Part III Transmission Media And Lower-Layer Communication Software Specification

Release information (as of August 7th 2001)

a) Version1.0	March 18th	2000 released	Open to the consortium member
	July	2000	Open to the public
b) Version1.01	May 23rd	2001	Open to the public
c) Version2.00	August 7th	2001	Open to the consortium member

Notes: On and after Version2.00, Powerline communication protocol has drawn together as Powerline communication A.

Contents

Chapter 1 Overview of Lower-layer Communication Software and Transmission Media Communication Protocol Specification

1.1 Positioning of Communication Layers

The following figure shows the positioning of transmission media in this Standard.

5 types of transmission media are supposed which are shown in the lowest layer (power line, low-power wireless, extended HBS, infrared IrDA, and LON).

Connections to communication middleware (A to E in the following figure) are specified in Part 6 Discrete Lower-Layer Communication Interfaces.

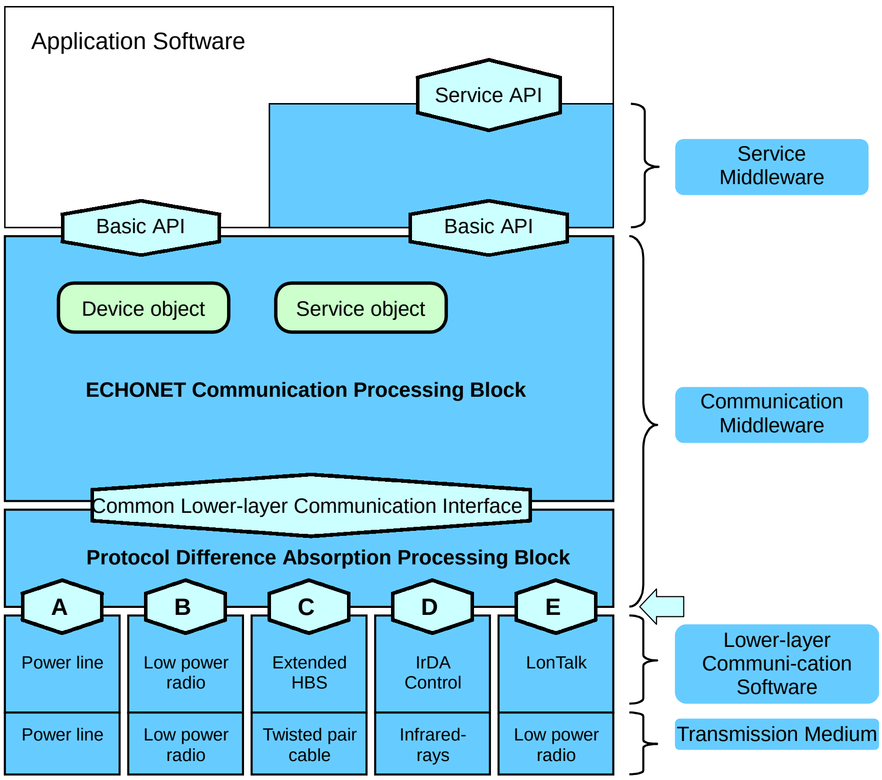


Figure ECHONET Architecture

1.2 Overview of Lower-layer Communication Software

ECHONET specifies the following five types of Lower-layer Communication Software. Details are described in Chapter 2 and after.

① Power line communication software

Lower-layer Communication Software for which the transmission medium is existing indoor power lines. Must conform to Radio Law regulations. Specifications are provided for two types: type-A (direct spectrum spread) and type-B (multiple carriers).

② Low-power radio communication software

Lower-layer Communication Software for which the transmission medium is low-power radio. Must conform to ARIB Standard STD-16 and STD-30.

③ IrDA communication software

Lower-layer Communication Software for which the transmission medium is infrared rays. Must conform to IrDA CIR Standard (IrDA Control). 8m communication distance, 75kbps transmission speed, and 13.8msec response speed are required. 1:N (max 8) communication must be adaptable.

④ LonTalk communication software

Lower-layer Communication Software for which the transmission medium is low-power radio. Must conform to LonTalk protocol. As protocol processing is independent of transmission media, this type of software is applicable to various types of media, and its future expansion to other media will be discussed.

⑤ Extended HBS communication software

Lower-layer Communication Software for which the transmission medium is twisted pair cable through expanding EIAJ ET-2101 (HBS). Transmission distance (extended to 1km max), a single medium couple, and detection of duplicate address, etc. are different.

Relationships between software and supported transmission media are shown below.

Transmission medium	Power line	Low-power radio	Infrared	Twisted pair cable
Power line	○	–	–	–
Low-power radio	–	○	–	–
IrDA	–	–	○	–
LonTalk	–	○	–	–
Extended HBS	–	–	–	○

The following functions are essential for lower-layer Communication Software:

- Guarantee of unique self-MAC address within subnet
- Function as ECHONET data container
- Communication guarantee within subnet
- Function to store self-profile and to notify communication middleware.

  MAC address length

  MAC address mask pattern

  In case of NULL, prepared rule are applied.

  MAC address

  Maximum data length

  Lower-layer communications software identification ID

  Transmission medium identification ID

  Broadcast function identification ID

  Transmission rate
- Function to store self-status and to notify to communication middleware.

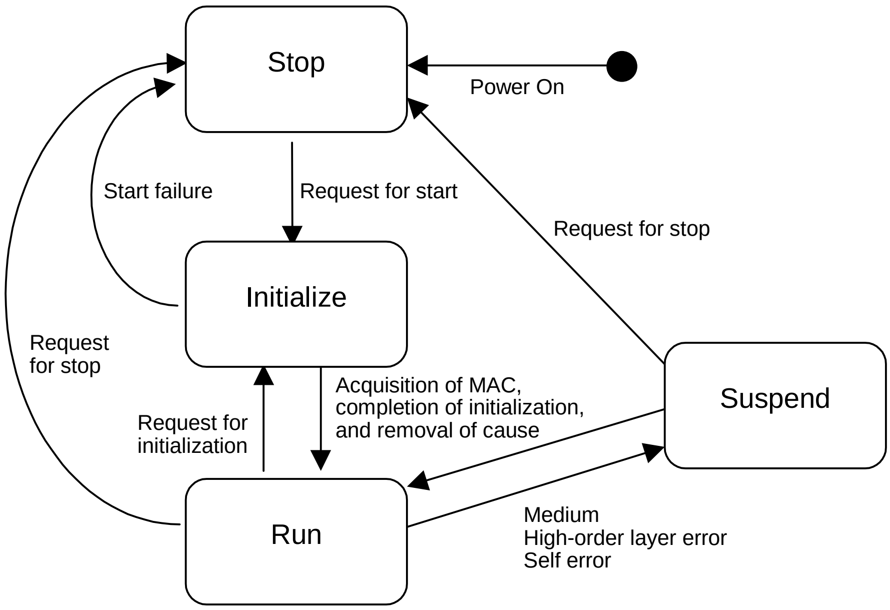
  The following four statuses shall be mandatory:

  Stop

  Initialize

  Run

  Suspend



1.3 Overview of New Transmission Media

The types and characteristics of transmission media to be supported by ECHONET are shown below.

① Power line

Power lines already laid indoors are used as a transmission medium. As existing power lines are used to transmit signals, special new cables are not needed. Reduced installation burden is a key advantage.

ECHONET supports two methods: “power line A” (direct spectrum spread) and “power line B” (multiple carriers).

Object: Dwellings, small and medium-sized buildings, stores, etc.

(100V/200V lines of single-phase 2-wire 100V, or single-phase 3-wire 100V/200V)

- Use: Applications to which power line communication protocol is applied
  efficient use of energy (EMS), centralized monitoring and controlling of equipment, maintenance, etc.

② Low-power radio

Ease of installation and no need for rewiring makes this medium effective for both new and existing buildings. Battery power supply permits use for devices installed in places without AC power supply, and for portable devices.

Characteristics of low-power radio transmission are follows.

(1) Transmission distance of several to several tens of meters is attained with maximum output 10mW.
(2) Through wall communication is possible (room to room, room to outdoors).
(3) Radio frequency are restricted by law.
(4) Japanese law does not require radio license for device user.

This Standard provides intermittent receiving function, which reduces power consumption in receive-waiting status and enables long-time operation with battery power supply.

③ Infrared-rays

- No wiring operation is required
- Efficient for use with portable devices
- No leakage to outside of building (high security)

④ Twisted pair cable

- High reliability
- High security

1.4 Relations to Other Standards

① Power line

This Standard conforms to Enforcement Regulations of the Radio Law. These regulations can be obtained from the Association for the Promotion of Telecommunications (Voice (+81)-3-3940-3951, Fax (+81)-3-3940-4055).

② Low-power radio

This Standard conforms to the ARIB Standard including the following contents.

- Laws

  (Radio Law, Telecommunications Business Law)
- Ministerial ordinances

  (provided by the Ministry of Posts and Telecommunications on the basis of the following laws: Enforcement Regulations of the Radio Law, Rules of Radio Equipment, Rules related to Technical Standard Conformance Certification, Enforcement Regulations of the Telecommunications Business Law, Rules of Terminal Equipment, Rules related to Technical Standard Conformance Authorization)

- Notification of the Ministry of Posts and Telecommunications
  (on the basis of laws and ministerial ordinances)

The ARIB Standard can be obtained from the Association of Radio Industries and Businesses (Voice(+81)-3-5510-8590, Fax(+81)-3-3592-1103, http://www.arib.or.jp/).

④ Infrared ray

This Standard conforms to the IrDA Control standard provided by IrDA (Infrared Data Association). IrDA Control can be obtained from their home page (http://www.irda.org/).

⑤ LonTalk

LonTalk protocol is applied to layers 1 to 3 of transmission media communication protocol.

ARIB RCR STD-16 of specific low-power radio is applied as transmission medium.

Chapter 2 PLC-A System Communication Protocol Specification

2.1 System Overview

This system is a high-reliability data transmission system based on direct spread spectrum, has a high degree of freedom of receiving system, and can cope with deterioration (distortion, noise) of transmission line characteristics.

2.1.1 Scope of the Standard

The standard for the PLC-A system consists of mechanical/physical specifications, electrical specifications, and logical specifications of layer 1 and logical specifications of layers 2 and 3. The mechanical/physical specifications specify connectors and intended power lines. The electrical specifications specify the modulator/demodulator unit. The logical specifications of layers 1 to 3 specify processing for each layer and signal interfaces between layers.

The electrical interface specifications between the electrical specifications (modulator/demodulator unit) and logical specifications are not specified.

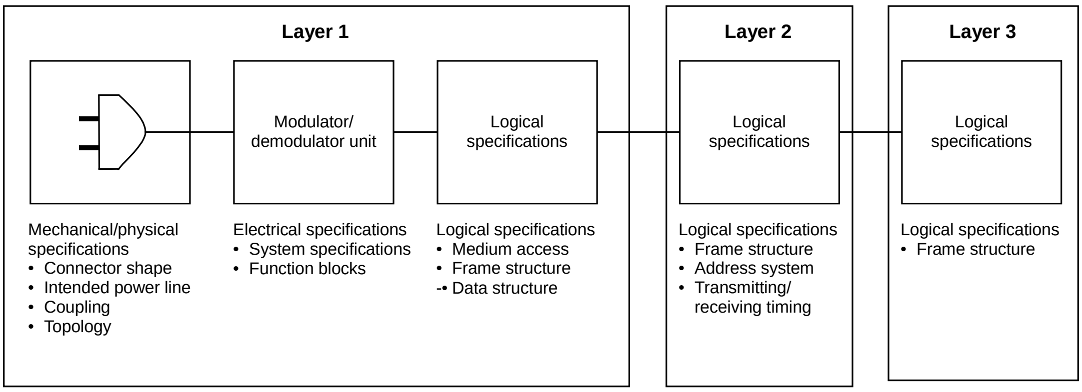


Fig. 2.1 Scope of the Standard

2.2 Mechanical/Physical Specifications

2.2.1 Connector shape

AC plug, plug socket, direct connection

2.2.2 Intended power line

The electric system of the intended power line shall be single-phase 2-wire or single-phase 3-wire, 100 V or 200 V.

However, for the 3-wire type, a means for transmitting signals between phases shall be required.

* A measure for the 3-phase 3-wire 200 V power cable shall be discussed in the future as required.

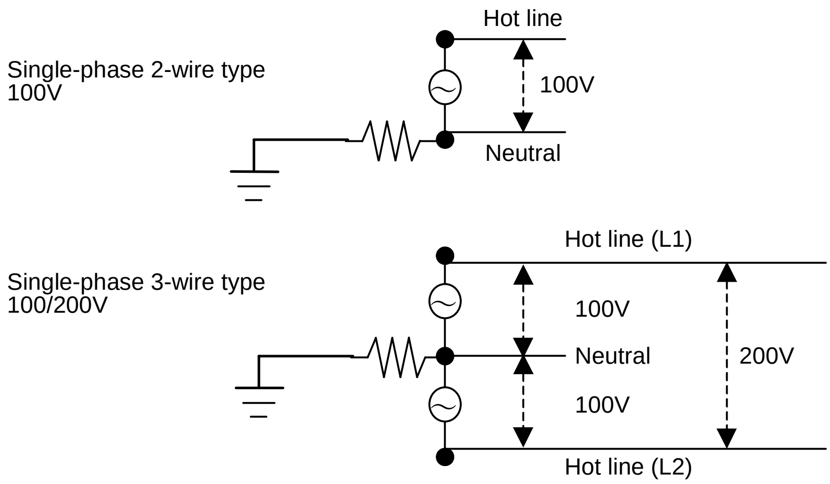


Fig. 2.2 Electric System

2.2.3 Medium Specifications

(1) Coupling system

A line coupling system for injecting signals between L1 and the neutral wire, between L2 and the neutral wire or between L1 and L2 shall be adopted.

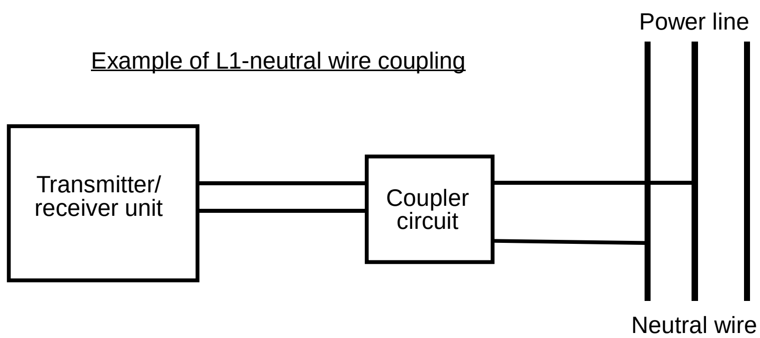


Fig. 2.3 Coupling System

2.2.4 Topology

Regarding the topology for working with the power line laying form of dwellings, medium/small buildings and stores, no special restrictions shall be specified.

