CONTROL command frame	ACCEPTED response frame
subfunction	ALLOCATE_ATTACH (03_{16})	
status	not used (FF_{16})	ACTIVE (03_{16})
plug ID	specified plug ID or any available plug (BF_{16})	specified plug ID or allocated plug ID
plug Offset	not used (3 FF FF FF FF FF_{16})	Offset address of the plug
port ID	specified port ID or any available port (F_{16})	specified port ID or allocated port ID
port bits	not used (11_2)	supported value
connected node ID	specified node ID to be connected (consumer)	←
connected plug offset	offset address of the specified plug to be connected (consumer)	←
connected port ID	consumer port (0_{16})	←
connected port bits	supported value from consumer plug	←
connected plug ID	plug ID of the consumer	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	retrieved value from the consumer	←
retry count	retrieved value from the consumer	←

Note – "←" means "same as the command frame"

After the target returns an ACCEPTED response to the controller, the target waits for an *oAPR* register update by the consumer.

Note that ALLOCATE_ATTACH can be used for only the producer, so the *port ID* field shall not be 0_{16}.

If the fields that are used to specify the parameters (other than fields that are described as "not used") include invalid values or the target cannot allocate the requested port resource or any error condition occurs, the target returns a REJECTED response.

Table 6.12 illustrates the value of each field in the CONTROL command and the REJECTED response frame for the ALLOCATE_ATTACH subfunction.

Table 6.12 – Command and REJECTED response for ALLOCATE_ATTACH

field	CONTROL command frame	REJECTED response frame
subfunction	ALLOCATE_ATTACH (03_{16})	
status	not used (FF_{16})	error code
plug ID	specified plug ID or any available plug (BF_{16})	←
plug Offset	not used (3 FF FF FF FF FF_{16})	←
port ID	specified port ID or any available port (F_{16})	←
port bits	not used (11_2)	←
connected node ID	specified node ID to be connected (consumer)	←
connected plug offset	offset address of the specified plug to be connected (consumer)	←
connected port ID	consumer port (0_{16})	←
connected port bits	supported value from consumer plug	←
connected plug ID	plug ID of the consumer	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	retrieved value from the consumer	←
retry count	retrieved value from the consumer	←

Note – "←" means "same as the command frame"

In a REJECTED response frame, the *status* field includes an error status value as defined in Table 6.4.

6.3.3 ALLOCATE_ATTACH_FRAME subfunction

The ALLOCATE_ATTACH_FRAME subfunction is used for a producer to transfer a single frame. After a frame has been transmitted, the connection will be broken automatically by the producer.

The producer returns an INTERIM response on successful port allocation. After the INTERIM response, an ACCEPTED or REJECTED response will be returned to the controller as a final response and the port will become transition to the FREE state.

After the connection has been broken, both the producer port and the consumer port states change to the FREE state, so there is no need to issue the DETACH_RELEASE subfunction to the producer port, and no need to issue the DETACH and RELEASE subfunctions to the consumer port.

Table 6.13 illustrates the value of each field in the CONTROL command frame and the successful INTERIM response and subsequent ACCEPTED or REJECTED response frame for the ALLOCATE_ATTACH_FRAME subfunction.

Table 6.13 – Command and INTERIM response frame of ALLOCATE_ATTACH_FRAME

field	CONTROL command frame	INTERIM response frame	ACCEPTED response frame	REJECTED response frame
subfunction	ALLOCATE_ATTACH_FRAME (83_{16})			
status	not used (FF_{16})	ACTIVE (03_{16})	FREE (01_{16})	error code
plug ID	specified plug ID or any available plug (BF_{16})	specified plug ID or allocated plug ID	←	←
plug Offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	Offset address of the plug	←	←
port ID	producer port[1] (1_{16})	←	←	←
port bits	not used (11_2)	supported value	←	←
connected node ID	specified node ID to be connected (consumer)	←	←	←
connected plug offset	offset address of the specified plug to be connected (consumer)	←	←	←
connected port ID	consumer port (0_{16})	←	←	←
connected port bits	supported value from consumer plug	←	←	←
connected plug ID	plug ID of the consumer	←	←	←
ex	exclusive (1_2)	←	←	←
connection count	not used ($3F_{16}$)	←	←	←
write interval	retrieved value from the consumer	←	←	←
retry count	retrieved value from the consumer	←	←	←

Note – "←" means "same as the command frame"

After the target returns an INTERIM response to the controller, the target waits for an *oAPR* register update by the consumer.

Note that ALLOCATE_ATTACH_FRAME can be used for only the producer, so the *port ID* field shall not be zero.

After a frame has been transmitted to the consumer, the target returns the final response according the result. If a frame had been transmitted successfully, the target returns an ACCEPTED response.

If a frame has not been transmitted with error conditions, the target returns a REJECTED response.

If a REJECTED response is returned, the *status* field includes an error code as defined in Table 6.4.

The ALLOCATE_ATTACH_FRAME command may be rejected without returning an INTERIM response if the fields which are used to specify the parameters (other than fields that are described as "not used") include invalid values or the target cannot allocate the requested port resource or any error condition has occurred.

Table 6.14 illustrates the CONTROL command frame and the REJECTED response frame for the ALLOCATE_ATTACH_FRAME subfunction.

Table 6.14 – Command and REJECTED response for ALLOCATE_ATTACH_FRAME

field	CONTROL command frame	REJECTED response frame
subfunction	ALLOCATE_ATTACH (FRAME) (83_{16})	
status	not used (FF_{16})	error code
plug ID	specified plug ID or any available plug (BF_{16})	←
plug Offset	not used (3 FF FF FF FF FF_{16})	←
port ID	producer port[1] (1_{16})	←
port bits	not used (11_2)	←
connected node ID	specified node ID to be connected (consumer)	←
connected plug offset	offset address of the specified plug to be connected (consumer)	←
connected port ID	consumer port (0_{16})	←
connected port bits	supported value from consumer plug	←
connected plug ID	plug ID of the consumer	←
ex	exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	retrieved value from the consumer	←
retry count	retrieved value from the consumer	←

Note – "←" means "same as the command frame"

In a REJECTED response frame, the *status* field includes an error code as defined in Table 6.4.

6.3.4 ATTACH subfunction

The ATTACH subfunction is used for the consumer to inform the offset address of the producer plug and port for establishing a connection.

Table 6.15 illustrates the value of each field in the CONTROL command frame and the ACCEPTED response frame for the ATTACH subfunction.

Table 6.15 – Command and ACCEPTED response frame of ATTACH

field	CONTROL command frame	ACCEPTED response frame
subfunction	ATTACH (02_{16})	
status	not used (FF_{16})	ACTIVE (03_{16})
plug ID	allocated plug ID	←
plug Offset	Offset address of the plug	←
port ID	consumer port (0_{16})	←
port bits	supported value	←
connected node ID	specified node ID to be connected (producer)	←
connected plug offset	offset address of the specified plug to be connected (producer)	←
connected port ID	port ID of the producer port	←
connected port bits	supported value from producer plug	←
connected plug ID	plug ID of the producer	←
Ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	01_{16}
write interval	not used (F_{16})	required write interval value
retry count	not used (F_{16})	required retry count value

Note − "←" means "same as the command frame"

After the target returns an ACCEPTED response to the controller, the target updates the *oAPR* register in the producer.

Note that ATTACH can be used for only the consumer, so the *port ID* field shall be 0_{16}.

If the fields that are used to specify the parameters (other than fields that are described as "not used") include invalid value or any error condition has occurred, the target returns a REJECTED response.

Table 6.16 illustrates the CONTROL command frame and the REJECTED response frame for the ATTACH subfunction.

Table 6.16 – Command and REJECTED response for ATTACH

field	CONTROL command frame	REJECTED response frame
subfunction	ATTACH (02_{16})	
status	not used (FF_{16})	error code
plug ID	allocated plug ID	←
plug Offset	Offset address of the plug	←
port ID	consumer port (0_{16})	←
port bits	supported value	←
connected node ID	specified node ID to be connected (producer)	←
connected plug offset	offset address of the specified plug to be connected (producer)	←
connected port ID	port ID of the producer port	←
connected port bits	supported value from producer plug	←
connected plug ID	plug ID of the producer	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the command frame"

In a REJECTED response frame, the *status* field includes an error code as defined in Table 6.4.

6.3.5 ATTACH_FRAME subfunction

The ATTACH_FRAME subfunction is used in order for consumer to break a connection automatically after a frame has been transmitted, in addition to the ATTACH subfunction. The consumer returns an INTERIM response on success, followed by an ACCEPTED or REJECTED response after a frame is transmitted.

Table 6.17 illustrates the value of each field in the CONTROL command frame and the successful INTERIM response frame and the subsequent ACCEPTED response and REJECTED response frames for the ATTACH_FRAME subfunction.

Table 6.17 – Command and INTERIM response frame of ATTACH_FRAME

field	CONTROL command frame	INTERIM response frame	ACCEPTED response frame	REJECTED response frame
subfunction	ATTACH_FRAME (82_{16})			
status	not used (FF_{16})	ACTIVE (03_{16})	FREE (01_{16})	error code
plug ID	allocated plug ID	←	←	←
plug Offset	Offset address of the plug	←	←	←
port ID	consumer port (0_{16})	←	←	←
port bits	supported value	←	←	←
connected node ID	specified node ID to be connected (producer)	←	←	←
connected plug offset	offset address of the specified plug to be connected (producer)	←	←	←
connected port ID	port ID of the producer port	←	←	←
connected port bits	supported value from producer plug	←	←	←
connected plug ID	plug ID of the producer	←	←	←
ex	exclusive (1_2)	←	←	←
connection count	not used ($3F_{16}$)	1_{16}	0_{16}	0_{16}
write interval	not used (F_{16})	required write interval value	←	←
retry count	not used (F_{16})	required retry count value	←	←

Note − "←" means "same as the command frame"

After the target returns an INTERIM response to the controller, the target updates the *oAPR* register in the producer.