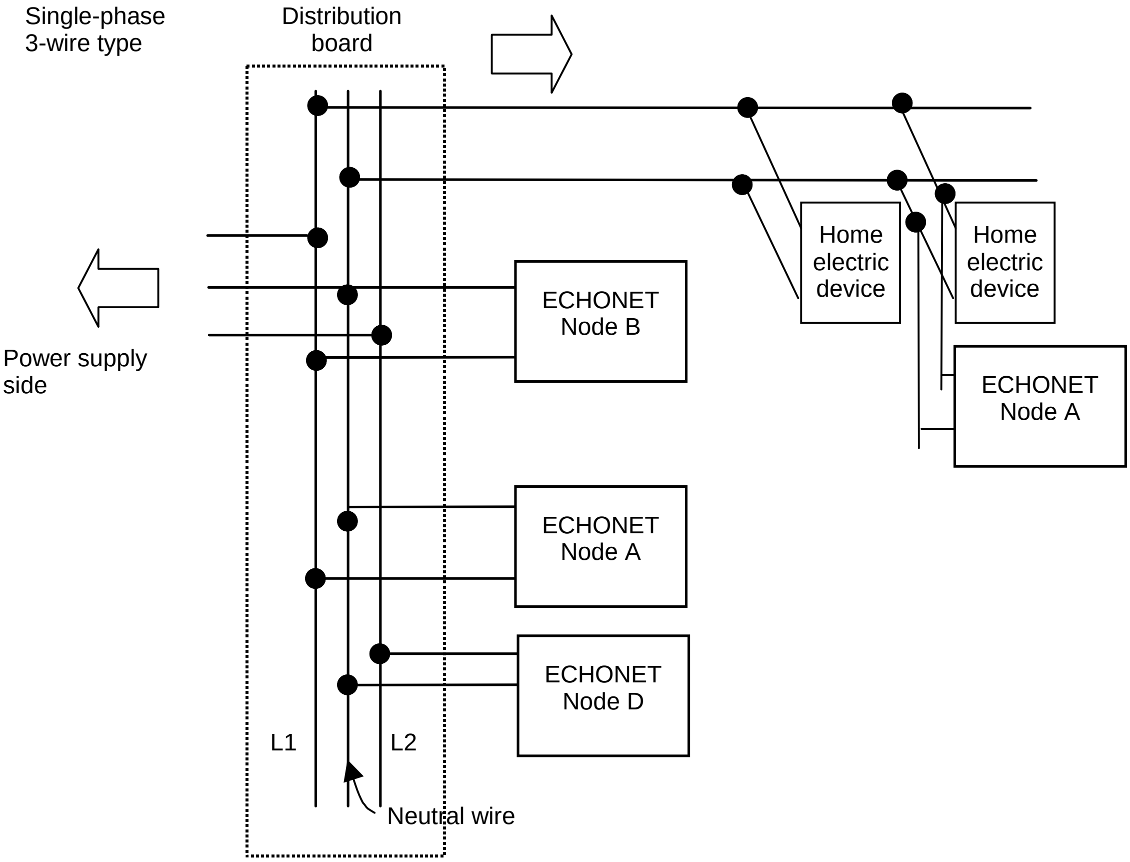


Fig. 2.4 Power Line Topology

2.3 Electrical Specifications

The power line carrier system of this Standard shall conform to Enforcement Regulations of the Radio Law, Article 46, 2-5 “Conditions of Special Carrier System Digital Data Transmitter using the Spread Spectrum Carrier Wave Modulation Type”.

2.3.1 System Specifications

(1) Spread Spectrum system
Direct spread spectrum (No spread code is specified.)

(2) Primary modulation system
Differential coding
However, if there is no difference between input data and the data of precedent to one bit when they are compared, “no change”, namely, “1 → 1” or “0 → 0”, shall be made. If there is a difference, “change”, namely, “1 → 0” or “0 → 1” shall be made.

(3) Transmission rate
9600 bps

(4) Carrier sense sensitivity
Input power 0.1 mW or less

(5) Transmitting power
10 mW/10 kHz or less (Maximum value is 120% or less of rated value.)

(6) Spread frequency range
10 kHz to 450 kHz

(7) Spurious signal intensity at output terminal
450 kHz-5 MHz (inclusive): 56 dBμV or less
5 MHz-30 MHz (inclusive): 60 dBμV or less

(8) Leakage electric field (at a distance of 30 m from the transmitter)
(A) Frequency in spread range: 100μV/m
(B) 526.5kHz to 1606.5kHz: 30μV/m
(C) Frequency other than A and B: 100μV/m

(9) Receiver sensitivity
Input power 0.1 mW or less

Supplement 1: Example of Modulator/Demodulator Unit Configuration

The power line is not designed to transmit high-frequency signals for communication for its primary use and has noise, attenuation, and impedance variation due to home electric devices.

The characteristics of the power line as a transmission line differ remarkably depending on the place of application. For this reason, free selection of a modulation/demodulation system shall be allowed without specifying a specific demodulation system. From the viewpoint of connectivity, different demodulation systems are acceptable.

Supplement 1.1 Example of Modulator Unit Configuration

One example of a modulator unit is shown in Fig. 2.5. The modulator unit consists of a data differential coder, spread code generator and multiplier block for multiplying differential coded data by a spread code.

Any optional spread code may be freely selected and shall not be specified.

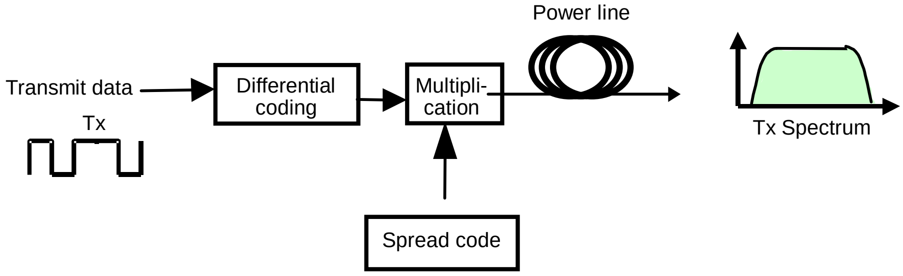


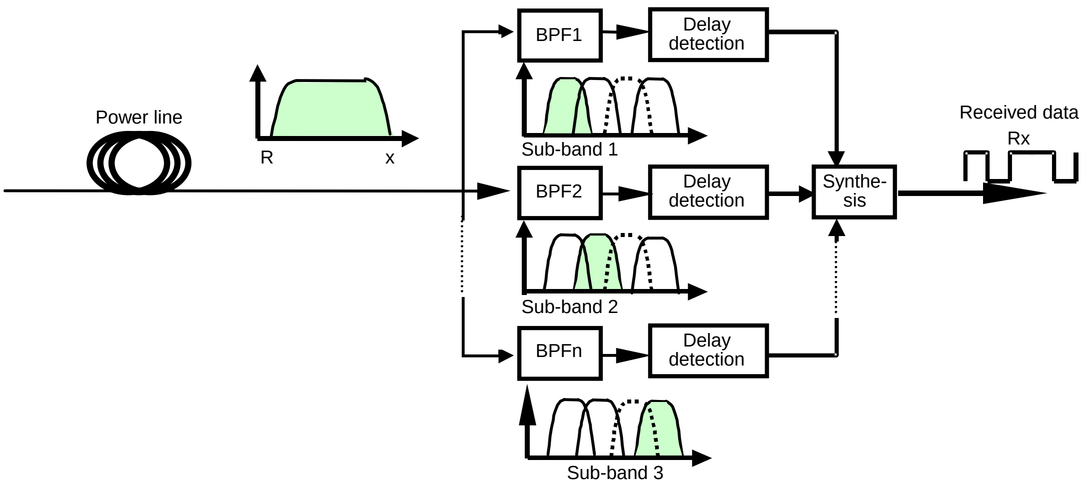
Fig. 2.5 Example of Modulator Unit (Direct Spread Spectrum) Configuration

Supplement 1.2 Example of Demodulator Unit Configuration

An example of a demodulator unit is shown in Fig. 2.6 Sub-band Delay Detection System.

This system uses the frequency diversity effect to obtain excellent receiving characteristics even in places with poor transmission characteristics.

As shown in Fig. 2.6, a received spectrum spread signal is frequency-divided using BPF 1 to n. The sub-band width and number of sub-bands are optional.



2.4 Logical Specifications

2.4.1 Layer 1

(1) Transmission control system

CSMA system

(2) Carrier sense

Carrier sense is available. An alternative is allowed.

(3) Pause period

Pause period of normal frame: 40 ms or more

Pause period of response signal or auto re-transmission time:

(4) Error correction

Option

(5) Layer 1 frame structure

Preamble	Synchronization code	Frame type	House code	Layer 1 payload	FEC code

(A) Preamble: Symbol synchronization code

For synchronization between the receiving timing of the receiver and the transmission timing of the transmitter, a preamble is used.

(B) Synchronization code: Frame synchronization code

The synchronization code is inserted between the preamble and the frame type field to indicate the beginning of data. The synchronization code shall be a fixed value. Before transmission, the synchronization code is modulated by the bit modulation system specified by the signal system and then transmitted.

(C) Frame type: Frame length/type definition code

This code specifies SHORT, MIDDLE, LONG, or ANSWER FRAME.

SHORT FRAME

Preamble 8 bytes	Synchronization code 2 bytes	Frame type 1 byte	House code 8 bytes	Layer 1 payload 40 bytes	FEC code

MIDDLE FRAME

Preamble 8 bytes	Synchronization code 2 bytes	Frame type 1 byte	House code 8 bytes	Layer 1 payload 54 bytes	FEC code

LONG FRAME

Preamble 8 bytes	Synchronization code 2 bytes	Frame type 1 byte	House code 8 bytes	Layer 1 payload 96 bytes	FEC code

ANSWER FRAME

Preamble 8 bytes	Synchronization code 2 bytes	Frame type 1 byte	House code 8 bytes	Layer 1 payload 16 bytes	FEC code

(D) House code: ID for house identification

1	2	3	4	5	6		8
Manufacturer code			identification code				

1. Manufacturer code
   – The 3 high-order bytes of the house code shall be a manufacturer code.
2. Identification code
   – The 5 low-order bytes of the house code shall be a discrete identification code.
   – The company that owns the "Manufacturer codes" shall be responsible for managing identification codes.
   – Unique numbers such as serial numbers shall be assigned.

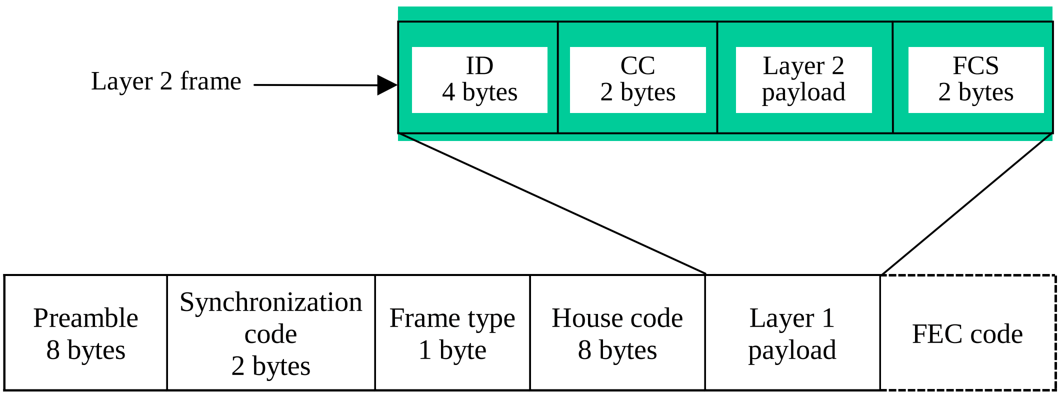
(E) Layer 1 payload: For data contents, see Section 2.4.2 (1) Layer 2 Frame Structure.

(F) FEC code: Redundant part for error correction processing

2.4.2 Layer 2

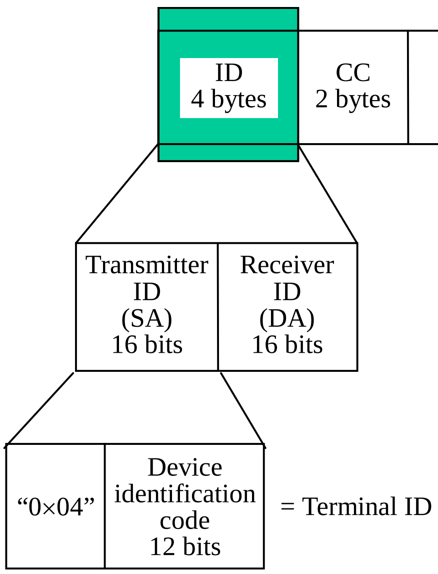
(1) Layer 2 frame structure

The layer 2 frame structure is as follows:



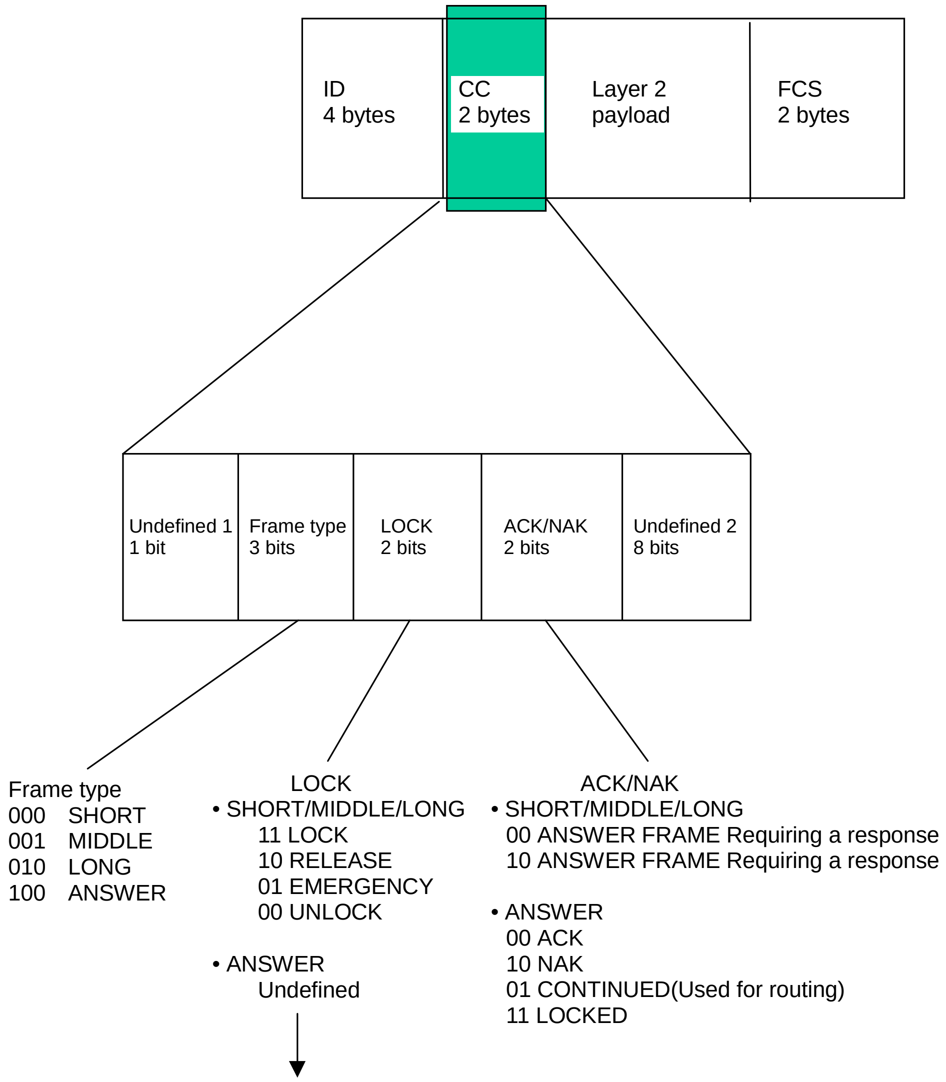
(A) ID:

This consists of a transmitter terminal ID (physical address) and a receiver terminal ID (physical address).



LSB first (conforming to HBS)
The data length is provisional.
For FCS, ID to layer 2 payload are calculated.

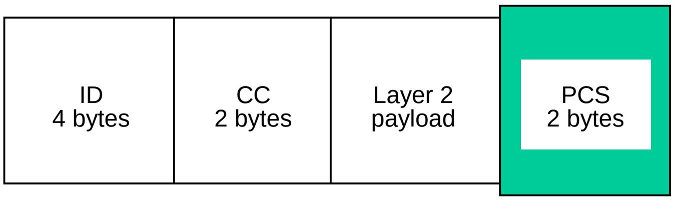
(B) CC: Control code



Regarding LOCK, LOCK is sent at the beginning of a sequencial transmission and RELEASE is sent at the end of it. The receiver side shall cause RELEASE automatically in 2 seconds after receipt of LOCK.
When LOCK is unused, specify UNLOCK.

(C) Layer 2 payload: For data contents, see Section 2.4.3 (1) Layer 3 frame structure.

(D) FCS: Frame inspection sequence



FCS determination formula

Generating polynomial G (x) = $X^{16} + X^{12} + X^{5} + 1$ (CRC-CCITT recommendations)

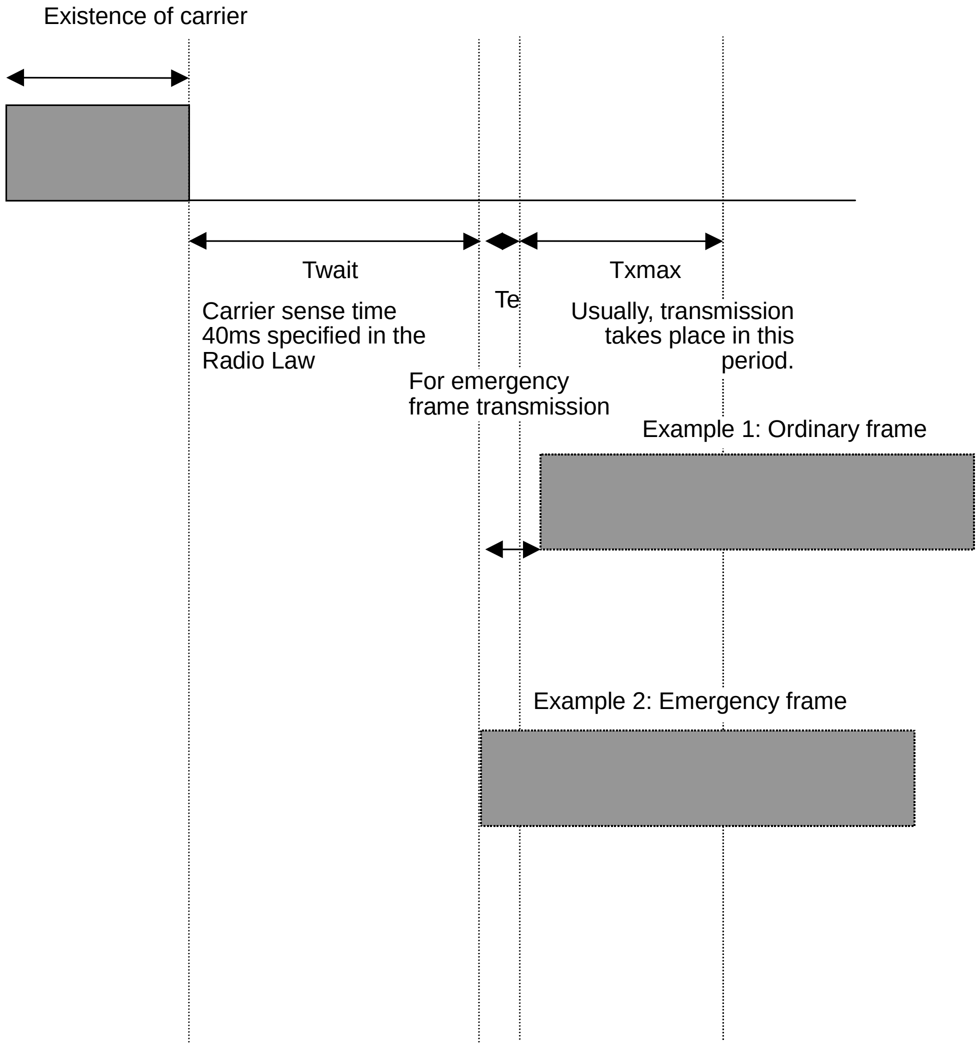
(2) Layer 2 address system

No.	Object	MAC address (HEX)	
1	Plug and play manager address	40	00
2	Discrete address	40	01 to EF
3	Broadcast address	40	F0
4	For future reserve	40	F1 to FE
5	Reserved for P&P	40	FF

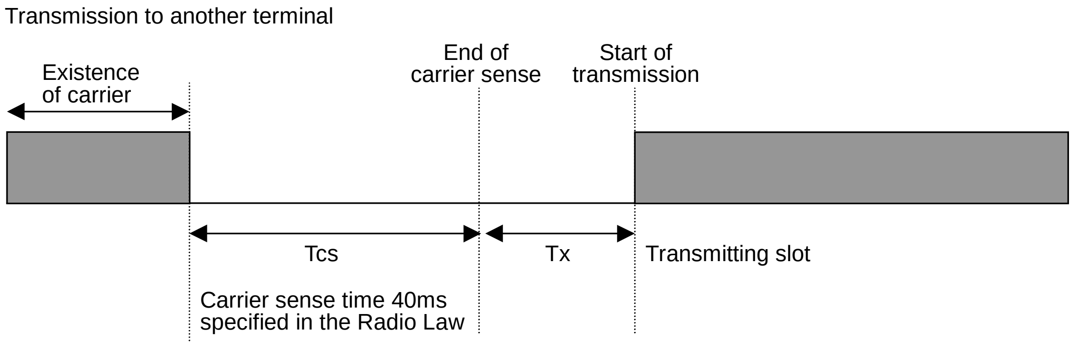
In this case, the 8 high-order bits of the terminal ID shall be fixed at 0x40 for now. (In future, this will be extended.) The 8 low-order bits shall be a Node ID comprising an ECHONET address.

(3) Transmission timing

Transmitting timing

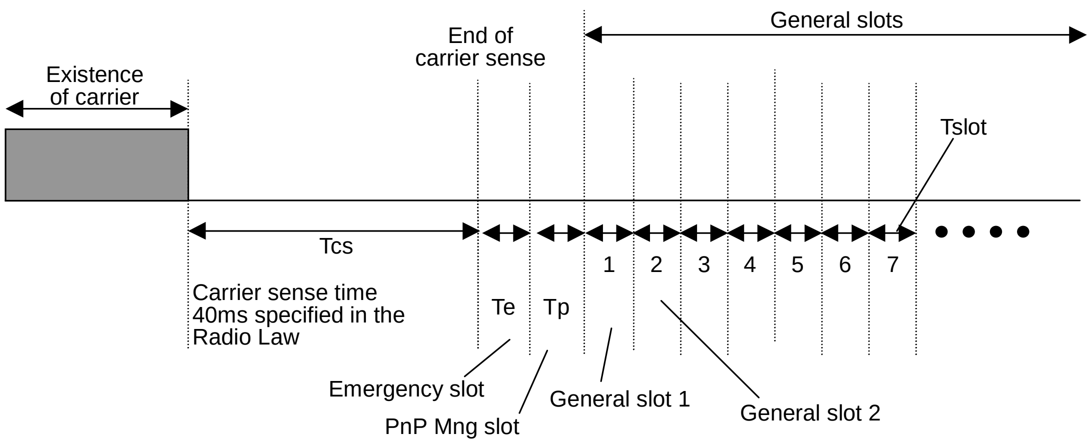


1. At the transmission timing on the power line, carrier sense of Tcs = 40 ms is performed in accordance with the Enforcement Regulations of the Radio Law. After completion of carrier sense, a TX slot waiting time is taken and then the corresponding transmission slot is transmitted. For this reason, transmission is started in Tcs + Tx ms after no carrier is available on the power line.



2. Transmission slot

   As transmission slots, there exist a) 1 emergency slot, b) 1 PnP Mng slot, and c) 256 general terminal slots. These slots are specified by the following timing:



It is desirable that the resolution of carrier sense should be 100 μsec or less.

3. General terminals determine the slots to be transmitted by the magic number Nmagic. Nmagic is generated from terminal native data and terminal independent data, with the following conditions:
   a) A different value should be generated for each transmission.
   b) Even the same types of terminals should be able to output different values.
4. When different terminals attempt to use the same slot at the same time, a collision will occur. When terminals are not provided with collision detecting capability, two types of transmission shall be performed. When an error occurs on the receiving side, the error processing procedure on the receiving side shall be observed.

Transmission timing

Transmission timing on the power line is shown in Fig. 2.7.

When the transmitting side transmits one of the SHORT, MIDDLE or LONG frames, the receiving side receives it. If the received frame satisfies the standard conditions of layer 1 and layer 2 and the receiver ID (DA) matches the MAC address of the receiving side, the receiving side shall send back an ANSWER FRAME within the timeout period, Tout. The timeout period, Tout, shall be 15 to 35 ms.

If the above conditions are not satisfied on the receiving side as shown in Fig. 2.8, the receiver shall not send back an ANSWER FRAME. The transmitting side shall resend the frame after Tout elapses. This resend processing shall be attempted twice. If there is still no response, transmission shall be stopped.

As an exception to transmission timing, during simultaneous broadcast communication or during communication to a provisional address terminal, even if the received frame satisfies the standard conditions of layer 1 and layer 2, the receiving side need not send back an ANSWER FRAME.

Transmission timing

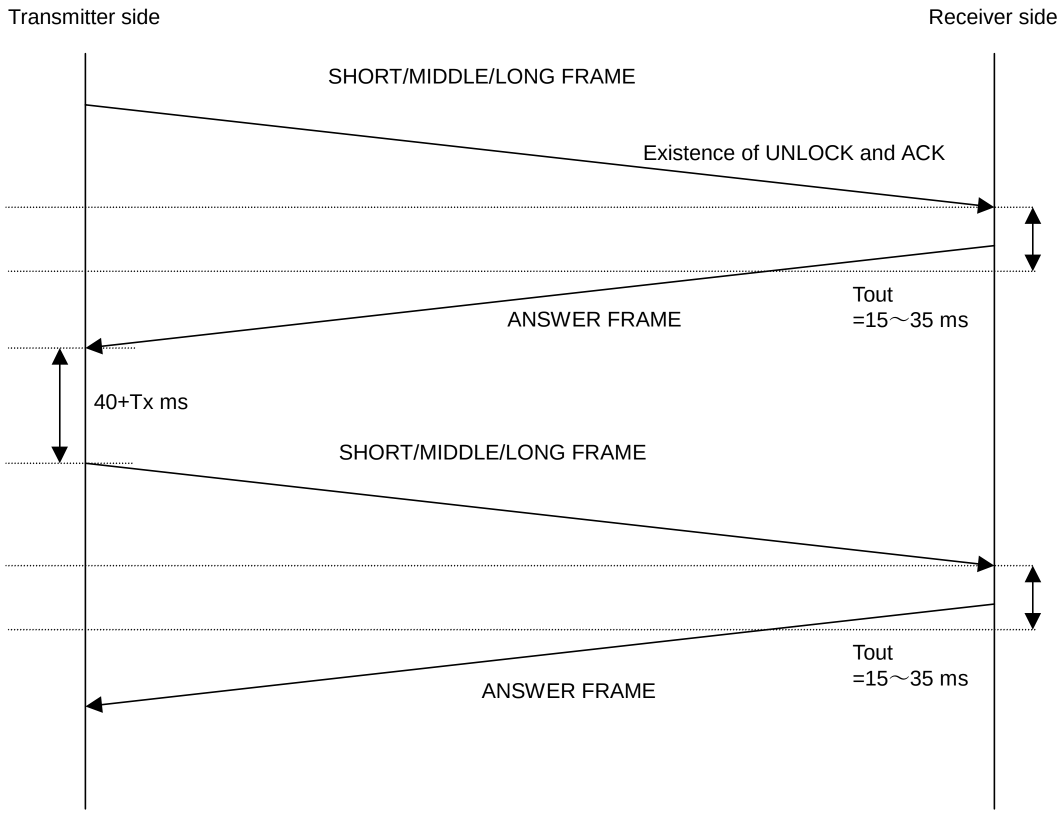


Fig. 2.7 Transmission timing

Transmission timing (Resend)