Note that ATTACH_FRAME can be used by only the consumer, so the *port ID* field shall be 0_{16}.

After a frame has been received from the producer, the target returns the final response according the result. If a frame has been received successfully, the target returns an ACCEPTED response. If a frame has been received with errors, the target returns a REJECTED response.

In a REJECTED response frame, the *status* field indicates an error code as defined in Table 6.4.

The ATTACH_FRAME may be rejected without returning an INTERIM response, if the fields which are used to specify the parameters (other than fields that are described as "not used") include any invalid values or any error condition has occurred.

Table 6.18 illustrates the value of each field in the CONTROL command frame and the REJECTED response frame for the ATTACH_FRAME subfunction.

Table 6.18 – Command and REJECTED response for ATTACH_FRAME

field	CONTROL command frame	REJECTED response frame
subfunction	ATTACH_FRAME (82_{16})	
status	not used (FF_{16})	error code
plug ID	allocated plug ID	←
plug Offset	Offset address of the plug	←
port ID	consumer port (0_{16})	←
port bits	supported value	←
connected node ID	specified node ID to be connected (producer)	←
connected plug offset	offset address of the specified plug to be connected (producer)	←
connected port ID	port ID of the producer port	←
connected port bits	supported value from producer plug	←
connected plug ID	plug ID of the producer	←
ex	exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the command frame"

In a REJECTED response frame, the *status* field includes an error code as defined in Table 6.4.

6.3.6 ADD_OVERLAY subfunction

The ADD_OVERLAY subfunction is used to overlay the existing connection by the same controller that established the connection, or other controllers.

A successful ADD_OVERLAY command results in the connection count value being incremented.

When the *connection count* field is 63, which means there the maximum number of overlays for the connection has been reached, the ADD_OVERLAY command shall be rejected by returning a REJECTED response.

The controller shall specify the target port information (plug ID, port ID, offset address, etc.) and the connected port information, which may be retrieved from the target by using the STATUS command.

Table 6.19 illustrates the value of each field in the CONTROL command frame and the ACCEPTED response frame for the ADD_OVERLAY subfunction.

Table 6.19 – Command and ACCEPTED response frame of ADD_OVERLAY

field	CONTROL command frame	ACCEPTED response frame
subfunction	ADD_OVERLAY ($0A_{16}$)	
status	not used (FF_{16})	ACTIVE (03_{16}) or SUSPENDED (06_{16})
plug ID	allocated plug ID	←
plug Offset	Offset address of the plug	←
port ID	consumer port (0_{16})	←
port bits	supported value	←
connected node ID	specified node ID to be connected (producer)	←
connected plug offset	offset address of the specified plug to be connected (producer)	←
connected port ID	port ID of the producer port	←
connected port bits	supported value from producer plug	←
connected plug ID	plug ID of the producer	←
ex	not exclusive (0_2)	←
connection count	not used ($3F_{16}$)	incremented connection count value
write interval	not used (F_{16})	required write interval value
retry count	not used (F_{16})	required retry count value

Note − "←" means "same as the command frame"

When the target returns an ACCEPTED response, the connection count value is incremented and returned in the *connection count* field of the response frame.

Note that ADD_OVERLAY can be used for only the consumer, so the *port ID* field shall be 0_{16}.

If the fields which are used to specify the parameters (other than fields that are described as "not used") include an invalid value or any error condition has occurred, the target returns a REJECTED response.

Table 6.20 indicates the command frame and the REJECTED response frame for the ADD_OVERLAY subfunction.

Table 6.20 – Command and REJECTED response frame of ADD_OVERLAY

field	CONTROL command frame	REJECTED response frame
subfunction	ADD_OVERLAY ($0A_{16}$)	
status	not used (FF_{16})	error code
plug ID	allocated plug ID	←
plug Offset	Offset address of the plug	←
port ID	consumer port (0_{16})	←
port bits	supported value	←
connected node ID	specified node ID to be connected (producer)	←
connected plug offset	offset address of the specified plug (producer)	←
connected port ID	port ID of the producer port	←
connected port bits	supported value from producer plug	←
connected plug ID	plug ID of the producer	←
ex	not exclusive (0_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the command frame"

When a REJECTED response is returned, the ***status*** field contains an error code as defined in Table 6.4.

6.3.7 DETACH subfunction

The DETACH subfunction is used for the consumer, to remove an overlaid connection if the connection count is greater than one, or to break the connection if the connection count is 1. The controller shall specify the plug ID and port ID values of the target.

The successful DETACH addressed to the overlaid port results in the connection count value being decremented. When the *connection count* field is one, which means there is a single connection, the decremented connection count results in the connection being broken (detached).

If the controller detects the connection count is set to zero in the ACCEPTED response frame for the DETACH subfunction, the controller is responsible for breaking this connection by issuing the DETACH_RELEASE and RELEASE subfunctions.

Table 6.21 illustrates the value of each field in the CONTROL command frame and the ACCEPTED response frame for the DETACH subfunction.

Table 6.21 – Command and ACCEPTED response frame of DETACH

field	CONTROL command frame	ACCEPTED response frame
subfunction	DETACH (06_{16})	
status	not used (FF_{16})	ACTIVE (03_{16}) or SUSPENDED (06_{16}) or INACTIVE (04_{16})
plug ID	specified plug ID	←
plug Offset	not used (3 FF FF FF FF FF_{16})	Offset address of the plug
port ID	consumer port (0_{16})	←
port bits	not used (11_2)	supported value
connected node ID	not used (FF FF_{16})	connected node ID
connected plug offset	not used (3 FF FF FF FF FF_{16})	offset address of the connected plug
connected port ID	not used (F_{16})	port ID of the producer port
connected port bits	not used (11_2)	supported value from producer plug
connected plug ID	not used (FF_{16})	plug ID of the producer
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	decremented count
write interval	not used (F_{16})	required write interval value
retry count	not used (F_{16})	required retry count value

Note − "←" means "same as the command frame"

If the returned value of the *connection count* field is zero, the returned value of *status* is INACTIVE. If the returned value of the *connection count* field is non-zero, it indicates that the connection still exists and the returned value of *status* is ACTIVE or SUSPENDED.

After the target returns an ACCEPTED response with *connection count* = 0 to the controller, the target enters the INACTIVE state and stops updating the *oAPR* register in the producer.

Note that the DETACH subfunction can only be used by the consumer, so the *port ID* field value shall be always 0_{16}.

If the fields which are used to specify the parameters (other than fields that are described as "not used") include any invalid value or any error condition has occurred, the target returns a REJECTED response.

Table 6.22 illustrates the value of each field in the CONTROL command frame and the REJECTED response frame.

Table 6.22 – Command and REJECTED response for DETACH

field	CONTROL command frame	REJECTED response frame
subfunction	DETACH (06_{16})	
status	not used (FF_{16})	error code
plug ID	specified plug ID	←
plug Offset	not used (3 FF FF FF FF FF_{16})	←
port ID	consumer port (0_{16})	←
port bits	not used (11_2)	←
connected node ID	not used (FF FF_{16})	←
connected plug offset	not used (3 FF FF FF FF FF_{16})	←
connected port ID	not used (F_{16})	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the command frame"

In a REJECTED response frame, the *status* field includes an error code as defined in Table 6.4.

6.3.8 DETACH_RELEASE subfunction

The DETACH_RELEASE subfunction is used by the producer in order to break the connection and release its port resource. The controller shall specify the plug ID and port ID values of the target.

Table 6.23 illustrates the value of each field in the CONTROL command frame and the ACCEPTED response frame for the DETACH_RELEASE subfunction.

Table 6.23 – Command and ACCEPTED response frame of DETACH_RELEASE

field	CONTROL command frame	ACCEPTED response frame
subfunction	DETACH _RELEASE(07_{16})	
status	not used (FF_{16})	FREE (01_{16})
plug ID	specified plug ID	←
plug Offset	not used (3 FF FF FF FF FF_{16})	←
port ID	specified port ID	←
port bits	not used (11_2)	←
connected node ID	not used (FF FF_{16})	←
connected plug offset	not used (3 FF FF FF FF FF_{16})	←
connected port ID	not used (F_{16})	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the command frame"

After the target returned an ACCEPTED response to the controller, the target stops issuing Serial Bus transactions addressed to the consumer.

Note that the DETACH_RELEASE subfunction can only be used by the producer, so the *port ID* field value shall be specified and shall not be 0_{16}.

If the fields that are used to specify the parameters (other than fields that are described as "not used") include any invalid values or any error condition has occurred, the target returns a REJECTED response.

Table 6.24 illustrates the value of each field in the CONTROL command frame and the REJECTED response frame for the DETACH_RELEASE subfunction.

Table 6.24 – Command and REJECTED response frame of DETACH_RELEASE

field	CONTROL command frame	REJECTED response frame
subfunction	DETACH _RELEASE(07_{16})	
status	not used (FF_{16})	status value
plug ID	specified plug ID	←
plug Offset	not used (3 FF FF FF FF FF_{16})	←
port ID	specified port ID	←
port bits	not used (11_2)	←
connected node ID	not used (FF FF_{16})	←
connected plug offset	not used (3 FF FF FF FF FF_{16})	←
connected port ID	not used (F_{16})	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the command frame"

In a REJECTED response frame, the *status* field includes an error code as defined in Table 6.4.

6.3.9 RELEASE subfunction

The RELEASE subfunction is used to release the consumer port. The controller shall specify the plug ID and port ID values of the target.

Table 6.25 illustrates the value of each field in the CONTROL command frame and the ACCEPTED response frame of the RELEASE subfunction.