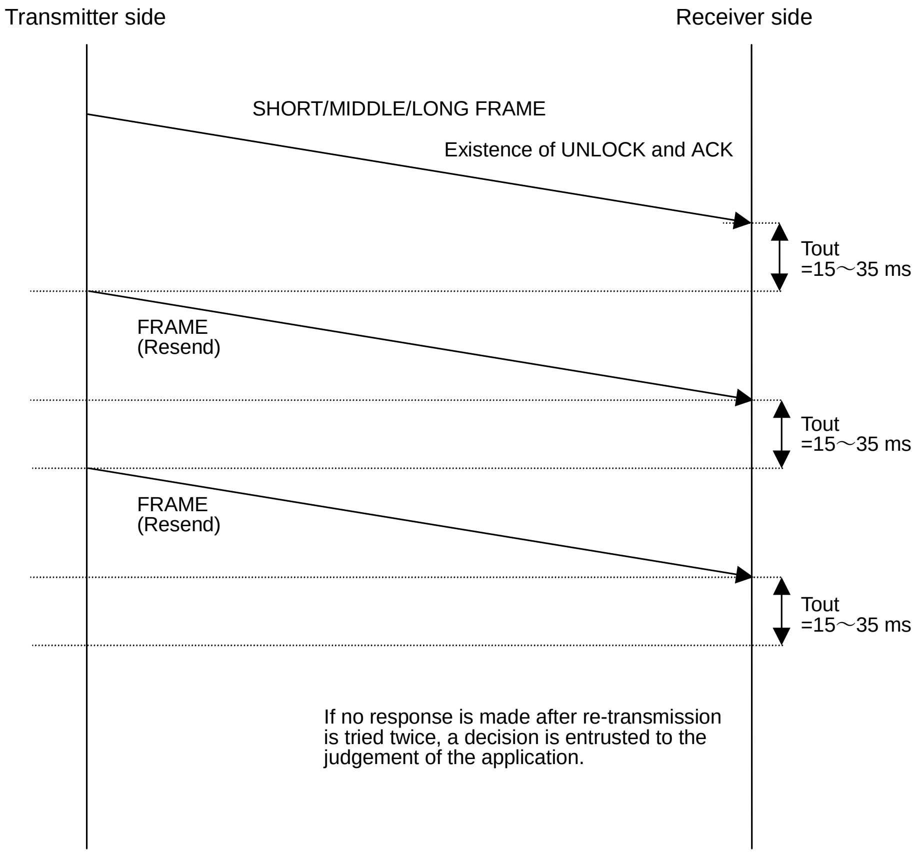


Fig. 2.8 Transmission timing (Resend)

Transmission timing (Communication to simultaneous broadcast and provisional address terminals)

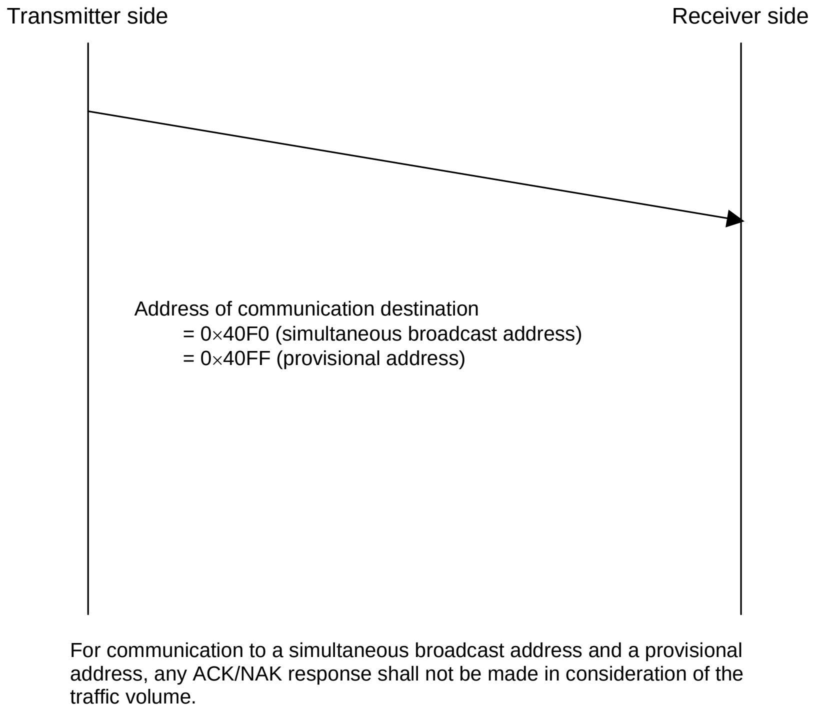


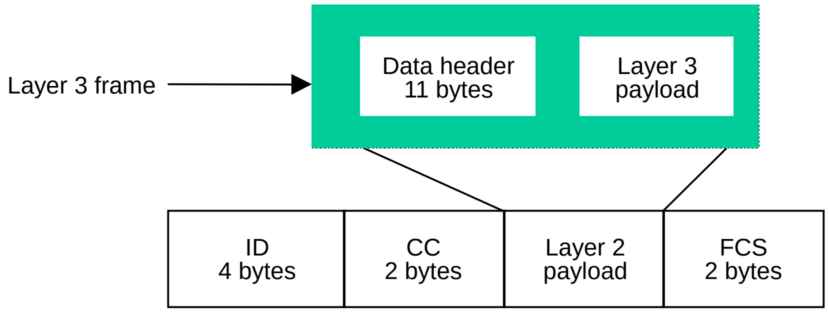
Fig. 2.9 Transmission timing (Communication to simultaneous broadcast and provisional address terminals)

2.4.3 Layer 3

The data header (consisting of a routing setting code, block No., valid byte counter (BC), and command selection switch) shall set routing, identify frames at transmission/reception of a series of frames uniquely, specify the number of valid bytes of layer 3 payload, and distinguish from other local commands the ECHONET commands within the layer 3 payload.

(1) Layer 3 frame structure

The layer 3 frame structure is as follows:

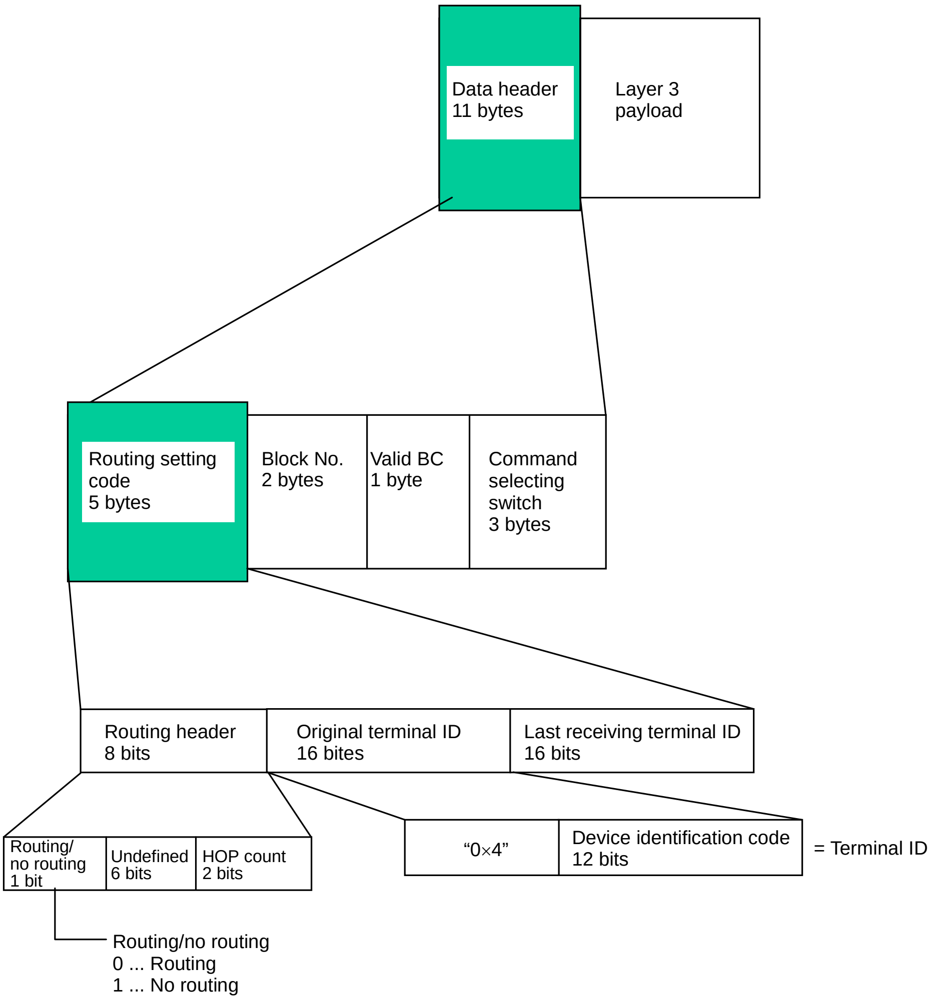


ANSWER FRAME consists only of a data header.

(A) Data header:

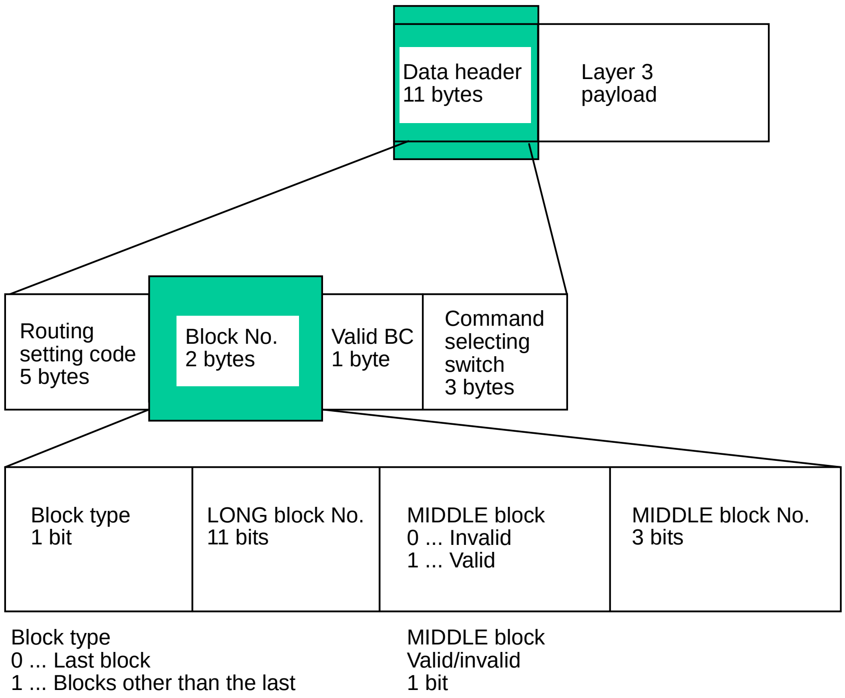
The data header consists of a routing setting code, block No., valid byte counter (BC), and command selection switch.

- Routing setting code



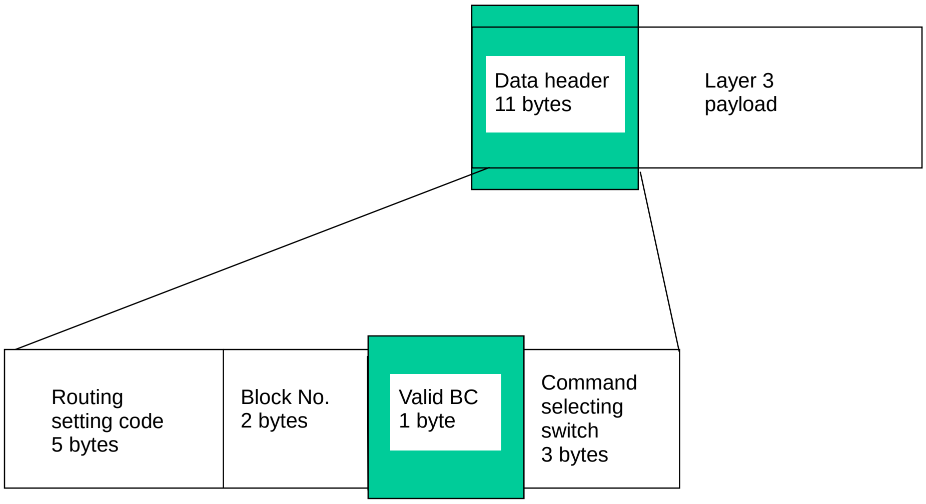
- Block No.

  The block No. identifies frames uniquely at transmission/reception of a series of frames.



- Valid byte counter

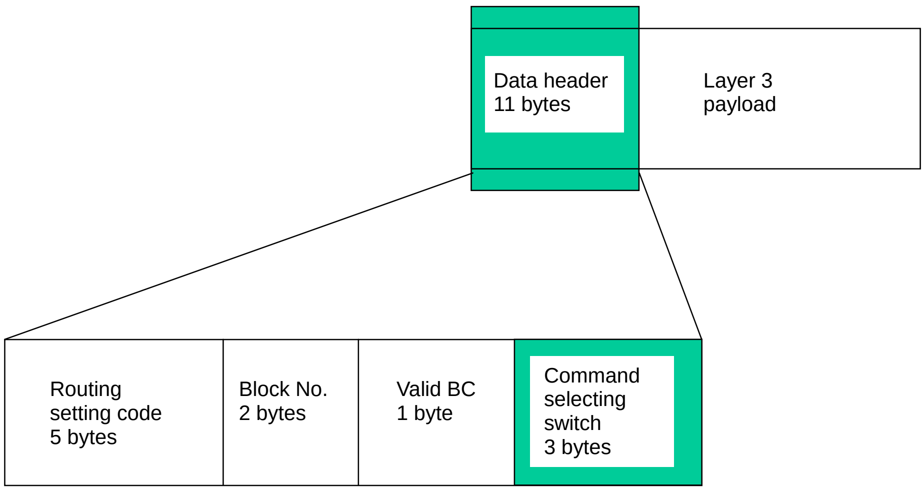
  This counter indicates the number of valid bytes of layer 3 payload.



- Command selection switch

  The command selection switch distinguishes ECHONET commands in the layer 3 payload from other local commands.

  (See Supplement 2.1 Original Command Set of Power Line Communication Protocol A System.)