Table 6.25 – Command and ACCEPTED response frame of RELEASE

field	CONTROL command frame	ACCEPTED response frame
subfunction	RELEASE (05_{16})	
status	not used (FF_{16})	FREE (01_{16})
plug ID	specified plug ID	←
plug Offset	not used (3 FF FF FF FF FF_{16})	←
port ID	consumer port (0_{16})	←
port bits	not used (11_2)	←
connected node ID	not used (FF FF_{16})	←
connected plug offset	not used (3 FF FF FF FF FF_{16})	←
connected port ID	not used (F_{16})	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note − "←" means "same as the command frame"

Note that RELEASE can be used by only the consumer, so the *port ID* field value shall be always zero.

If the fields which are used to specify the parameters (other than fields that are described as "not used") include any invalid values or any error condition had occurred, the target returns a REJECTED response.

Table 6.26 illustrates the value of each field in the CONTROL command frame and the REJECTED response frame for the RELEASE subfunction.

Table 6.26 – Command and REJECTED response frame of RELEASE

field	CONTROL command frame	REJECTED response frame
subfunction	RELEASE (05_{16})	
status	not used (FF_{16})	error code
plug ID	specified plug ID	←
plug Offset	not used (3 FF FF FF FF FF_{16})	←
port ID	consumer port (0_{16})	←
port bits	not used (11_2)	←
connected node ID	not used (FF FF_{16})	←
connected plug offset	not used (3 FF FF FF FF FF_{16})	←
connected port ID	not used (F_{16})	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the command frame"

In a REJECTED response frame, the *status* field includes an error code as defined in Table 6.4.

6.3.10 RESTORE_PORT subfunction

The RESTORE_PORT subfunction is used by both the producer and the consumer to re-establish the connection after a bus reset. Also, the RESTORE_PORT subfunction is used to re-establish the multicast connections by specifying the port ID value that has been connected.

Note that when a bus reset occurs, the node (producer or consumer) shall keep its connection-related information for 10 seconds. If no RESTORE_PORT had been issued within 10 seconds, the node shall release the connection-related information and return to its initial FREE state. After receiving RESTORE_PORT, the producer shall wait for the update of the *oAPR* register by the consumer, then start the segment transmission. According to this re-establishment procedure, the controller shall issue RESTORE_PORT to the producer at first and issue RESTORE_PORT to the consumer later. Note that during the bus reset data may have been lost by the producer during these procedures if the producer had been sending time-dependent data frames.

The controller shall specify the *plug ID*, *port ID*, *connected node ID* and *ex* fields. The *connected node ID* field shall be updated with the new node ID if it changes after a bus reset.

If these values are not consistent with the previous values before a bus reset except for the *connected node ID* field, the target returns a REJECTED response.

Table 6.27 illustrates the value of each field in the CONTROL command frame and the ACCEPTED response frame of the RESTORE_PORT subfunction for the producer port.

Table 6.27 – Command and ACCEPTED response frame of RESTORE_PORT for the producer port

field/	CONTROL command frame	ACCEPTED response frame
subfunction	RESTORE_PORT (40_{16})	
status	not used (FF_{16})	ACTIVE (03_{16})
plug ID	specified plug ID	←
plug Offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	offset address of the plug
port ID	port ID of the producer port	←
port bits	not used (11_2)	supported value
connected node ID	node ID of consumer	←
connected plug offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	offset address of connected plug
connected port ID	consumer port (00_{16})	←
connected port bits	not used (11_2)	supported value from the consumer port
connected plug ID	not used (FF_{16})	connected plug ID of the consumer
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	required value from the consumer
retry count	not used (F_{16})	required value from the consumer

Note − "←" means "same as the command frame"

Table 6.28 illustrates the value of each field in the CONTROL command frame and the REJECTED response frame of the RESTORE_PORT subfunction for the producer port.

Table 6.28 – Command and REJECTED response frame of RESTORE_PORT for the producer port

field	CONTROL command frame	REJECTED response frame
subfunction	RESTORE_PORT (40_{16})	
status	not used (FF_{16})	error code
plug ID	specified plug ID	←
plug Offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	←
port ID	port ID of the producer port	←
port bits	not used (11_{02})	←
connected node ID	node ID of consumer	←
connected plug offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	←
connected port ID	consumer port (00_{16})	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the command frame"

In a REJECTED response frame, the *status* field includes an error code as defined in Table 6.4.

Table 6.29 illustrates the value of each field in the CONTROL command frame and the ACCEPTED response frame of the RESTORE_PORT subfunction for the consumer port.

Table 6.29 – Command and ACCEPTED response frame of RESTORE_PORT for the consumer port

field	CONTROL command frame	ACCEPTED response frame
subfunction	RESTORE_PORT (40_{16})	
status	not used (FF_{16})	ACTIVE (03_{16}) or SUSPENDED (06_{16})
plug ID	specified plug ID	←
plug Offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	offset address of the plug
port ID	consumer port (00_{16})	←
port bits	not used (11_2)	supported value
connected node ID	node ID of producer	←
connected plug offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	offset address of connected plug
connected port ID	port ID of the producer port	←
connected port bits	not used (11_2)	supported value from the producer port
connected plug ID	not used (FF_{16})	connected plug ID of the producer
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	01_{16}
write interval	not used (F_{16})	required write interval value
retry count	not used (F_{16})	required retry count value

Note − "←" means "same as the command frame"

Table 6.30 illustrates the value of each field in the CONTROL command frame and the REJECTED response frame of the RESTORE_PORT subfunction for the consumer port.

Table 6.30 – Command and REJECTED response frame of RESTORE_PORT for the consumer port

field	CONTROL command frame	REJECTED response frame
subfunction	RESTORE_PORT (40_{16})	
status	not used (FF_{16})	error code
plug ID	specified plug ID	←
plug Offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	←
port ID	consumer port (00_{16})	←
port bits	not used (11_2)	←
connected node ID	node ID of producer	←
connected plug offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	←
connected port ID	port ID of the producer port	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note − "←" means "same as the command frame"

In a REJECTED response frame, the *status* field includes an error code as defined in Table 6.4.

6.3.11 RESTORE_PORT_FRAME subfunction

The RESTORE_PORT_FRAME subfunction is used by the producer and consumer to re-establish the connection, which had been established by the ALLOCATE_ATTACH_FRAME or ATTACH_FRAME subfunction command.

Note − When a bus reset has occurred, the node (producer or consumer) shall keep its connection-related information for 10 seconds. If no RESTORE_PORT_FRAME has been issued within 10 seconds, the node shall release its connection-related information and return to its initial FREE state. After receiving RESTORE_PORT_FRAME, the producer shall wait an update of the *oAPR* register by the consumer, then restart segment transmission. According to this re-establishment procedure, the controller shall issue RESTORE_PORT_FRAME or RESTORE_PORT to the producer first and issue RESTORE_PORT_FRAME or RESTORE_PORT to the consumer later.

If RESTORE_PORT_FRAME is issued to the producer, it returns an INTERIM response on success, followed by an ACCEPTED/REJECTED response after frame transmission.

Table 6.31 shows the command frame CONTROL command frame and the successful INTERIM response frame as well as the ACCEPTED and REJECTED response frames for the RESTORE_PORT_FRAME subfunction.

Table 6.31 – Command and response frame of RESTORE_PORT_FRAME for the producer port

field	CONTROL command frame	INTERIM response frame	ACCEPTED response frame	REJECTED response frame
subfunction	RESTORE_PORT_FRAME ($C0_{16}$)			
status	not used (FF_{16})	ACTIVE (03_{16})	FREE (01_{16})	error code
plug ID	specified plug ID	←	←	←
plug Offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	offset address of the plug	←	←
port ID	port ID of the producer port	←	←	←
port bits	not used (11_2)	supported value	←	←
connected node ID	node ID of consumer	←	←	←
connected plug offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	offset address of connected plug	←	←
connected port ID	consumer port (00_{16})	←	←	←
connected port bits	not used (11_2)	supported value from the consumer port	←	←
connected plug ID	not used (FF_{16})	connected plug ID of the consumer	←	←
ex	exclusive (1_2)	←	←	←
connection count	not used ($3F_{16}$)	←	←	←
write interval	not used (F_{16})	required value from the consumer	←	←
retry count	not used (F_{16})	required value from the consumer	←	←

Note – "←" means "same as the previous frame"

After a frame has been transmitted to the consumer, the producer returns a final response according to the result. If a frame has been transmitted successfully, the producer returns an ACCEPTED response. If a frame had been transmitted with errors, the producer returns a REJECTED response. In a REJECTED response frame, the *status* field indicates an error code as defined in Table 6.4.

The RESTORE_PORT_FRAME command may be rejected without returning an INTERIM response, if the command includes any invalid parameters or any error conditions has occurred.

Table 6.32 illustrates the value of each field in the CONTROL command frame and the REJECTED response frame for the RESTORE_PORT_FRAME subfunction for the producer port.

Table 6.32 – Command and REJECTED response for RESTORE_PORT_FRAME for the producer port

field	CONTROL command frame	REJECTED response frame
subfunction	RESTORE_PORT_FRAME ($C0_{16}$)	
status	not used (FF_{16})	error code
plug ID	specified plug ID	←
plug Offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	←
port ID	port ID of the producer port	←
port bits	not used (11_2)	←
connected node ID	node ID of consumer	←
connected plug offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	←
connected port ID	consumer port (00_{16})	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
connection count	exclusive (1_2)	←
ex	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the previous frame"

When RESTORE_PORT_FRAME is issued to the consumer, it returns an INTERIM response on success, followed by an ACCEPTED/REJECTED response after frame transmission.

Table 6.33 shows the command frame CONTROL command frame and the successful INTERIM response as well as the ACCEPTED and REJECTED response frames for the RESTORE_PORT_FRAME subfunction for the consumer port.