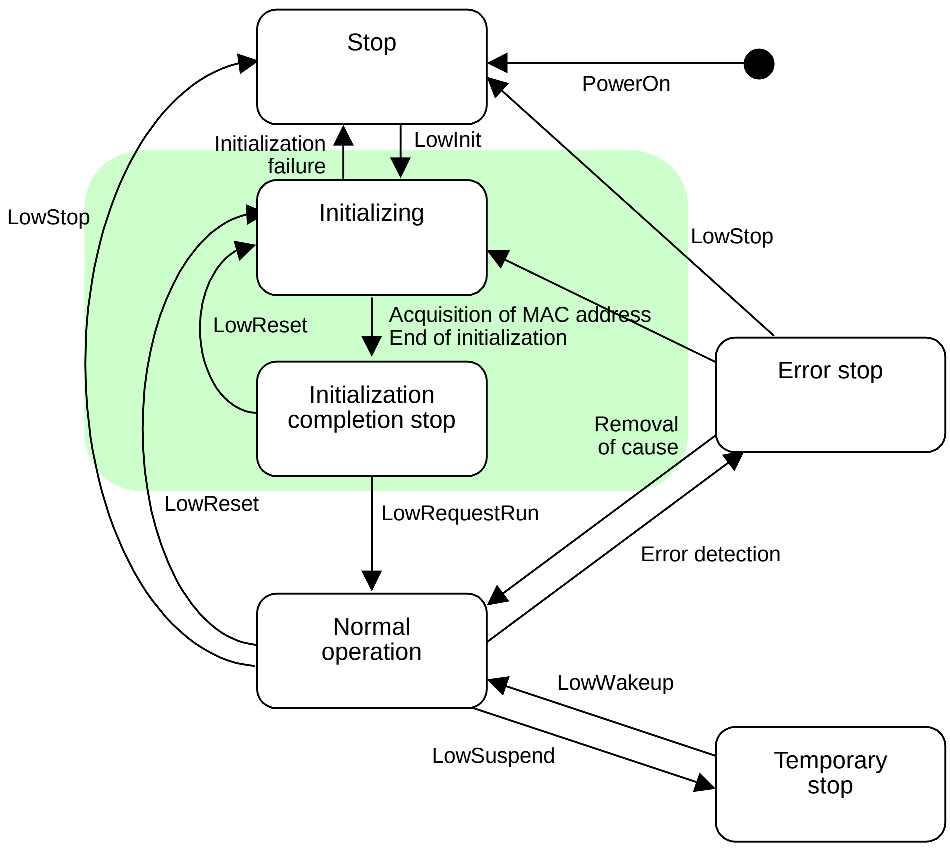
2.5 Basic Sequence

2.5.1 Basic concept

This subsection classifies the Individual lower-layer communications software status as shown below, and describes an outline of the sequence in each status.

① Stop status
② Initialize processing status
③ Normal operation status
④ Error stop status

The following figure shows the state transition diagram of each status.



2.5.2 Stop status

The stop status signifies a status where no lower-layer communications software operations are performed. This status is provided immediately after Power On. An outline of processing immediately after state transition and an outline of the discrete Lower-Layer communication interface services that the stop status receives, and its processing, are described below.

(1) Trigger and action

Waits for a Individual Lower-layer Communication Interface service.

For initializing the transceiver, reset processing is performed immediately after Power On.

(2) Status acquisition service (LowGetStatus)

Returns LOW_STS_STOP as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)

Sends back the stop status as status.

The following is a trigger to perform state transition.

(1) Transition trigger to the initialize processing status

Transition is caused by an initialization service (LowInit).

2.5.3 Initialize processing status

The initialize processing status signifies that the lower-layer communications software is initialized.

An outline of processing immediately after state transition and an outline of Individual Lower-layer Communication Interface services that the initialize processing status receives and its processing are described below.

(1) Trigger and action

① Obtains a unique MAC address in the SUBNET

The MAC address of the ECHONET node newly connected to the power line domain is given by the one plug-and-play manager (P&PMng) on the domain of the power line communication protocol A system using the Register_ID function of the lower-layer communications software, which will be described later. Here, the Register_ID function is executed by an original local command of the PLC-A system protocol that is distinguished from the ECHONET command by the command selection switch. (See Supplement 2.1 Original Command Set of PLC-A system protocol.)

Register_ID Procedure

1. When the P&PMng is installed in its own domain, a correct house code is manually or automatically set beforehand by the installer.The P&P Mng shall holds the maximum number of nodes and the MAC addresses for the nodes.The MAC address of the P&PMng is the plug-and-play manager address (0×4000).

2. After a house code is correctly set, the P&PMng performs a simultaneous broadcast of its own house code periodically. This is called announce address 0.

3. The ECHONET node newly set in the power line domain (set at a provisional address) receives announce address 0 for 2T0 or more. This operation is called “ OVERHEAR”. The ECHONET node is already factory-set at the provisional address (0×40FF), which is a tentative address allowing the self-node to be identified tentatively. This house code is a “NONE” code.

4. Result of overhear

   In the following case only:

   1) Only one house code has been received, and yet
   2) The self-address is a provisional address.

      The ECHONET code gets the received house code and sets it as its own house code and also makes an application for a formal address (Request_ID) for the P&PMng, together with terminal attributes (maker name of ECHONET node, terminal type, etc.).

   In the following cases:

   3) Fails to receive a house code.
   4) Receives multiple house codes.

      They are abnormal states. The ECHONET node performs error procedure. The contents of this error processing are not specified in this Standard.

   5) A formal address is already set.

      In this case, Register_ID is not required, so no operation is performed.

5. The P&PMng that has received an application for a formal address gives a proper MAC address (0×4001 to 0×40FF) from the MAC addresses prepared for itself.

This Register-ID processing procedure is shown in Fig. 2.10.

The terminal attribute of ECHONET nodes A and A' is a, and the terminal attribute of ECHONET node B is b.

On the other hand, the P&PMng shall hold formal addresses 0×4001, 0×4002, and 0×4003 beforehand to be distributed later.

When the P&PMng performs the aforementioned announce address 0 in this status, overhear occurs.

Consequently, ECHONET node A makes a request (Req_ID) for a formal address with the attached terminal attribute a to the P&PMng. The P&PMng gives the formal address 0×4001 to ECHONET node A with the terminal attribute a. At this stage, however, the MAC address of ECHONET node A remains a provisional address and the destination address of the formal address giving a command is inevitably set to the provisional address. Accordingly, the information on terminal attribute a is added to it. This prevents another ECHONET node provisional address from accidentally receiving it in this stage.

The ECHONET node, whose MAC address is a provisional address, transmits a request for a formal address, and only when the attribute information added to the formal address giving the command matches its own terminal attribute does the ECHONET node receive it and make it its own MAC address. The ECHONET node that has changed the MAC address into a formal address notifies the P&PMng of the completion of address setting. After that, the P&PMng distributes a formal address to each ECHONET node in the same way by referring to the formal address and the terminal attribute being the information native to each ECHONET node. The terminal attribute information includes terminal functions, etc., and its details shall be determined at operation.

In this case, the Register_ID processing of ① to ④ in Fig. 2.10 is executed by the local commands described in "Supplement 2.1 Original Command Set of Power Line Communication Protocol A System".

As shown in Fig. 2.11, the P&PMng uses the top-priority slot (See Section 2.4.2 (3) Transmission timing, 2. Transmission slots). Accordingly, when ECHONET node A makes a request for a formal address to the P&PMng, the P&PMng can give the request greater priority than a similar request from the ECHONET node A', so that this does not result in confusion, such as multiple terminals of the same terminal attribute having the same formal address.

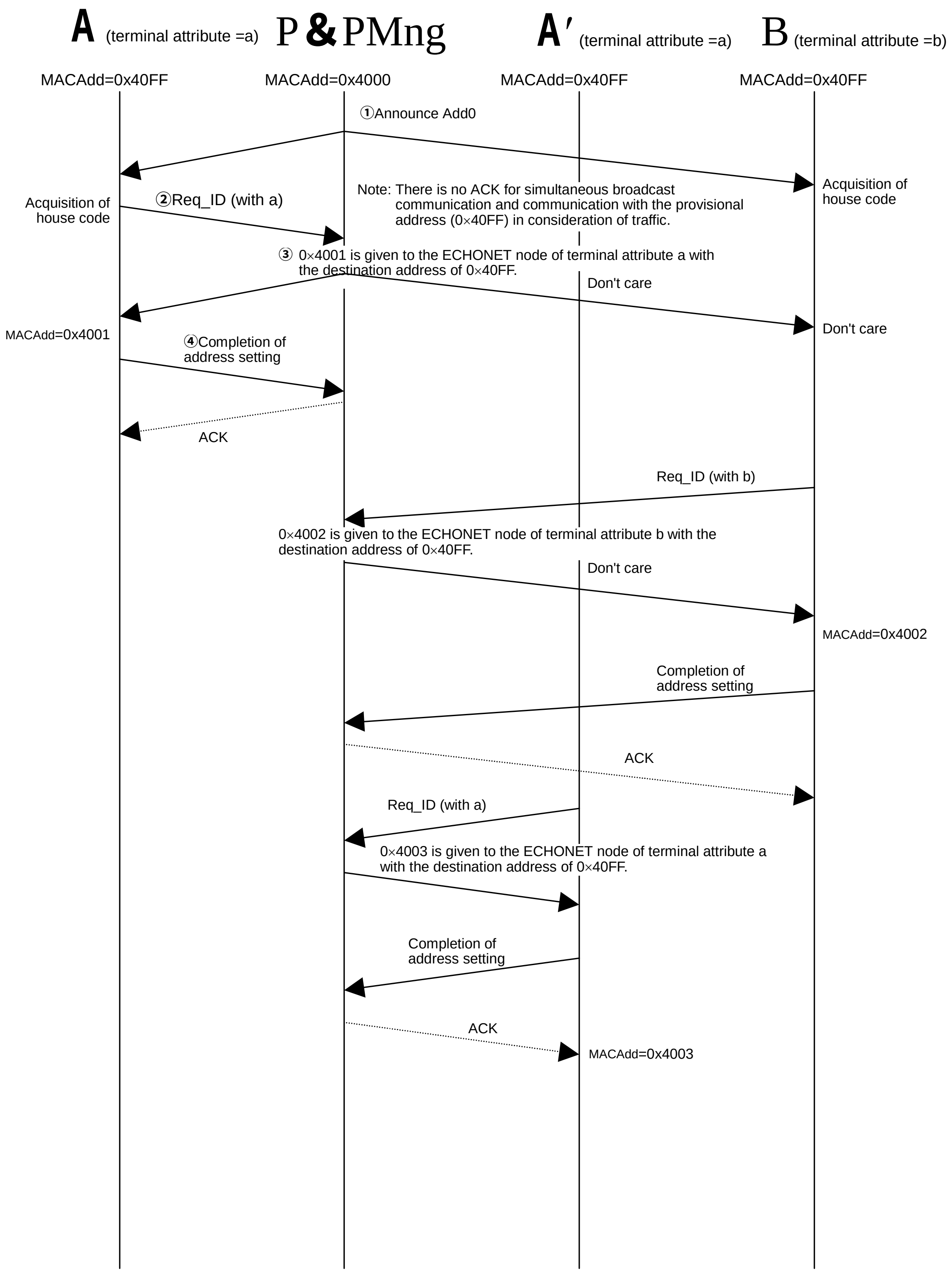
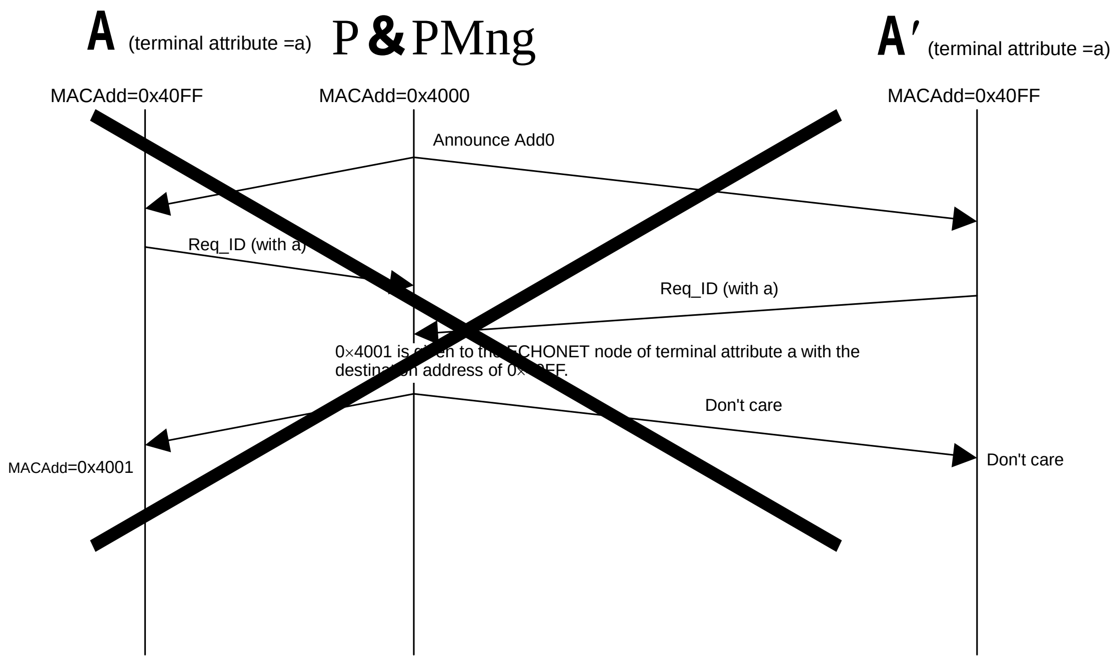


Fig. 2.10 Register_ID Processing Procedure



At transmission, data is not transmitted in this order by the top-priority slot of the P&PMng, so that the same address is never distributed to the ECHONET nodes with the same terminal attribute. Furthermore, a terminal check is made by the extended announce Add 0.

Fig. 2.11 Register_ID Processing Procedure (2)
(This case would never occur in actual use.)

② To Obtain a House Code

From the P&PMng that holds a correct house code, the house code is obtained from the above announce address 0.

(2) Status acquisition service (LowGetStatus)

Return LOW_STS_INIT as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)

Return the operating status as status.

The trigger for state transition is shown below.

(1) Transition trigger to initialization completion stop status

Transition takes place when both a MAC address and a house code have been obtained.

2.5.4 Initialization completion stop status

The initialization completion stop status signifies a status where the lower-layer communications software is completed and a request for operation start from communications middleware is in wait. An outline of processing immediately after state transition and an outline of Individual Lower-layer Communication Interface services that the initialization completion stop status receives, and its processing, are described below.

(1) Trigger and action

Waits for Individual Lower-layer Communication Interface service.

(2) Status acquisition service (LowGetStatus)

Returns LOW_STS_INIT as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)

Returns the operating status as status.

(4) Physical address acquisition service (LowGetMacAddress)

Returns a MAC address.

(5) Profile data acquisition service (LowGetProData)

Returns profile data.

The following is a trigger to perform state transition.

(1) Transition trigger to normal operation status
Transition is caused by operation start instruction service (LowRequestRun).

2.5.5 Normal operation status

The normal operation status signifies a status where data is transmitted to or received from a transmission medium as the primary function of the lower-layer communications software. An outline of processing immediately after state transition and an outline of the Individual Lower-layer Communication Interface services that the normal operation status receives and its processing are described below.

(1) Trigger and action
Waits for the Individual Lower-layer Communication Interface service.

(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_INIT as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)
Returns the operating status as status.

(4) Physical address acquisition service (LowGetMacAddress)
Returns a MAC address.