Table 6.33 – Command and response frame of RESTORE_PORT_FRAME for the consumer port

field	CONTROL command frame	INTERIM response frame	ACCEPTED response frame	REJECTED response frame
subfunction	RESTORE_PORT_FRAME ($C0_{16}$)			
status	not used (FF_{16})	ACTIVE (03_{16})	FREE (01_{16})	error code
plug ID	specified plug ID	←	←	←
plug Offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	offset address of the plug	←	←
port ID	consumer port (00_{16})	←	←	←
port bits	not used (11_2)	supported value	←	←
connected node ID	node ID of producer	←	←	←
connected plug offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	offset address of the plug to be connected	←	←
connected port ID	port ID of the producer port	←	←	←
connected port bits	not used (11_2)	supported value from producer plug	←	←
connected plug ID	not used (FF_{16})	plug ID of the producer	←	←
ex	exclusive (1_2)	←	←	←
connection count	not used ($3F_{16}$)	01_{16}	00_{16}	00_{16}
write interval	not used (F_{16})	required write interval value	←	←
retry count	not used (F_{16})	required retry count value	←	←

Note – "←" means "same as the previous frame"

After a frame has been transmitted to the consumer, the consumer returns a final response according to the result. If a frame has been transmitted successfully, the producer returns an ACCEPTED response. If a frame had been transmitted with errors, the producer returns a REJECTED response.

In a REJECTED response frame, the *status* field indicates an error code as defined in Table 6.4.

Table 6.34 illustrates the value of each field in the CONTROL command frame and the REJECTED response frame for the RESTORE_PORT_FRAME subfunction for the consumer port.

Table 6.34 – Command and REJECTED response for RESTORE_PORT_FRAME for the consumer port

field	CONTROL command frame	REJECTED response frame
subfunction	RESTORE_PORT_FRAME ($C0_{16}$)	
status	not used (FF_{16})	error code
plug ID	specified plug ID	←
plug Offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	←
port ID	consumer port (00_{16})	←
port bits	not used (11_2)	←
connected node ID	node ID of producer	←
connected plug offset	not used ($3\ FF\ FF\ FF\ FF\ FF_{16}$)	←
connected port ID	port ID of the producer port	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
connection count	exclusive (1_2)	←
ex	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the previous frame"

In a REJECTED response frame, the *status* field includes an error code as defined in Table 6.4.

6.3.12 SUSPEND_PORT subfunction

The SUSPEND_PORT subfunction is used by the consumer port to suspend the connection. When a connection is suspended, the producer discards the remainder of the frame data and no data is transmitted until the RESUME_PORT subfunction is issued.

Table 6.35 illustrates the value of each field in the CONTROL command frame and the ACCEPTED response frame of the SUSPEND_PORT subfunction.

Table 6.35 – Command and ACCEPTED response frame of SUSPEND_PORT

field	CONTROL command frame	ACCEPTED response frame
subfunction	SUSPEND_PORT (10_{16})	
status	not used (FF_{16})	SUSPENDED (06_{16})
plug ID	specified plug ID	←
plug Offset	not used (3 FF FF FF FF FF_{16})	←
port ID	consumer port (0_{16})	←
port bits	not used (11_2)	←
connected node ID	not used (FF FF_{16})	←
connected plug offset	not used (3 FF FF FF FF FF_{16})	←
connected port ID	not used (F_{16})	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the previous frame"

Note that SUSPEND_PORT can be used by the consumer only, so the *port ID* field value shall be 0_{16}.

If any passed parameters are invalid or the consumer port is already in the SUSPENDED state or any error condition has occurred, the target returns a REJECTED response.

Table 6.36 illustrates the value of each field in the CONTROL command frame and the REJECTED response frame for the SUSPEND_PORT subfunction.

Table 6.36 – Command and REJECTED response frame of SUSPEND_PORT

field	CONTROL command frame	REJECTED response frame
subfunction	SUSPEND_PORT (10_{16})	
status	not used (FF_{16})	error code
plug ID	specified plug ID	←
plug Offset	not used (3 FF FF FF FF FF_{16})	←
port ID	consumer port (0_{16})	←
port bits	not used (11_2)	←
connected node ID	not used (FF FF_{16})	←
connected plug offset	not used (3 FF FF FF FF FF_{16})	←
connected port ID	not used (F_{16})	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the previous frame"

In a REJECTED response frame, the *status* field includes an error code as defined as in Table 6.4.

6.3.13 RESUME_PORT subfunction

The RESUME_PORT subfunction is used for the suspended consumer port to resume frame transmission.

The resumed asynchronous connection layer restarts frame transmission from the beginning of the next outgoing frame and during the SUSPENDED state, frames may be discarded by the producer.

Table 6.37 illustrates the value of each field in the CONTROL command frame and the ACCEPTED response frame of the RESUME_PORT subfunction.

Table 6.37 – Command and ACCEPTED response frame of RESUME_PORT

field	CONTROL command frame	ACCEPTED response frame
subfunction	RESUME_PORT (20_{16})	
status	not used (FF_{16})	ACTIVE (03_{16})
plug ID	specified plug ID	←
plug Offset	not used (3 FF FF FF FF FF_{16})	←
port ID	consumer port (0_{16})	←
port bits	not used (11_2)	←
connected node ID	not used (FF FF_{16})	←
connected plug offset	not used (3 FF FF FF FF FF_{16})	←
connected port ID	not used (F_{16})	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note − "←" means "same as the previous frame"

Note that RESUME_PORT can be used by only the consumer, so the *port ID* field value shall always be zero.

If the passed parameters are invalid or the consumer port is not in a SUSPENDED state or any error condition had been occurred, the target returns a REJECTED response.

Table 6.38 illustrates the value of each field in the CONTROL command frame and the REJECTED response frame for the RESUME_PORT subfunction.

Table 6.38 – Command and REJECTED response frame of RESUME_PORT

field	CONTROL command frame	REJECTED response frame
subfunction	RESUME_PORT (20_{16})	
status	not used (FF_{16})	error code
plug ID	specified plug ID	←
plug Offset	not used (3 FF FF FF FF FF_{16})	←
port ID	consumer port (0_{16})	←
port bits	not used (11_2)	←
connected node ID	not used (FF FF_{16})	←
connected plug offset	not used (3 FF FF FF FF FF_{16})	←
connected port ID	not used (F_{16})	←
connected port bits	not used (11_2)	←
connected plug ID	not used (FF_{16})	←
ex	not exclusive (0_2) or exclusive (1_2)	←
connection count	not used ($3F_{16}$)	←
write interval	not used (F_{16})	←
retry count	not used (F_{16})	←

Note – "←" means "same as the previous frame"

In a REJECTED response frame, the *status* field includes an error code as defined as in Table 6.4.

6.4 STATUS command

The ASYNCHRONOUS CONNECTION command also supports a STATUS command. The STATUS command is used for retrieving the information about the port and its connection state, so the controller shall specify the plug ID and port ID values.

If the target supports the specified asynchronous plug and/or port, the target returns a STABLE response frame, which includes the port information it has. Otherwise, if the target does not have the specified plug and/or port, the target returns a NOT IMPLEMENTED response with the response frame that has all the same field values as the command frame.

Furthermore, if any "not used" fields include an unspecified value, the target returns a NOT IMPLEMENTED response. Table 6.39 below illustrates the STATUS command frame values.

Table 6.39 – STATUS Command and STABLE response frame

field	STATUS command frame	STABLE response frame
subfunction	FF_{16}	
status	not used (FF_{16})	current value
plug ID	specified plug ID	←
plug Offset	not used (3 FF FF FF FF FF_{16})	current value
port ID	specified port ID	←
port bits	not used (11_2)	current value
connected node ID	not used (FF FF_{16})	current value
connected plug offset	not used (3 FF FF FF FF FF_{16})	current value
connected port ID	not used (F_{16})	current value
connected port bits	not used (11_2)	current value
connected plug ID	not used (FF_{16})	current value
ex	not used (1_2)	current value
connection count	not used ($3F_{16}$)	current value
write interval	not used (F_{16})	current value
retry count	not used (F_{16})	current value

Note − "←" means "same as the previous frame"

When a STATUS command is issued to the producer port, the *port ID* value shall be set to specified port ID value (1_{16} ~E_{16}) that identifies the producer port. The response frame may include the current value of each field, according to the current state of the port as defined in Table 6.40 below:

Table 6.40 – Possible STATUS response from the producer port

port state fields	FREE	ACTIVE	WAIT
status	FREE (01_{16})	ACTIVE (03_{16})	WAIT (05_{16})
plug ID	←	←	←
plug Offset	O	O	O
port ID	←	←	←
port bits	O	O	O
connected node ID	X	O	X
connected plug offset	X	O	O
connected port ID	X	O	O
connected port bits	X	O	O
connected plug ID	X	O	O
ex	X	O	O
connection count	X	X	X
write interval	X	O	O
retry count	X	O	O

Note − "←" means "same as the specified value in the command frame". "O" means "returning the current value". "X" means "no information", returns the same value as the command frame.

Note − The states of the asynchronous port are defined in Chapter 7.

When a STATUS command is issued to the consumer port, *port ID* value shall be set to zero. The response frame may include the current value of each field, according to the current state of the port as defined in Table 6.41 below:

Table 6.41 – Possible STATUS response from the consumer port

port state fields	FREE / FIXED	ACTIVE / INACTIVE / SUSPENDED	WAIT
status	FREE (01_{16}) / FIXED(02_{16})	ACTIVE(03_{16}) / INACTIVE(04_{16}) / SUSPENDED(06_{16})	WAIT (05_{16})
plug ID	←	←	←
plug Offset	O	O	O
port ID	←	←	←
port bits	O	O	O
connected node ID	X	O	X
connected plug offset	X	O	O
connected port ID	X	O	O
connected port bits	X	O	O
connected plug ID	X	O	O
ex	X	O	O
connection count	X	O	O
write interval	O	O	O
retry count	O	O	O

Note − "←" means "same as the command frame" . "O" means "returning the current value". "X" means "no information", returns the same value as the command frame.

Note − The states of the asynchronous port are defined in Chapter 7.

7. Asynchronous Connection port states

7.1 Code definitions

All of the procedures and definitions in this chapter use the syntax specified in the Table 7.1 below.

Table 7.1 – State machine code definitions

```
typedef struct {
            Byte subfnc;                // subfunction
            Byte plugID;                // target plug identifier
            Byte status;                // plug status or result of command execution
            Octlet plugAddr;            // offset address of plug, including portID and portBits
            Doublet connectNodeID;      // node identifier of (to-be) connected node
            Octlet connectPlugOffset;   // offset address of (to-be) connected plug,
                                        //  including connectPortID and connectPortBits
            Byte connectPlugID;         // plug identifier of (to-be)connected port
            boolean ex;                 // exclusive request bit
            Byte connectionCount;       // connection count which the (consumer) port holds
            Byte writeInterval;         // write interval value requested from the consumer
            Byte retryCount;            // retry count value requested from the consumer
} portInfo;

portInfo *cInfo;    // portInfo stored in the consumer port of the target
portInfo *pInfo;    // portInfo stored in the producer port of the target
portInfo *req;      // portInfo stored in the command frame which is requested by the controller
portInfo *hold;     // portInfo stored for deferred response
Doublet ctrl;       // controller nodeID, retrieved from AV/C command frame.
Doublet ctrl_bak;   // backuped controller nodeID stored in the target "PLUG" to check the exclusive
                    // access. Its initial value is 0xFFFF.
boolean dr;         // flag for disconnect request stored in the target port, set to 1 if the MSB
                    // of subfunction field had been set to 1.
boolean suspendflg; // flag for suspended state before bus reset

#define legal_access          ( !cInfo->ex || ( ctrl_bak == ctrl ) )
                    // true if the requested command is from the controller who claimed to access
                    // the plug by issuing command with ex=1, or the plug is NOT allocated
                    // by a controller by issuing command with ex=0.

void initialize( portInfo *xInfo)       // do the power-reset initialization, as follows:
{
   invalidate( xInfo );
   xInfo->plugID = PLUG_ID;                         // Defined Plug ID value assigned for this port
   xInfo->plugAddr = PORT_ADDRESS;                  // Defined Plug Address value assigned for this port
   if ( isConsumer( xInfo ) ){
      xInfo->writeInterval = INITIAL_INT_VALUE;     // INITIAL_INT_VALUE is the device specific value
      xInfo->retryCount = INITIAL_RETRY_VALUE;      // INITIAL_RETRY_VALUE is the device specific value
   }
   dr = suspendflg = FALSE;
}

Byte avc_cmd( Doublet *ctrlID, portInfo *req );
                        // Valid "ASYNCHRONOUS CONNECTION" AV/C command frame reception event,
                        // returns subfunction, or NULL when no event arrived.
                        // As req->plugID field value should be specified, the command itself is passed
                        // to the proper plug management components. If the initial command includes "any
                        // available port" for producer, the node searches the available port to start
                        // its state machine.
                        // In the state machine diagrams, other AV/C commands than ASYNCHRONOUS CONNECTION
                        // are not described and make no state transitions, but they shall be handled as
                        // defined in [3] or other specifications.
                        // Also "ASYNCHRONOUS CONNECTION" commands with invalid field values are not
                        // fully described and make no state transitions, but shall be rejected with REJECTED
                        // response or NOT IMPELEMENTED response, as specified in Chapter 6.

Byte avc_rsp( Doublet ctrlID, Byte rsp, portInfo *);
                        // generate AV/C response frame to the controller specified as ctrlID.
                        // rsp specifies the response code of AV/C response frame, and other fields of the
                        // response frame are set by using the portInfo structure.

void invalidate( portInfo * );          // invalidate portInfo, setting all the bit to 1 except for PlugID and
                                        // PlugAddr, then set portInfo->status to FREE value.

bool EndOfFrame_ind( BYTE *mode );      // event indication from Asynchronous Connections layer,
                                        // which indicates the connection layer detects "LAST" or "TOSS" or "LESS"
                                        // or "JUNK". "mode" returns register mode value from AsyncConnections
                                        // laver.
```

Table 7.2 – State machine code definitions (continued)

```
void memcpy( portInfo *dst, portInfo *src);     // copy the src structure to the dst

void setupInfo( portInfo *stat, portInfo *req )   // exchange the valid field value between stat and req
{                                                 // as follows:
  stat->subfnc = req->subfnc;           // copy the subfunction value
  stat->status = req->status;           // store status value, req->status value should be set before setupInfo()
  switch( req->subfunc ){
    case ALLOCATE:
        stat->ex = req->ex;                       // set the ex bit
        req->plugAdr = stat->plugAdr;             // return plug address
        req->connectionCount = stat->connectionCount = 0;   // set connectionCount to 0
        req->writeInterval = stat->writeInterval; // return (initial) writeInterval
        req->retryCount = stat->retryCount;       // return (initial) retryCOunt
        break;
    case ALLOCATE_ATTACH:
    case ALLOCATE_ATTACH_FRAME:
        stat->ex = req->ex;                       // set the ex bit
        req->plugAdr=stat->plugAdr;               // return the plug address
        memcpy(stat,req);                         // set other fields as requested
        break;
    case ATTACH:
    case ATTACH_FRAME:
        req->connectionCount = 1;                 // set connectionCount to 1
        req->writeInterval = stat->writeInterval; // return (initial) writeInterval
        req->retryCount = stat->retryCount;       // return (initial) retryCOunt
        memcpy(stat,req);                         // set other fields as requested
        break;
    case ADD_OVERLAY:
        stat->connectionCount++;                  // increment a connectionCount value
        req->writeInterval = stat->writeInterval; // return (initial) writeInterval
        req->retryCount = stat->retryCount;       // return (initial) retryCOunt
        memcpy(req,stat);                         // return the current state values
        break;
    case DETACH:
        stat->connectionCount--;                  // decrement a connectionCount value
        req->writeInterval = stat->writeInterval; // return (initial) writeInterval
        req->retryCount = stat->retryCount;       // return (initial) retryCOunt
        memcpy(req,stat);                         // return the current state values
        break;
    case RESTORE_PORT:
    case RESTORE_PORT_FRAME:
        stat->connectNodeID = req->connectNodeID; // set connectNodeID
        if ( isComsumer( stat ) )
            stat->connectionCount = 1;            // set connectionCount to 1
        req->writeInterval = stat->writeInterval; // return (initial) writeInterval
        req->retryCount = stat->retryCount;       // return (initial) retryCOunt
        memcpy(req,stat);                         // return the current state values
        break;
    case SUSPEND_PORT:
    case RESUME_PORT:
    case DETACH_RELEASE:
    case RELEASE:
        break;                                    // no fields to be exchanged
    }
}

bool Break_ind();   // returns TRUE when an indication from Asynchronous Connections layer ocurrred,
                    // which indicates the connection is broken because of the following conditions
                    // occurred:
                    //  (a) connected port indicated "FREE", so the port confirmed "FREE".
                    //  (b) other error conditions occurred.

bool Timeout_ind(); // returns TRUE when an indication from Asynchronous Connections layer, which
                    // indicates the connection timeout observed at the transport layer.

Byte SetErrorCode();          // returns the error code from the execution results from AsyncConnections layer,
                              // or from other internal conditions.

void AttachEvent_req( portInfo * );     // ATTACH event request to AsyncConnections layer
void DetachEvent_req( portInfo * );     // DETACH event request to AsyncConnections layer
void RestoreEvent_req( portInfo * );    // RESTORE event request to AsyncConnections layer
void ReleaseEvent_req( portInfo *);     // RELEASE event request to AsyncConnections layer
void BreakEvent_req( portInfo * );      // BREAK event request to AsyncConnections layer
void SuspendEvent_req( portInfo * );    // SUSPEND event request to AsyncConnections layer
void ResumeEvent_req( protInfo * );     // RESUME event request to AsyncConnections layer
```

7.2 Consumer port states

7.2.1 Consumer port state machine

The behavior of a consumer plug is specified by its state machine definition as illustrated by Figure 7.1.