(5) Profile data acquisition service (LowGetProData)
Returns profile data.

(6) Data transmission service (LowSendData)
Received protocol difference absorption processor data is divided according to the data size, and each divided data is translated into lower-layer communications software data and then output to the transmission medium.

(7) Data reception service (LowRecvData)
Lower-layer communications software data received from a transmission medium is translated into protocol difference absorption processor data and then output to the protocol difference absorption processor.

The following are triggers to perform state transition.

(1) Transition trigger to stop status

Transition is caused by end service (LowStop).

When data is received, the data is abandoned. When data is transmitted, a request for data transmission is rejected, an error return is made, and the operation is stopped.

(2) Transition trigger to suspension status

Transition is caused by lower-layer communication suspension service (LowSuspend).

(3) Transition trigger to initialize processing status

Transition is caused by reset instruction service (LowReset).

(4) Transition trigger to error stop status

Transition is caused by a house code duplicate reception error that occurs upon reception of multiple house codes when a MAC address is obtained by the lower-layer communications software.

2.5.6 Error stop status

The error stop status signifies a status where operation is stopped by the occurrence of an error. An outline of processing immediately after state transition and an outline of the Individual Lower-layer Communication Interface services that the error stop status receives, and its processing, are described below.

(1) Trigger and action

Performs error processing.

(2) Status acquisition service (LowGetStatus)

Returns LOW_STS_INIT as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)

Returns the stop status as status.

The following are triggers to perform state transition:

(1) Transition trigger to stop status

Transition is caused by end service (LowStop).

When data is received, the data is abandoned. When data is transmitted, a request for data transmission is rejected, an error return is made, and the operation is stopped.

(2) Transition trigger to initialize processing status

Transition is caused by reset instruction service (LowReset).

(3) Transition trigger to normal operation status

Transition is caused by removing the cause of the error. The cause of the house code duplicate reception error is removed by manually re-setting the house code.

2.5.7 Suspension status

The suspension status signifies a status where operation is paused by an instruction from the communications middleware. An outline of processing immediately after state transition and an outline of the Individual Lower-layer Communication Interface services and its processing are described below.

(1) Trigger and action

Stops operation of lower-layer communications software.

When data is received, the data is abandoned. When data is transmitted, a request for data transmission is rejected, an error return is made, and operation is stopped.

(2) Status acquisition service (LowGetStatus)

Returns LOW_STS_SUSPEND as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)

Returns stop status as status.

The following are triggers to perform state transition.

(1) Transition trigger to normal operation status

Transition is caused by operation restart service (LowWakeUp).

The lower-layer communications software restarts a transmit/receive operation immediately.

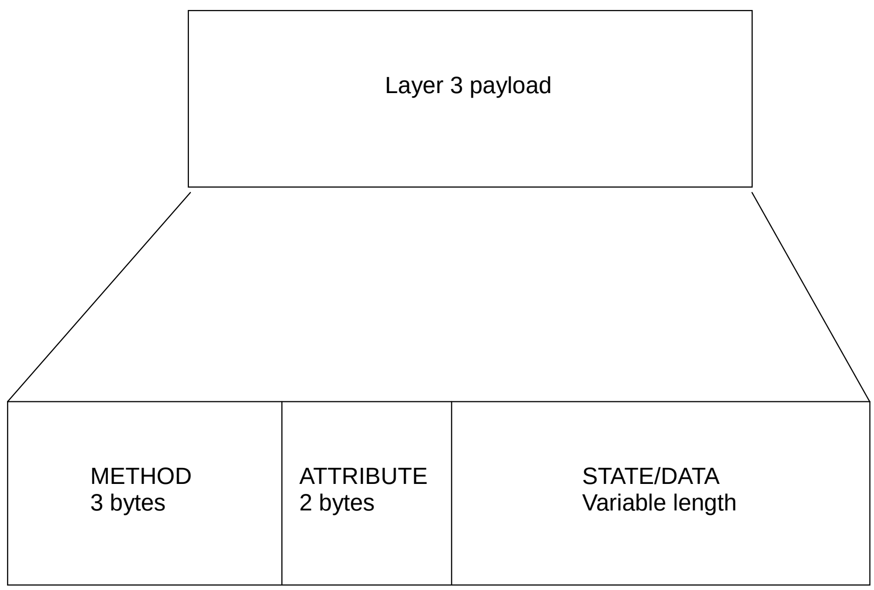
Supplement 2.1

Original Command Set of Power line Communication Protocol A System

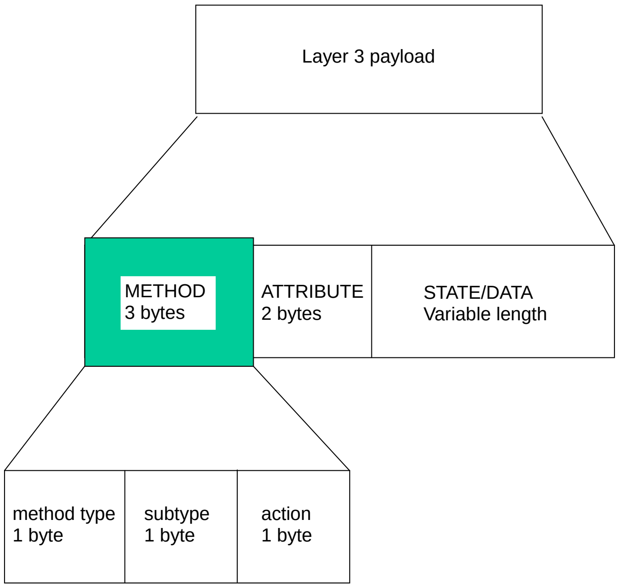
The original command set system of the power line communication protocol A system, which consists of local commands other than the ECHONET commands included in the layer 3 payload, is shown below for reference only.

This command set consists of METHOD (3 bytes), ATTRIBUTE (2 bytes), and STATE/DATA (variable length). METHOD determines processing for ATTRIBUTE, and ATTRIBUTE determines a control target.

The MAC address giving the processing Register_ID of the plug-and-play manager in “2.5 Basic Sequence, 2.5.3 Initialize processing status” is executed by this original command set.



METHOD consists of one byte of method type, one byte of subtype, and one byte of action, as shown below.



A list of commands is provided below for reference.

method type	Contents	Remark	value
READ	Read		0×00
WRITE	Write		0×01
INQUIRE	Request		0×02
RESET	Cancel a request		0×03
INDICATE	Indicate		0×04
MAKE	Add an item	Optional	0×05
REMOVE	Delete an item	Optional	0×06
OPEN	Start connection	Optional	0×10
CLOSE	End connection	Optional	0×11

subtype	Contents	Remark	Value
normal	Normal		0×00
with certification	With certification		0×01
with encryption	With certification or encryption		0×02

action	Contents	Remark	value
do	Request for execution	To be used for transmission	0×00
do with housecode	Request for execution	To be used for transmission	0×01
do with certification method	Request for execution	To be used for transmission	0×02
done	Complete execution	To be used for response	0×10
cannot	Cannot execute	To be used for response	0×20
busy	Cannot execute now	To be used for response	0×21
classified	Cannot execute (not qualified)	To be used for response	0×22

ATTRIBUTE consists of one byte of Table Selector (TS) and one byte of function_name or property_name.

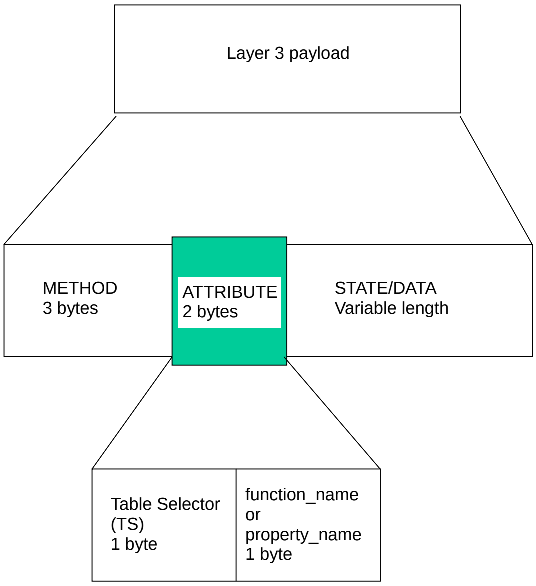


Table Selector and property_name of Table Selector = P&P list is provided below for reference.

Type	Table Selector	Table Selector value
General	General(GE)	0×00
Function proper	Timer(TM)	0×00
Air conditioning system	AirConditioner(AC)	0×01
Hot water supply system	WaterSupply(WS)	0×02
Lighting system	LightEquipment(LE)	0×03
Electromotive system	ElectricalApparatus(EA)	0×04
Cooking/housework system	CookingTools(CT)	0×05
Plug and play system	P&P	0×20
Common	Don't Care(DC)	any value

property_name	value
serial_number	0×00
terminalID	0×01
EchonetAddress	0×02
ACK_terminalID	0×03
maker	0×10
model	0×11
type	0×12
type_id	0×13
P&P	0×20

The MAC address giving the processing Register_ID of the plug-and-play manager is executed by the original command set shown below.

For the processing sequence, see Fig. 2.10 Register_ID Processing Procedure.

① Announce address 0

METHOD			ATTRIBUTE		STATE/DATA
methodtype	subtype	action	TS	property_name	DATA
INDICATE	With	do	P&P	Housecode	None
0×04	0×00	0×00	0×20	0×81	

② Req_ID

METHOD			ATTRIBUTE		STATE/DATA
methodtype	subtype	action	TS	property_name	DATA
INQUIRE	with certification	do with housecode	P&P	TerminalID	makercode(2), type(1), model(6)
0×02	0×01	0×01	0×20	0×01	0×0001, 01, 0123456789AB

③ Granting of formal address

METHOD			ATTRIBUTE		STATE/DATA
methodtype	subtype	action	TS	property_name	DATA
WRITE	with certification	do with housecode	P&P	TerminalID	makercode(2),type(1), model(6),terminalid(2)
0×01	0×01	0×01	0×20	0×01	0×0001, 01, 0123456789AB, 4001

④ Completion of address setting

METHOD			ATTRIBUTE		STATE/DATA
methodtype	Subtype	action	TS	property_name	DATA
WRITE	with certification	do with housecode	P&P	ACK_terminalID	terminalid(2)
0×01	0×01	0×01	0×20	0×03	0×4001

Supplement 2.2 Determination of P&PMng

Only one P&PMng must exist. When more than one P&PMng exists, they must be reduced to one by the survival method.

As a rule, the latest declared P&PMng should be the definitive P&PMng.

The P&PMng declared P&PMng must revert to a general terminal device immediately.

When a P&PMng change has been made, the MAC address given by the previous P&PMng is invalidated and the new P&PMng gives a new MAC address. To invalidate a MAC address, a reset command is used.

Supplement 2.3 Extended announce address 0

This process is performed to guarantee that a unique MAC address in the SUBNET is given properly to an ECHONET node.

The P&PMng checks periodically to see if the ECHONET node holding the MAC address given by it exits correctly on the power line. This is also intended to check if communication can be performed even if the ECHONET node really exists, because of near or remote distance, noise, or distortion on the power line. In some cases, the ECHONET node has been removed and does not exist. This operation is called extended announce address 0. The ECHONET node check method is not specified, but a proper command is sent out to the corresponding device and its response is checked.

As a result of extended announce address 0, the MAC address of a device that does not exist is deleted from the P&PMng registered address list and may be returned to the unregistered address list.

In this way, the number of MAC addresses that the P&PMng can give will be increased as a result. The MAC address deleting method is not specified in this Standard.

Chapter 3 PLC-B System Communication Protocol Specification

3.1 System Overview

This system relates to the power line carrier system using indoor power lines that is one of the types of transmission media defined in the ECHONET Standard, and that can work with existing dwellings and medium and small buildings/stores without special installation procedures.

The proposed multi-carrier system is a high-reliability communication system having high noise resistance compatible with various transmission line characteristics as compared with existing power line carrier communication systems.

3.1.1 Scope of the Standard

The standard of the PLC-B system consists of mechanical/physical specifications, electrical specifications, and logical specifications of layer 1, and logical specifications of layers 2 and 3. The mechanical specifications specify connectors and intended power lines. The electrical specifications specify the modulator/demodulator unit. The logical specifications of layers 1 to 3 specify each layer processing and signal interfaces between layers.

The electrical interface specifications between the electrical specifications (modulator/demodulator unit) and the logical specifications are not specified. Discussion of PLC-B system is limited to layer 1 in the mechanical/physical characteristics, electrical characteristics and logical specifications. Layers 2 and 3 of this system are the same as those of the PLC-A system.

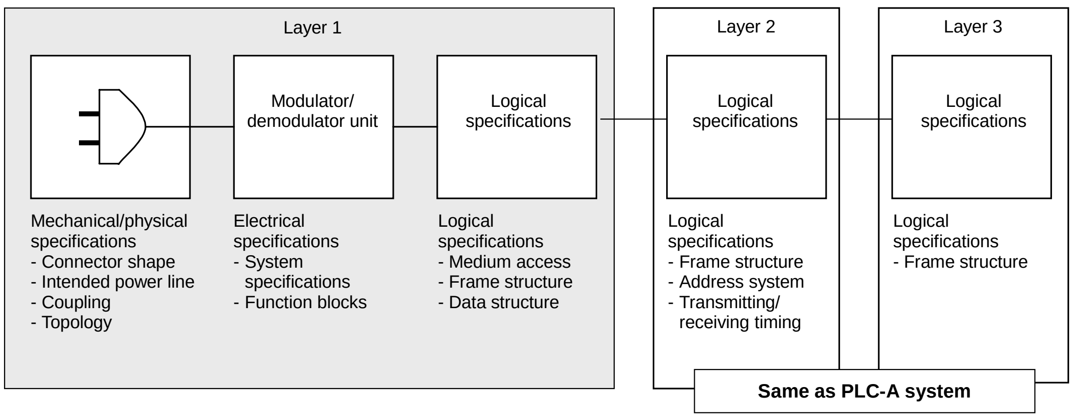


Fig. 3.1 Scope of the Standard

3.1.2 Modem Specifications

Item	Specification
Communication system	Multi-carrier system
Primary modulation system	DQPSK, DBPSK, or D8PSK
Access system	N:N
Number of terminals	255 terminals max. (Goal specification for physical layers)
Operating frequency	10KHz～450KHz
Transmission rate	Variable rate (36.5kbps/24.4kbps/12.2kbps/8.12kbps/4.06kbps)
Adaptive control system	Adaptive frequency hopping system/adaptive rate change system
System compatible with legal regulations	Special carrier system

*1: An application for model authorization for the special carrier system has not been made.