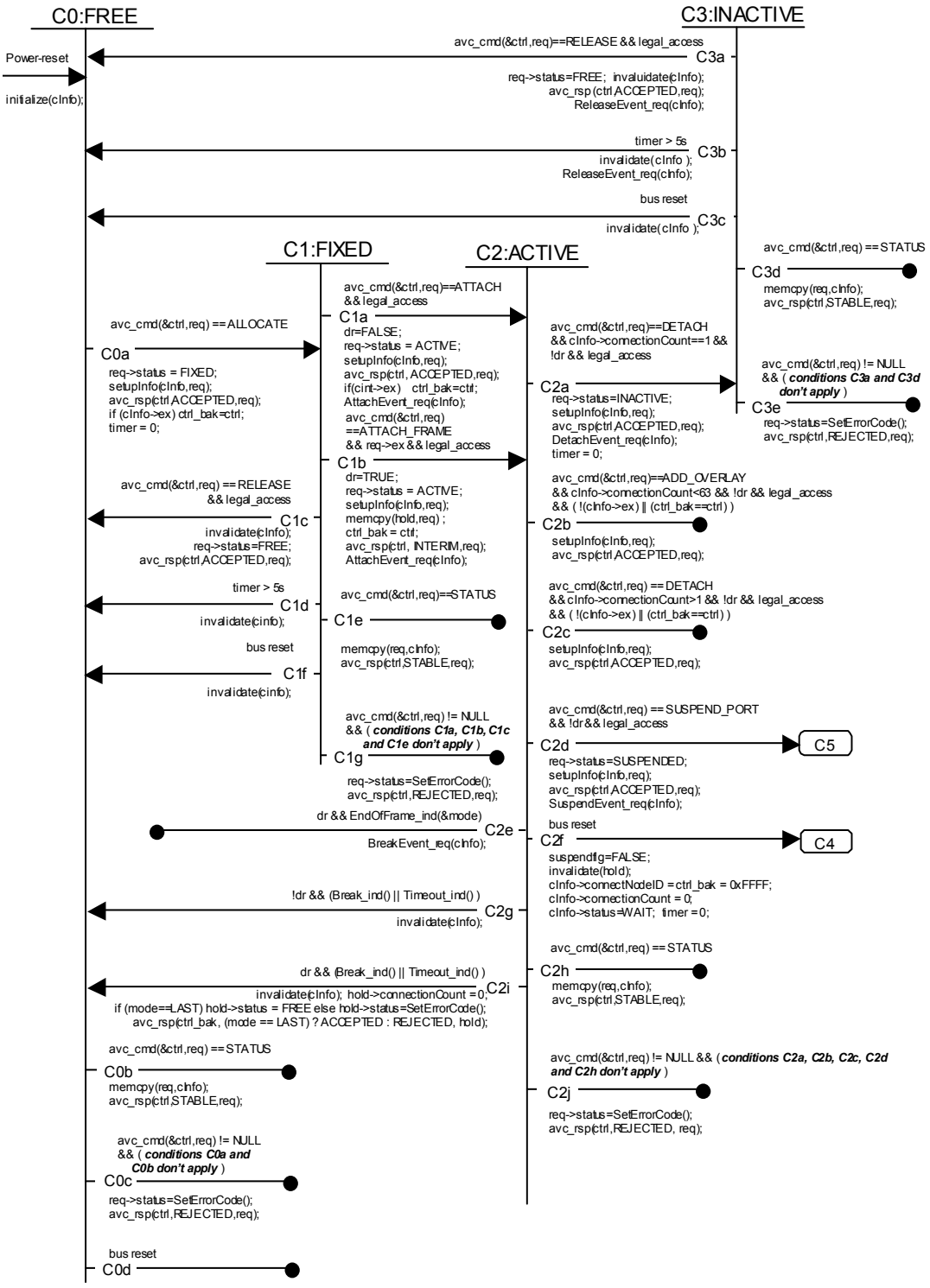


Figure 7.1 – Consumer port state machine

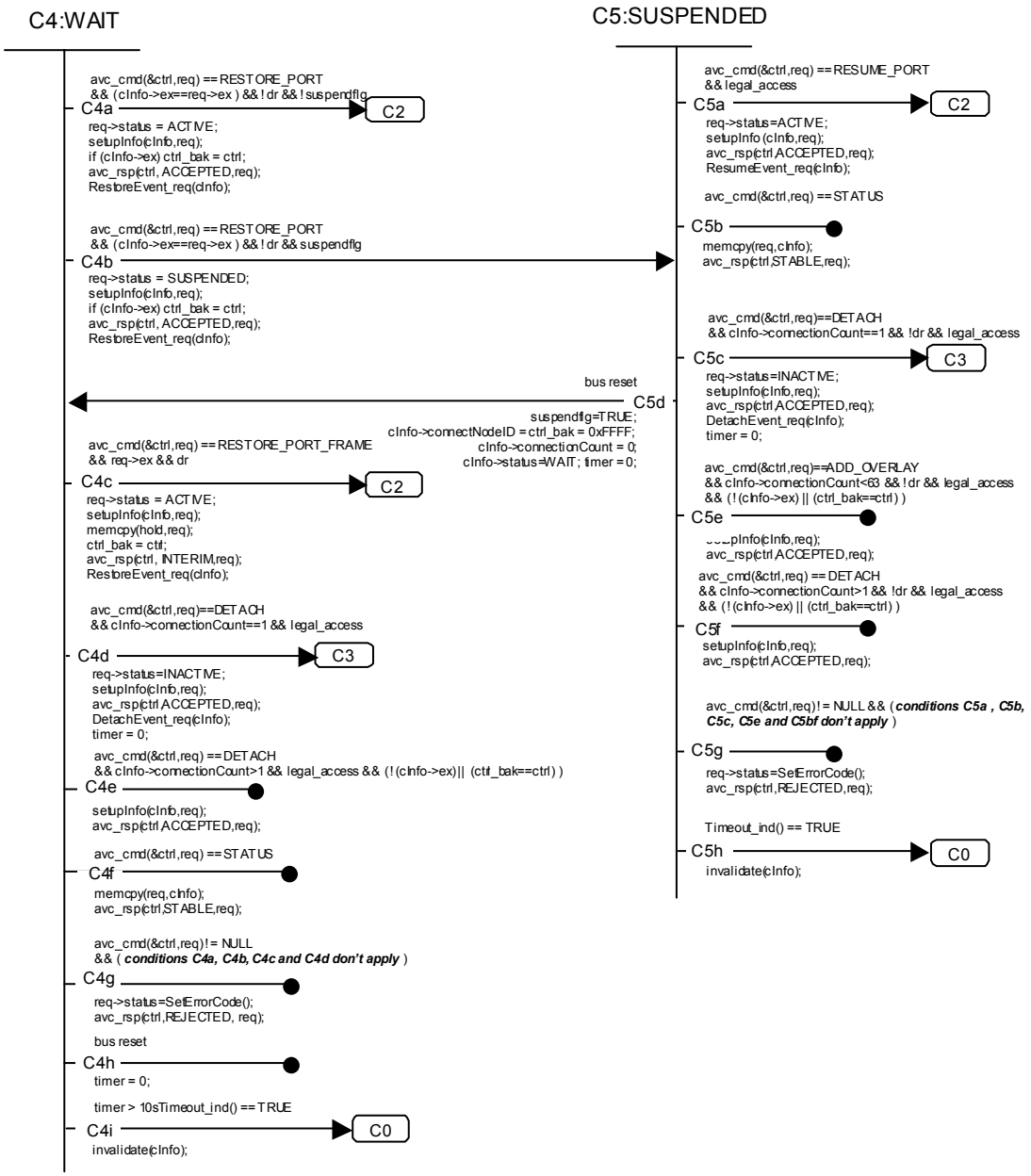


Figure 7.2 – Consumer port state machine (continued)

7.2.2 Consumer port state machine notes

State C0:FREE. The *FREE* state is the initial state of the port with no resources committed. While in the *C0:FREE* state, the purpose of the ALLOCATE subfunction is to transition the port to the *C2:ACTIVE* (connected) state by passing through the intermediate *C1:FIXED* state. These state transitions are listed below.

Transition C0a. When a valid ALLOCATE subfunction is received, the node copies port information to return in the response frame to the controller, then transitions to the *C1:FIXED* state. If the *ex* bit in the command frame had been set to one, the target stores the node ID of the controller to reject the following control commands from other controllers. Also, the port resets the timer to detect a 5-second timeout for transitions from *C1:FIXED* to *C2:ACTIVE*.

Transition C0b. When a STATUS command is requested, the port reports the current port information by returning a STABLE response frame.

Transition C0c. All other connection management subfunctions are rejected by returning a REJECTED response frame with an error code in the *status* field.

Transition C0d. Bus resets while in the *C0:FREE* state leaves the port in the same state.

State C1:FIXED. In the FIXED state the ports resources have been allocated, but the port is not yet prepared to accept write or lock transactions and cannot send lock transactions to the producer port (since this port has not yet been identified). While in the C1:FIXED state, the purpose of the ATTACH or ATTACH_FRAME subfunction is to transition the port to the C2:ACTIVE (connected) state. If there has not been valid transition from C1:FIXED to C2:ACTIVE within 5 seconds, the port transitions to C0:FREE state. These state transitions are listed below.

Transition C1a. A valid ATTACH subfunction transitions the port to the fully-connected *C2:ACTIVE* state. The ATTACH subfunction command frame includes the connection information such as producer port address. After returning an ACCEPTED response frame to the controller, the port requests the asynchronous connections layer to start by issuing *AttachEvent_req()*. Although not illustrated, the *oAPR* register on the connected producer port is also updated to activate asynchronous connection communications.

Transition C1b. A valid ATTACH_FRAME subfunction transitions the port to the fully-connected *C2:ACTIVE* state. The ATTACH_FRAME subfunction command frame includes the connection information such as producer port address. The port stores the requested connection information (for the final response), then returns an INTERIM response frame to the controller. The port then requests to an asynchronous connections layer to start by issuing *AttachEvent_req()*. Although not illustrated, the *oAPR* register on the connected producer port is also updated to activate asynchronous connection communications.

Transition C1c. A valid RELEASE subfunction returns the port to the initial *C0:FREE* state. (This is normally the final step in a connection-abort sequence, which releases the consumer after a producer-port connection failure is discovered). The port invalidates the port information and returns an ACCEPTED response frame to the controller.

Transition C1d. After a 5-second connection timeout, the consumer port transitions to the *C0:FREE* state. The port invalidates the port information.

Transition C1e. When the STATUS command with *subfunction* set to STATUS is requested, the port reports the current port information by generating a STABLE response frame.

Transition C1f. A bus reset returns the port to its initial *C0:FREE* state. The port invalidates the port information.

Transition C1g. Other subfunctions are rejected, because they have no meaning while in this transient state or the following stable state. The node returns a REJECTED response to the controller with the error code in the *status* field.

State C2:ACTIVE. In the *ACTIVE* state the port is operational. While in the *C2:ACTIVE* state, the purpose of the subfunctions is to allow overlays (which leaves the port in the *C2:ACTIVE* state and increments the connection count) and to allow disconnection by transitioning the port to the *C3:INACTIVE* state. These state transitions are listed below.

Transition C2a. A valid DETACH subfunction addressed to a port handling no overlays (*connection count* == 1) state transitions the port to a half-disconnected *C3:INACTIVE* state. After returning an ACCEPTED response to the controller, the port requests to the asynchronous connections layer to stop requesting the data by issuing *DetachEvent_req()*. Also, the port resets the timer to detect a 5-second timeout for transitions from *C3:INACTIVE* to *C0:FREE*.

Transition C2b. A valid ADD_OVERLAY subfunction increments the connection count if the *connection count* was less than 63, leaving the port connected in its *C2:ACTIVE* state. The node returns an ACCEPTED response frame on success.

Transition C2c. A valid DETACH subfunction decrements the connection count if the *connection count* value was bigger than one, leaving the port connected in its *C2:ACTIVE* state. The node returns an ACCEPTED response frame on success.

Transition C2d. The valid SUSPEND_PORT subfunction transitions to *C5:SUSPENDED* state. After returning an ACCEPTED response to the controller, the port requests to an asynchronous connections layer to suspend by *SuspendEvent_req()*.

Transition C2e. When the previous issued attachment subfunction had been ATTACH_FRAME and *dr* had been set to one and *EndOfFrame_ind(&mode)* was indicated from an asynchronous connections layer (the *mode* value describes the *iAPR.mode* value indicated by the connected producer port), the port requests the asynchronous connections layer to break the connection by issuing *BreakEvent_req()* to start the disconnection sequence described in Figure 5.10.

Transition C2f. A bus reset transitions the port to the *C4:WAIT* state, in preparation of accepting the expected RESTORE_PORT or RESTORE_PORT_FRAME subfunction (these command restores the node ID of its connected plug). The port sets its *connect node ID* value to 0xFFFF (invalid node ID), and *connection count* to zero.

Transition C2g. When the previous issued attachment subfunction had been ATTACH (*dr* had been set to zero) and there had been an indication from an asynchronous connections layer that shows the connection is broken by connected node, timeout or other reasons, the port invalidates the port information, then transitions to *C0:FREE* state.

Transition C2h. When STATUS command is requested, the port reports the current port information by generating a STABLE response frame.

Transition C2i. While the *dr* is one, the *Break_ind()* indication or the *Timeout_ind()* indication from the asynchronous connections layer transitions the port to an initial *C0:FREE* state. The port invalidates the port information. If the *mode* value retrieved from the asynchronous connections layer had been *LAST*, an ACCEPTED response will be used, otherwise a REJECTED response with the error code in the *status* field will be used.

Transition C2j. Other subfunctions are rejected. The node returns a REJECTED response to the controller with the error code in the *status* field.

State C3:INACTIVE. In the *INACTIVE* state the port is half disabled; write or lock transactions are accepted (because the connected producer port may still be active) but lock requests are not generated by this port. While in the *C3:INACTIVE* state, the purpose of the subfunctions is to allow disconnection by

transitioning the port to the *C0:FREE* state. If there has not been a valid transition from *C3:INACTIVE* to *C0:FREE* within 5 seconds, the port transitions to *C0:FREE* state. These state transitions are listed below.

Transition C3a. The valid RELEASE subfunction releases the port's allocated resources and returns the port to the *C0:FREE* state. The port invalidates the port information and returns an ACCEPTED response to the controller, then requests to an asynchronous connections layer to release the port by *DisconnectEvent_req()*.

Transition C3b. After a 5-second release timeout, the consumer port transitions to the *C0:FREE* state. The port invalidates the port information.

Transition C3c. A bus reset returns the port to its initial *C0:FREE* state. The port invalidates the port information.

Transition C3d. When a STATUS command with *subfunction* set to STATUS is requested, the port reports the current port information by generating a STABLE response frame.

Transition C3e. Other subfunctions are rejected. The port returns a REJECTED response to the controller with the error code in the *status* field.

State C4:WAIT. In the *WAIT* (post reset) state the port is disabled (asynchronous connection requests are not accepted or generated). The RESTORE_PORT or RESTORE_PORT_FRAME subfunction, which restores the node ID value, is accepted. The intent is to temporarily maintain knowledge of pre-existing connections, so that the re-establishment of the connection can be given precedence over new connection command sequences. The DETACH subfunction is also accepted, to allow the controller to break the connection in case the connected producer node has disappeared after the bus reset.

Transition C4a. When the *suspendflg* is set to FALSE (which means that the port had been in *C2:ACTIVE* state before the bus reset), the valid RESTORE_PORT subfunction transitions the port to the fully connected *C2:ACTIVE* state, setting the connection count to one when this is done. The port stores the connected node ID values to the port information, then sets its connection count value to one (executed in *setupInfo()*). Then the port returns an ACCEPTED response frame to the controller, then requests an asynchronous connections layer to restart by using *RestoreEvent_req()*. Although not illustrated, the *oAPR* register on the connected producer port is also updated to re-activate asynchronous connection communications. Note that the *ex* flag shall be the same value as previously requested before the bus reset, and *dr* shall be zero.

Transition C4b. When the *suspendflg* set to TRUE (this means the port had been *C5:SUSPENDED* state before bus reset), the valid RESTORE_PORT subfunction transitions the port to the fully connected (but suspended) *C5:SUSPENDED* state, setting the connection count to one when this is done. The port stores the connected node ID values to the port information, then sets its connection count value to one. The port returns an ACCEPTED response frame to the controller, and requests an asynchronous connections layer to restart by using *RestoreEvent_req()*. Although not illustrated, the *oAPR* register on the connected producer port is also updated, to re-activate asynchronous connection communications. Note that the *ex* flag shall be the same value as previously requested before the bus reset, and the *dr* bit shall be zero.

Transition C4c. A valid RESTORE_PORT_FRAME subfunction transitions the port to the fully-connected *C2:ACTIVE* state, setting the connection count to one when this is done. The port stores the connected node ID values to the port information. The port returns an INTERIM response frame to the controller and requests an asynchronous connections layer to restart by issuing *RestoreEvent_req()*. Although not illustrated, the *oAPR* register on the connected producer port is also updated, to re-activate asynchronous connection communications. Note that the *ex* and *dr* values shall be the same as previously requested before the bus reset and the *dr* bit shall be one.

Transition C4d. A valid DETACH subfunction addressed to the port handling no overlays (*connection count* == 1) state transitions the port to a half-disconnected *C3:INACTIVE* state. After returning an ACCEPTED response to the controller, the port requests to an asynchronous connections layer to stop requesting the data by *DetachEvent_req()*. Also, the port resets the timer to detect the 5-second timeout for transitions from *C3:INACTIVE* to *C0:FREE*.

Transition C4e. A valid DETACH subfunction decrements the connection count if the *connection count* value was greater than one, leaving the port connected in its *C5:SUSPENDED* state. The node returns an ACCEPTED response frame on success.

Transition C4f. When a STATUS command with *subfunction* set to STATUS is requested, the node reports the current port information by generating a STABLE response frame.

Transition C4g. Other subfunctions are rejected. The node returns a REJECTED response to the controller with the error code in the *status* field.

Transition C4h A bus reset leaves the port in an unchanged state.

Transition C4i. When an asynchronous connections layer indicates *Timeout_ind()* after a 10-second reconnection timeout, the consumer port transitions to the *C0:FREE* state. The port invalidates the port information.

State C5:SUSPENDED. In the *SUSPENDED* state the port is suspended (asynchronous connection is suspended to skip the frame transmissions). Only the RESUME_PORT subfunction, which re-enables the frame transmission, is accepted.

Transition C5a. A valid RESUME_PORT subfunction sets the asynchronous connections layer to resume from the *C5:SUSPENDED* state to *C2:ACTIVE* state. The port returns an ACCEPTED response frame to the controller, then requests that the asynchronous connections layer resume by issuing *ResumeEvent_req()*.

Transition C5b. When STATUS command is requested, the node reports the current port information by generating a STABLE response frame.

Transition C5c. A valid DETACH subfunction addressed to the port handling no overlays (*connection count* == 1) state transitions the port to a half-disconnected *C3:INACTIVE* state. After returning an ACCEPTED response to the controller, the port requests to the asynchronous connections layer to stop requesting the data by issuing *DetachEvent_req()*. Also, the port resets the timer to detect a 5-second timeout for transitions from *C3:INACTIVE* to *C0:FREE*.

Transition C5d. A bus reset transitions the port to the *C4:WAIT* state, in preparation of accepting the expected RESTORE_PORT subfunction (this subfunction restores the node ID of its connected plug). The port sets the flag indicating that the state had been a *C5:SUSPENDED* state, then sets its *connect node ID* value to 0xFFFF (invalid node ID) and *connection count* to zero.

Transition C5e. A valid ADD_OVERLAY subfunction increments the connection count if the *connection count* was less than 63, leaving the port connected in its *C5:SUSPENDED* state. The node returns an ACCEPTED response frame on success.

Transition C5f. A valid DETACH subfunction decrements the connection count if the *connection count* value was bigger than 1, leaving the port connected in its *C5:SUSPENDED* state. The node returns an ACCEPTED response frame on success.

Transition C5g. Other subfunctions are rejected. The node returns a REJECTED response to the controller with the error code in the *status* field.

Transition C5h. When the previously issued attachment subfunction had been ATTACH (*dr* had been set to zero) and there had been an indication from an asynchronous connections layer that shows the connection is broken by a connected node, timeout or other reasons, the port invalidates the port information, then transitions to *C0:FREE* state.

7.3 Producer port states

7.3.1 Producer port state machines

As described in Section 5.6, the producer plug may contain more than one producer port to support the multicast connections.

Since the producer "port" (not the producer "plug") is connected to the consumer, the producer port state transitions may occur independently from other ports within the same plug.

As the connection management commands should specify the *plug ID* value, the received command is passed to its internal plug management components.

When the target receives the ALLOCATE_ATTACH subfunction with "*any available port*", the target searches the available port, selects one then activates that port.

The behavior of a producer port is specified by its state machine definition, illustrated by the Figure 7.3.