3.2 Mechanical/Physical Specifications

3.2.1 Connector shape

The connector shape shall be the same as that of the PLC-A system described in 2.2.1.

3.2.2 Intended power line

The intended power line shall be the same as that of the PLC-A system described in 2.2.2.

3.2.3 Coupling

The intended power line shall be the same as that of the PLC-A system described in 2.2.3.

3.2.4 Topology

The intended power line shall be the same as that of the PLC-A system described in 2.2.4.

3.3 Electrical Specifications

3.3.1 System specifications

(1) Transmit signal system

(A) Modulation system

(a) System

This is a multi-carrier system that performs communications by putting modulated signals on multiple tones spread at equal frequency spacing.

(b) Tone frequency

4.3125kHz × n (n=32, 48, 64, 80, 96)

(c) Number of tones

Basic: 3

Definition of Communication Tone

The tone positions of △f × n (n = 32, 48, 64, 80, 96) of 4.3125 kHz spacing (△f = 4.3125 kHz) are specified. Of these tone positions, 3 tones with equal spacing are selected for communication.

Tones with tone No. n = 48, 64, and 80 are defined as the default tones.

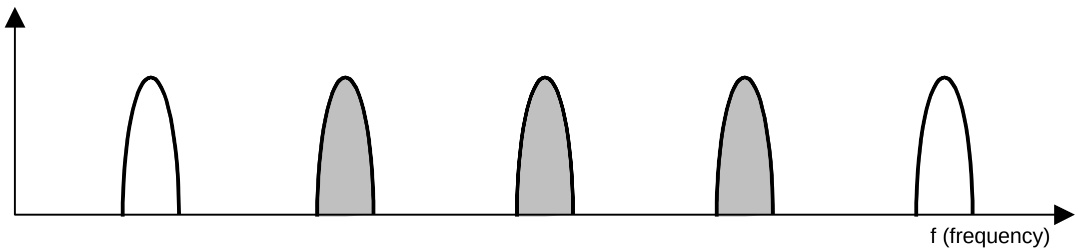


Fig. 3.5 Communication Tones

(d) Hopping function

The tone frequency is caused to hop in an adaptable form depending on the transmission line condition.

(e) Transmission rate

Mandatory: 8.12 kbps

Optional: 36.5 kbps, 24.4 kbps, 12.2 kbps, or 4.06 kbps.

(f) Primary modulation system

- DQPSK

  Two-bit and 1-symbol data is converted into phase difference ⊿θ according to Table 3.1 Phase Shift Table. ⊿θ is added to the previous phase and mapping is performed to the constellation point (Fig. 3.6) on the Gaussian plane. Supposing that when the n-th data is transmitted, the constellation is (X_n, Y_n), ⊿θ can be represented by the following formula. However, the initial value is specified as $(X_0, Y_0) = (1, 1)$.

$$\Delta\theta = \arctan(Y_n / X_n) - \arctan(Y_{n-1} / X_{n-1})$$

Table 3.1 Phase Shift Table

Data	⊿θ [rad]
0 0	0
0 1	π／2
1 0	3π／2
1 1	π

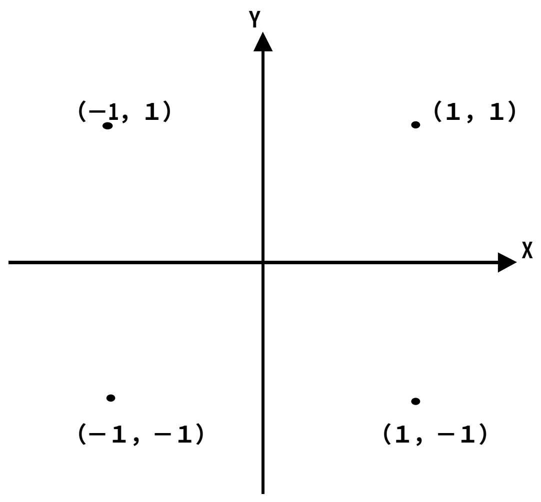


Fig. 3.6 DQPSK Constellation (X_n, Y_n)

- DBPSK

  One-bit and 1-symbol data is converted into phase difference ⊿θ according to Table 3.2 Phase Shift Table. ⊿θ is added to the previous phase and mapping is performed to the constellation point (Fig. 3.7) on the Gaussian plane. Supposing that when the n-th data is transmitted, the constellation is (X_n, Y_n), ⊿θ can be represented by the following formula. However, the initial value is specified as (X_0, Y_0) = (1, 1).

$$⊿\theta = \arctan(Y_n / X_n) - \arctan(Y_{n-1} / X_{n-1})$$

Table 3.2 Phase Shift Table

Data	⊿θ [rad]
0	0
1	π

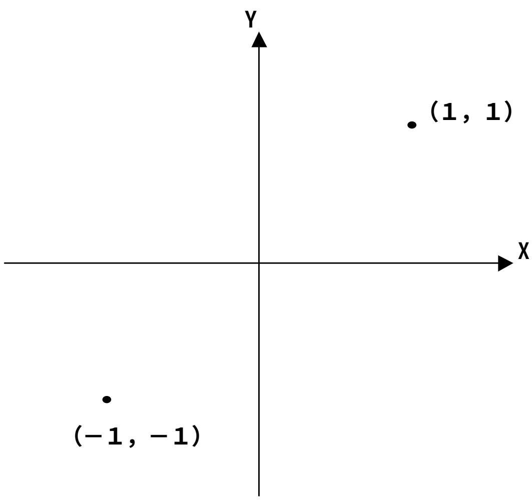


Fig. 3.7 DBPSK Constellation (X_n, Y_n)

- D8PSK

  Three-bit and 1-symbol data is converted into phase difference ⊿θ according to Table 3.3 Phase Shift Table. ⊿θ is added to the previous phase and mapping is performed to the constellation point (Fig. 3.8) on the Gaussian plane. Supposing that when the n-th data is transmitted, the constellation is (X_n, Y_n), ⊿θ can be represented by the following formula. However, the initial value is specified as $(X_0, Y_0) = (1, 1)$.

$$\Delta\theta = \arctan(Y_n / X_n) - \arctan(Y_{n-1} / X_{n-1})$$

Table 3.3 Phase Shift Table

Data	⊿θ [rad]
0 0 0	0
0 0 1	π／4
0 1 0	3π／4
0 1 1	π／2
1 0 0	7π／4
1 0 1	3π／2
1 1 0	π
1 1 1	5π／4

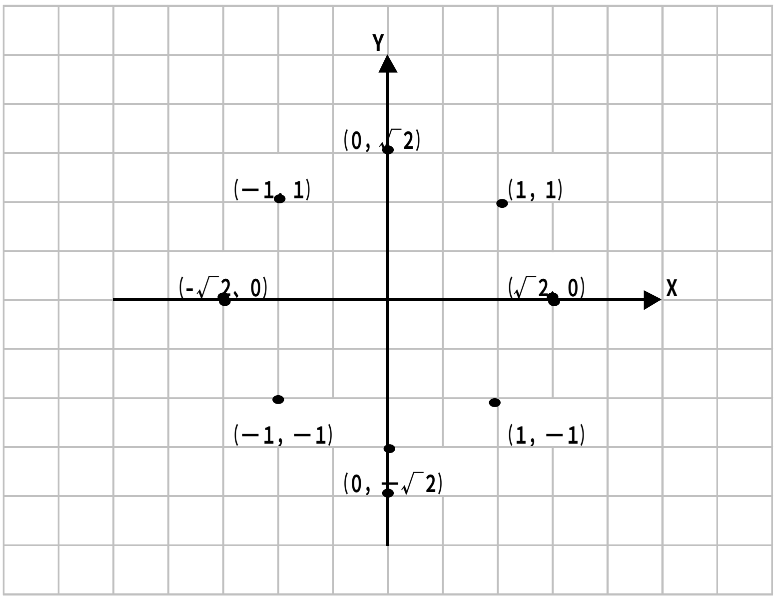


Fig. 3.8 D8PSK Constellation (X_n, Y_n)

3.3.2 Rules of transmitting output

(1) Operating frequency
10KHz ～ 450KHz

(2) Transmitting power
75mW ～ 25mW/tone

(3) Spurious intensity at output terminal
Basic wave output -43 dB or less

3.3.3 Rules of receiving signal

(1) Receiver sensitivity
Input power 0.1 mW or less

(2) Carrier sense sensitivity
Input power 0.1 mW or less

3.4 Logical Specifications

3.4.1 Layer 1

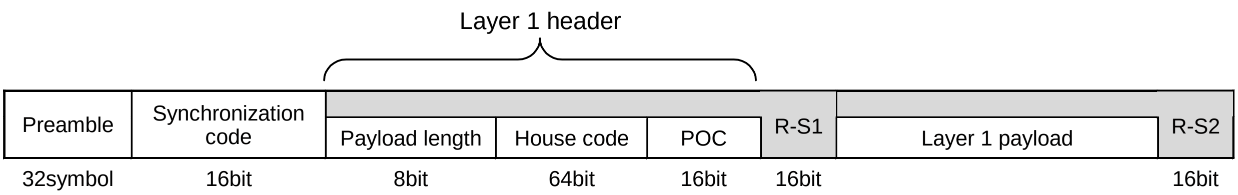
(1) Transmission control system
CSMA system

(2) Carrier sense
Carrier sense is available .

(3) Pause period
Pause period for normal frame: 40 ms or more
Pause time for response signal or auto re-transmission: 15mS ～ 35mS

(4) Error correction
Target range: From the frame type to POC (mandatory) and layer 1 payload (optional)
System: Read Solomon code
Correction capability: 1 symbol

(5) Layer 1 frame structure

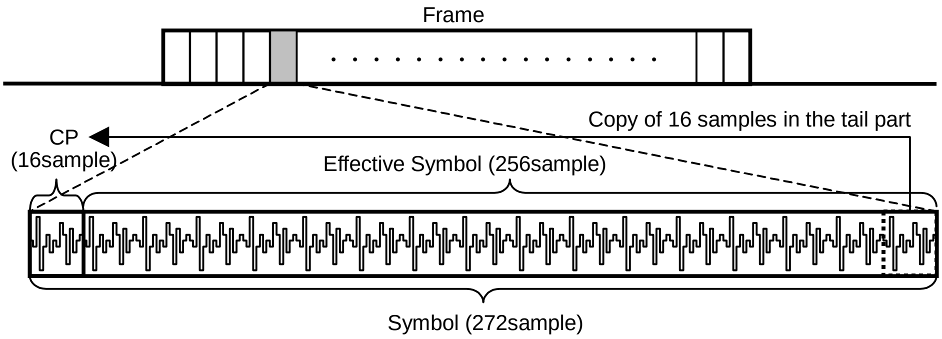


(A) Cyclic prefix

A communication frame consists of multiple symbols. The symbol is the minimum unit of logical communication. Physically, the symbol is a group of 256 units of data resulting from sampling waveform data for a symbol cycle (4.3125 kHz) by a sample frequency (1.104 MHz). This group of 256 units of sample data is called an effective symbol.

At actual transmission, a copy of the final 1/16 (equivalent to 16 units of sample data) of the effective symbol is added to the head of the effective symbol with the object of preventing inter-symbol interference. This is called the Cyclic Prefix (hereafter referred to as CP). Because the phase of the beginning end of the effective symbol matches the phase of the terminating end, the phases match at the boundary between the CP and an effective symbol, resulting in a continuous waveform.

Accordingly, a single symbol consists of CP (16 samples) + effective symbol (256 samples), or 272 samples in total. The CP is added to every symbol comprising a frame (preamble to payload).



(B) Preamble: Symbol synchronization code

To synchronize the receiving timing of the receiver with the transmission timing of the transmitter, the following preambles are used.

(1) Preamble 1

Preamble 1 is generated as a composite wave of continuous sine waves equivalent to each tone frequency with regard to all tones to be used for transmission. Preamble 1 is output for 16 symbols at the beginning of a frame. The receiving side performs carrier sense using preamble 1.

(2) Preamble 2

Preamble 2 is generated as a composite wave of signals (with a phase shifted by π for each symbol) with a phase inverted at each transmission of one symbol of the sine wave equivalent to each tone frequency with regard to all tones to be used for transmission. Preamble 2 is output for 16 symbols subsequent to preamble 1. The receiving side performs symbol synchronization to locate a symbol boundary by using preamble 2.

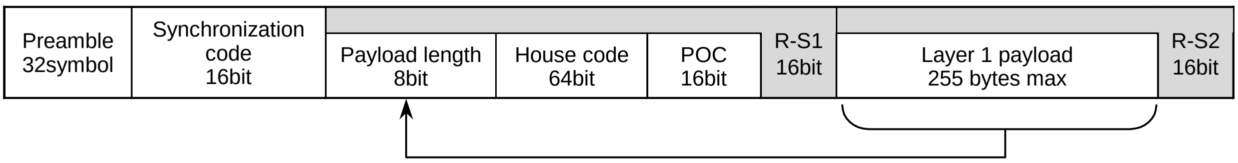
(C) Synchronization code: Frame synchronization code

The synchronization code shall be a 16-bit fixed code based on a 15-bit M series code and generated though modulation by the bit modulation system specified in the signal system, and then transmitted immediately before the payload length field.

Synchronization code: 0110010001111010

The receiving side detects the beginning of effective data by using the synchronization code and performs frame synchronization.

(D) Payload length: Indicates the byte length of layer 1 payload.
The layer 1 payload shall be 255 bytes max.
The numeric value of the payload length field indicates the number of bytes of layer 1 payload.



(E) House code: ID for house identification

1	2	3	4	5	6	7	8
Manufacturer code			identification code				

(1) Manufacturer code
- The 3 high-order bytes of the house code shall be a manufacturer code.

(2) Identification code
- The 5 low-order bytes of the house code shall be a discrete identification code.
- A unique number shall be assigned to each manufacturer code.

(F) POC: <u>P</u>owerline communication <u>O</u>verhead <u>C</u>ontrol field
For the control related to noise resistance communication setting changes, control commands for changes shall be prepared. These commands are inserted into the POC field to exchange commands for control.
The following figure shows a POC field structure:

Communication mode 2bit	Change instruction 1bit	Node state 1bit	Tone group	Set position	Primary modulation system	Carrier system 1bit	Reserve 3bit

Communication mode: In anticipation of the future specification of a high-speed communications mode, the communications mode is prepared to indicate the current communication mode. At present, only mode 1 (low-speed mode) is available.

Communication mode

Communication mode (2bit)	Mode 1 [0 0]
	Mode 2 [0 1]
	Mode 3 [1 0]
	Reserved [1 1]

Change instruction: To change the primary modulation system, carrier system, tone set position, etc., the change instruction is set to 1.