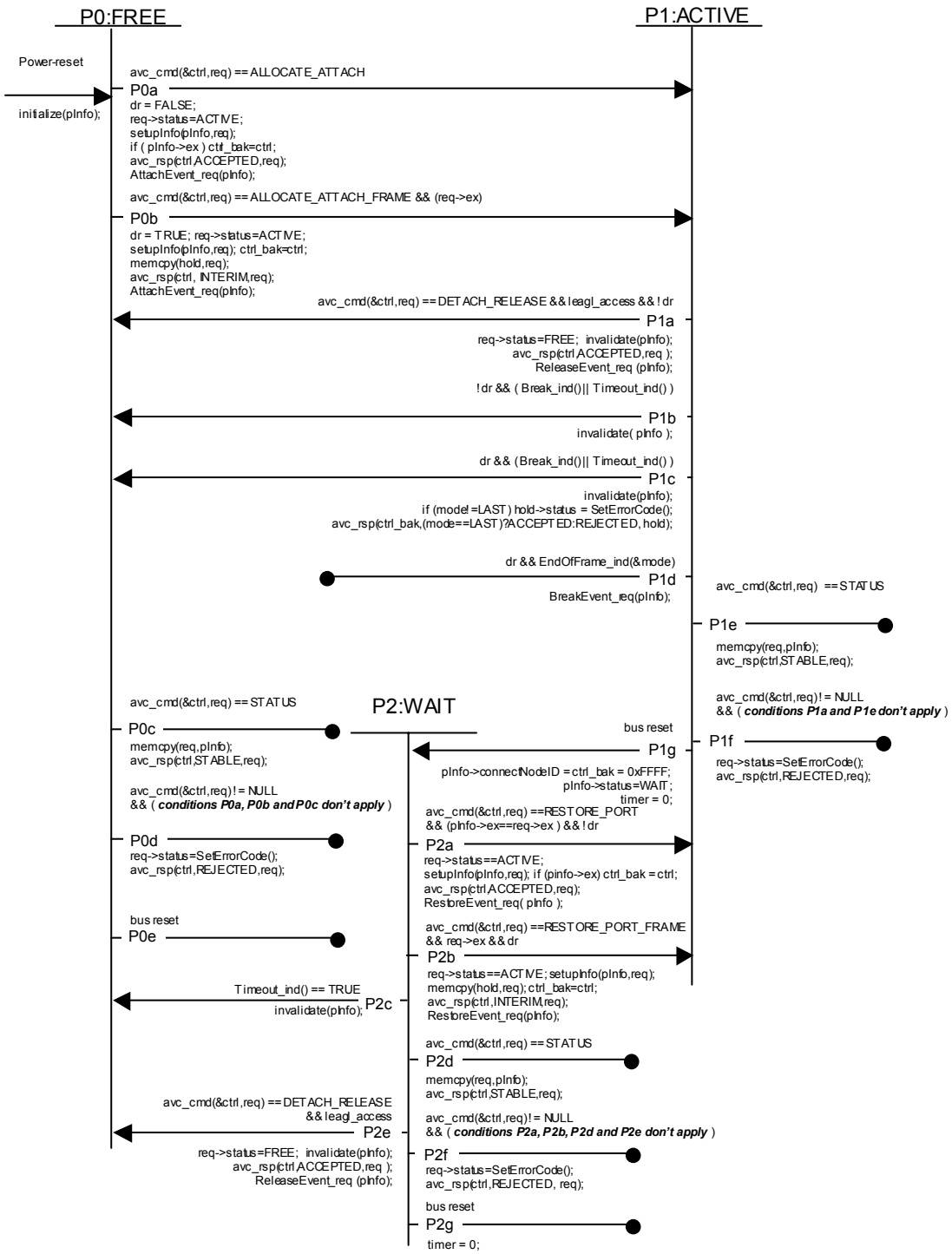


Figure 7.3 – Producer port state machine

7.3.2 Producer port state machine notes

State P0:FREE. The *FREE* state is the initial state of the port, with no committed resources. While in the *P0:FREE* state, the purpose of the ALLOCATE_ATTACH or ALLOCATE_ATTACH_FRAME subfunction is to transition the port to the *P1:ACTIVE* (connected) state. These state transitions are listed below.

Transition P0a. A valid ALLOCATE_ATTACH subfunction transitions the port to be connected in the *P1:ACTIVE* state. The ALLOCATE_ATTACH subfunction command frame includes the connection information such as the consumer port address. If the *ex* bit in a command frame has been set to one, the target stores the node ID of the controller to reject the following control commands from other controllers.

The port returns an ACCEPTED response frame to the controller, then requests to the asynchronous connections layer to start by issuing *AttachEvent_req()*. Although not illustrated, the *oAPR* register on the connected producer port is also updated by the consumer to activate asynchronous connection communications.

Transition P0b. A valid ALLOCATE_ATTACH_FRAME subfunction transitions the port to the connected to be *P1:ACTIVE* state. The ALLOCATE_ATTACH_FRAME subfunction command frame includes the connection information such as consumer port address. The command frame shall include *ex* bit set to one, and the port sets its internal *dr* value to one. The port stores the requested connection information (for the final response), then returns an INTERIM response frame to the controller, then requests to an asynchronous connections layer to start by issuing *AttachEvent_req()*. Although not illustrated, the *oAPR* register on the connected producer port is also updated by the consumer to activate asynchronous connection communications.

Transition P0c. When STATUS command is requested, the node reports the current port information by generating a STABLE response frame.

Transition P0d. All other connection management subfunctions are rejected, generating a REJECTED response frame with the error code in the *status* field.

Transition P0e. Bus resets while in the *C0:FREE* state leave the port in the same state.

State P1:ACTIVE. In the *ACTIVE* state the ports resources have been allocated and connected and the port can accept lock transactions from its connected port. The first thing the connected consumer has to do is to set the *oAPR.run* bit to one. Only after that, the producer port can start sending data by using write transactions.

Transition P1a. While the *dr* is zero, the valid DETACH_RELEASE subfunction transitions the port to an initial *P0:FREE* state. The port invalidates the port information and returns an ACCEPTED response frame to the controller. It then requests that the asynchronous connections layer stop sending the data by issuing *ReleaseEvent_req()*.

Transition P1b. While the *dr* bit is zero, the *Break_ind()* indication (which indicates the unexpected disconnection) or the *Timeout_ind()* indication (which indicates the timeout detection) from the asynchronous connections layer, transitions the port to a initial *P0:FREE* state. The port invalidates the port information.

Transition P1c. While *dr* is one, the *Break_ind()* indication or the *Timeout_ind()* indication from the asynchronous connections layer transitions the port to an initial *P0:FREE* state. The port invalidates the port information. If the *mode* value retrieved from the asynchronous connections layer had been *LAST*, an ACCEPTED response will be used, otherwise a REJECTED response with the error code in the *status* field will be used.

Transition P1d. When the previous issued attachment subfunction had been ALLOCATE_ATTACH_FRAME and *dr* had been set to one and *EndOfFrame_ind(&mode)* (which indicates the end of frame had been indicated by the producer port) was indicated from an asynchronous connections layer (the *mode* value describes the *iAPR.mode* value indicated by the connected producer port), the port requests the asynchronous connections layer to break the connection by issuing *BreakEvent_req()* to start the disconnection sequence described in Figure 5.9.

Transition P1e. When a STATUS command is requested, the port reports the current port information by generating a STABLE response frame.

Transition P1f. All other connection management subfunctions are rejected, generating a REJECTED response frame with an error code in the *status* field.

Transition P1g. A bus reset transitions the port to the *P2:WAIT* state, in preparation of accepting the expected RESTORE_PORT or RESTORE_PORT_FRAME subfunction (these command restores the node ID address of its connected plug). The port sets its *connect node ID* value to 0xFFFF (invalid node ID).

State P2:WAIT. In the *WAIT* (post reset) state the port is disabled (asynchronous connection requests are not accepted or generated). The connection management CONTROL command with *subfunction* set to RESTORE_PORT or RESTORE_PORT_FRAME, which recovers the node ID value of the consumer node, is accepted. The intent is to temporarily maintain knowledge of pre-existing connections, so that the re-establishment of the connection can be given precedence over new connection command sequences. The DETACH subfunction is also accepted, to allow the controller to break the connection in case the connected consumer node has disappeared after the bus reset.

Transition P2a. When the *dr* bit is set to zero, a valid RESTORE_PORT transitions the port to the connected *P1:ACTIVE* state. The port stores the connect node ID values to the port information. The port returns an ACCEPTED response frame to the controller, then requests an asynchronous connections layer to restart by issuing *RestoreEvent_req()*. Although not illustrated, the *oAPR* register on the connected producer port is also generated in order to re-activate asynchronous connection communications. Note that the *ex* flag shall be the same value as previously requested before the bus reset, and the *dr* bit shall be zero.

Transition P2b. When the *dr* bit is set to one, a valid RESTORE_PORT_FRAME subfunction transitions the port to the connected *P1:ACTIVE* state. The port stores the connected node ID values to the port information. The port returns an AV/C INTERIM response frame to the controller, then requests an asynchronous connections layer to restart by issuing *RestoreEvent_req()*. Although not illustrated, the *oAPR* register on the connected producer port is also updated, to re-activate asynchronous connection communications. Note that the *ex* and *dr* flags shall be the same value as previously requested before the bus reset and the *dr* bit shall be set to one.

Transition P2c. When an asynchronous connections layer indicates *Timeout_ind()* after a 10-second reconnection timeout, the producer port transitions to the *C0:FREE* state. The port invalidates the port information.

Transition P2d. When a STATUS command with *subfunction* set to STATUS is requested, the port reports the current port information by generating a STABLE response frame.

Transition P2e. A valid DETACH_RELEASE subfunction transitions the port to an initial *P0:FREE* state. The port invalidates the port information and returns an ACCEPTED response frame to the controller, then requests that the asynchronous connections layer stop sending data by issuing *ReleaseEvent_req()*.

Transition P2f. Other subfunctions are rejected. The node returns an AV/C REJECTED response to the controller with the error code in the *status* field.

Transition P2g. A bus reset leaves the port in an unchanged state.

Annexes

Annex A: Bibliography (informative)

A.1 Bibliography

The following document(s) provide useful informative information for the reader:

[B1] ANSI X3.159-1989, Programming Language—C.