Change instruction

Change instruction (1bit)	No change	[0]
	Change instruction	[1]

Node state: The status where the power supply is turned on and the status immediately after resetting is defined as a “new joining node”. The new joining node uses the default tone. Once the new joining node becomes an ordinary node, it never returns to the new joining node except in the status where the power supply is turned on and the status immediately after resetting.

To add a new node to the system during operation:

- When the ordinary node receives the frame of a new joining node, a change instruction is output by the next frame.
- When the new joining node receives the frame of an ordinary node, its POC setting is observed.

Node state

Node state (1bit)	New joining node	[0]
	Ordinary node	[1]

Tone group: The tone group is set. Nos.0-15 are available for setting.

In Ver 1.0, the tone group is fixed at No.0. At present, other tone groups have not been defined.

(Tone group No.0 = Tone No. n = Tone group consisting of 32, 48, 64, 80,and 96.)

Tone Group

Tone Group (4bit)	No. 0	[0 0 0 0]
	No. 1	[0 0 0 1]
	:	:
	No. 15	[1 1 1 1]

Set position: The tone set position is set.

Set position

Set position (2bit)	Middle (n=48, 64, 80)	[0 0]
	Low (n=32, 48, 64)	[0 1]
	High (n=64, 80, 96)	[1 0]
	Reserved	[1 1]

In the table, n denotes a tone number.

Primary modulation system: The modulation system indicates that system which is used for a transfer of layer 1 payload (including R-S2). With this, a modulation system is determined upon receipt of layer 1 payload. The modulation system for the synchronization code and layer 1 header is always DQPSK.

Primary modulation system

Modulation system (2bit)	DQPSK [0 0] (mandatory)
	DBPSK [0 1] (optional)
	D8PSK [1 0] (optional)
	Reserved [1 1]

Carrier system: The carrier system indicates how data is distributed to multiple tones used for a transfer of layer 1 payload. In the case of Same, the same data is transmitted to every tone, and any single tone permits receiving perfect data.

In the case of Difference, the data distributed to 3 tones must be combined into perfect data. The carrier system for the synchronization code and layer 1 header is always Same.

Carrier system

Carrier system (1bit)	Same [0] (mandatory)
	Different [1] (optional)

Rules of POC Control Sequence

- Regarding the primary modulation system and carrier system fields, the contents of the corresponding frame layer 1 payload system are written and transmitted. Accordingly, the node to receive the frame performs demodulation by the primary modulation system and carrier system indicated in the POC.

  A tone set position change shall apply to transmission/reception of frames subsequent to the frame that wrote a change instruction.
- If the received POC field is different from the self status, this status must be adjusted to the received POC.

(G) R-S1: Read Solomon coding processing code (layer 1 header part: mandatory)

(H) Layer 1 payload: For the contents of data, see Section 3.4.2 (1) Layer 2 frame structure.

(I) R-S2: Read Solomon coding processing code (layer 1 payload division: optional)

3.4.2 Layer 2

Layer 2 shall be the same as that of the PLC-A system described in Section 2.4.2.

3.4.3 Layer 3

Layer 2 shall be the same as that of the PLC-A system described in Section 2.4.3.

Supplement 1 Block Configuration Example of Multi-carrier System Transmitter/Receiver Unit

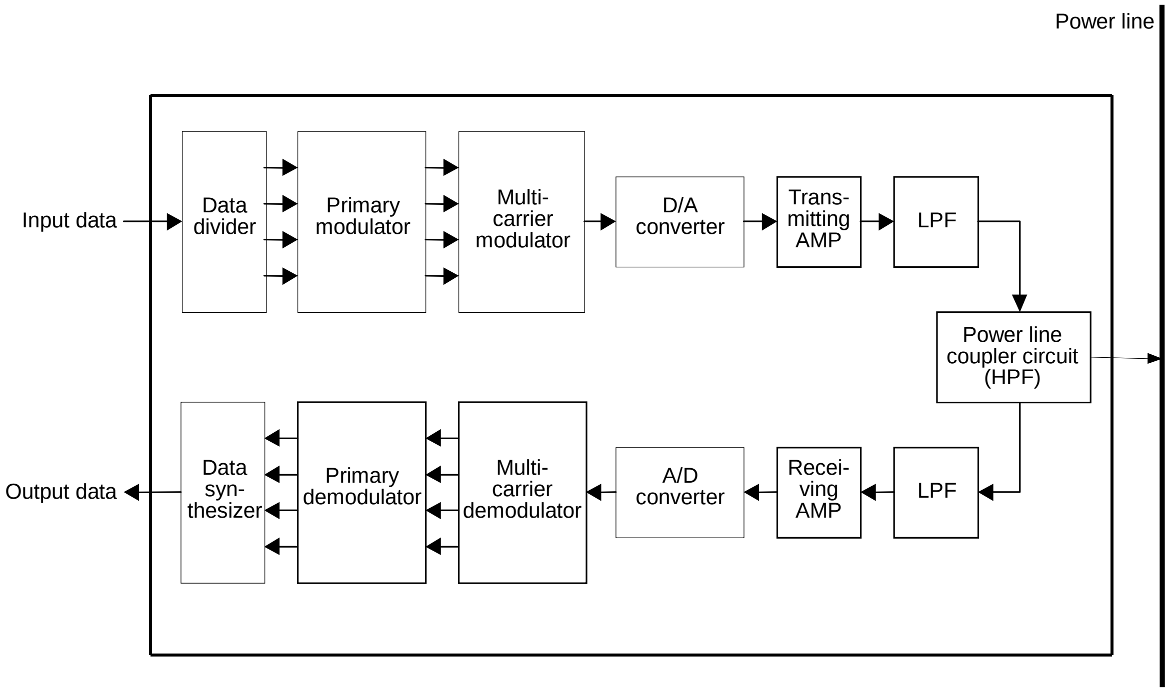


Fig. 3.7 Block Configuration Example of Multi-carrier System Transmitter/Receiver Unit

3.5 Basic Sequence

The basic sequence is the same as that of the PLC-A system described in Section 2.5.
In the PLC-B system, the following services are added in the initialization completion stop status and the normal operation status.

(1) Noise resistance communication acquisition service（PLCGetN-Information）
Returns noise resistance communication information.

(2) Noise resistance communication information setting（PLCSetN-Information）
Sets the noise resistance communication information specified by command.

Chapter 4 Low-Power Radio Communications Software Specification

4.1 System Overview

We now consider a low-power radio communications system using 400 MHz band radio waves and conforming to the laws and ARIB Standard.

Low-power radio waves reach a range of several meters to tens of meters, so radio interference is likely to occur among multiple radio systems and among radio devices. These Specifications take the following three points into consideration with respect to radio interference:

(1) Radio interference among multiple radio systems
- Use a different channel for each radio system.
- Identify the radio system of the opposite party by using a different identification code (radio system identification code) for each radio system.

(2) Radio interference among multiple devices in the same radio system
- Use multiple channels in one radio system.
- Identify the device of the opposite party by using a different identification code (device identification code) for each device.

(3) Radio interference with radio signals other than the ECHONET radio
- Can distinguish the radio signals of the ECHONET Standard from other radio signals by the frame synchronization signal in an early stage.

4.1.1 Communication Model

(1) Form

1:1 communication or 1:N or N:M communication and one-way, simplex or broadcast communication.

(2) Number of terminals

Several tens of terminals (approx.) per radio system

(3) Communication volume

One-time transmission data volume: Several tens of bytes (approx.)

(4) Transmission rate
Several kbps

(5) Transmission time
One-time transmission time: Several seconds to several tens of seconds

(6) Number of radio systems in which radio interference is supposed
Approx. 100 systems

4.1.2 ARIB Standard

The ARIB Standards include some standards by use. The low-power radio communication protocol considers RCR STD-16 (STD-16) for telemeter/telecontrol and RCR STD-30 (STD-30) for security.

4.2 Mechanical/Physical Characteristics

This Standard adopts STD-16 and STD-30.

4.3 Electrical Characteristics

This Standard adopts STD-16 and STD-30.

4.3.1 Transmission system and transmitting signal

(1) Radio wave type

FID (Frequency modulation without using any sub-carrier and transmission information of data transmission, telemetering or remote indication)

(2) Communication system

One-way system, simplex system, or broadcast communication system (for the same radio system only)

(3) Antenna power

10 mW or less

(4) Modulation system

Binary FSK (Frequency Shift Keying) modulation system by direct modulation

(5) Modulation rate

4800 bps or 2400 bps

(6) Code type

NRZ (Non-return-to-zero) coding

4.3.2 Frequency

(1) Operating frequency

At least one of the following frequency bands shall be used:

- 429 MHz band: 46 channels of 429.1750 to 429.7375 MHz (12.5 kHz spacing)
- 426 MHz band: 48 channels of 426.2500 to 426.8375 MHz (12.5 kHz spacing)

(2) Communication channel

- The operating frequency channels are divided into multiple channel groups and different communication channel groups are assigned to individual radio systems so that multiple radio communication systems may communicate smoothly.
- The number of channels available for one radio system shall be either 3 or 5, according to the frequency of radio system communications, so that multiple devices in the same system may perform numerous communications smoothly.

(A) 429 MHz band

The STD-16 is provided with 46 channels and divides them into two parts.

- 1 to 6 ch : Intermittent communications zone specifying a transmission time limit (40 sec. or less) and transmission pause time (2 sec. or more)
- 7 to 46 ch : Continuous communications zone without any time limit

This protocol treats both the continuous communications zone and intermittent communications zone in the same manner and provides a transmission time limit and a transmission pause time for use. Accordingly, this Standard uses channels 1 to 46 at a one-time transmission time of 40 seconds or less and a transmission interval of 2 seconds or more.

The number of channels to be used in one radio system is changed depending on the frequency of communication. When the radio system communication frequency is low, 3 channels (basic channels) are used. For high communication frequencies, 5 channels (basic channels + additional channels) are used.

For individual radio systems, communication channel groups A to F and communication channels for system setup are assigned as follows. In addition to communication channel groups A to F, a channel for system setup is prepared. This channel is used for radio system setup.

Communication channel group	Basic channel		Additional channel
	(STD-16 intermittent communications zone)	(STD-16 continuous communications zone)	
Group A	1 ch	8, 20 ch	35, 44 ch
Group B	2 ch	14, 29 ch	38, 41 ch
Group C	3 ch	10, 22 ch	34, 37 ch
Group D	4 ch	16, 31 ch	40, 43 ch
Group E	5 ch	12, 24 ch	36, 39 ch
Group F	6 ch	18, 33 ch	42, 45 ch
For system setup	6 ch	26, 46 ch	–

The following items are taken into consideration for the above communication channel group assignment:

(1) The 3 channels (basic channels) shall always include one channel for the intermittent communications zone to be used exclusively by the corresponding communication channel group.

→ The total number of communication channel groups is 6.

- Example: Channel 1 of group A is not used by other groups.

(2) The same channel shall not be shared with other communication channel groups.
- Example: Channels 8, 20, 35, and 44 of group A shall not be used by other groups.

(3) In the continuous communications zone using 3 channels (basic channels), these channels are not close to each other in one communication channel group. They shall not be adjacent to another communication channel group.
- Example: Channels 7, 9, 19, 21, 34, 36, 43, and 45 adjacent to channels 8, 20, 35, 44 of the group A are not used for the 3 channels.

(4) In the continuous communications zone using 5 channels (basic channels + additional channels), adjacent channels shall not be concentrated in a specific communication channel group.
- Example: Channel 35 in group A is adjacent to groups C and E. Channel 44 is adjacent to groups D and F.

(5) The channel for system setup shall also be used as a channel for group registration of “ECHONET LonTalk Protocol (low-power radio)” that uses the same frequency.
The standard frequency of communication shall be as follows, under the conditions that the one-time communication time is 1.5 sec., the number of radio systems for which radio interference is supposed is 200, and the probability of wait for transmission is 0.1% or less:
- When using 3 channels: Once or less for about 3 minutes
- When using 5 channels: Once or less for about 40 seconds

As the number of channels to be used increases, the communication frequency grows higher. but the number of channel selections for wait on the receiving side increases. Therefore, the one-time transmission time on the transmitting side becomes longer.

The channel priority for communication shall be as follows when 5 channels are used:
(1) Additional channel (For example, channels 35 and 44 in group A)
(2) Continuous communications zone out of the basic channels (For example, channel 8 and 20 in group A)
(3) Intermittent communications zone out of the basic channels (For example, channel 1 of group A)
When 3 channels are used, the above (1) shall not be used but the priority is (2) (3), in this order. In addition, when the ACK signal is transmitted, the channel that received the previous communication shall have top priority. For resend processing, the transmitting channel shall be changed each time.

(B) 426 MHz band

The STD-30 is provided with 48 channels. The STD-30 specifies all 48 channels as the intermittent communications zone with a fixed transmission time limit (3 sec. or less) and transmission pause time (2 sec. or more). Accordingly, in this Standard, channels 1 to 48 shall be used at a one-time transmission time of 3 sec. or less and a transmission interval of 2 sec. or more.

The number of channels to be used in one radio system is changed depending on the frequency of communication. For low radio system communication frequencies, 3 channels (basic channels) are used. For high communication frequencies, 5 channels (basic channels + additional channels) are used.

For individual radio systems, communication channel groups A to O and communication channels for system setup are assigned as shown below. Apart from communication channel groups A to O, a channel for system setup is prepared. This channel is used for radio system setup.

Communication channel group	Basic channel		Additional channel
	(To be exclusively used by a group)	(To be shared as basic and additional channels)	
Group A	1 ch	17, 34 ch	19, 38 ch
Group B	2 ch	19, 37 ch	23, 41 ch
Group C	3 ch	21, 40 ch	27, 42 ch
Group D	4 ch	23, 43 ch	31, 35 ch
Group E	5 ch	25, 46 ch	18, 40 ch
Group F	6 ch	27, 33 ch	22, 45 ch
Group G	7 ch	29, 36 ch	26, 34 ch
Group H	8 ch	31, 39 ch	30, 37 ch
Group I	9 ch	18, 42 ch	17, 44 ch
Group J	10 ch	20, 45 ch	21, 36 ch
Group K	11 ch	22, 48 ch	25, 43 ch
Group L	12 ch	24, 35 ch	29, 48 ch
Group M	13 ch	26, 38 ch	20, 33 ch
Group N	14 ch	28, 41 ch	24, 39 ch
Group O	15 ch	30, 44 ch	28, 46 ch
For system setup	16, 32, 47 ch		–

The following items are taken into consideration for the above communication channel group assignment:

(1) The communication channel groups of 3 channels (basic channels) shall use all 48 channels.

→ The total number of communication channel groups is 16.

(2) The 3 channels shall always include one channel to be used exclusively by the corresponding communication channel group.

- Example: Channel 1 of group A is not used by other groups.

(3) Adjacent channels shall not be concentrated in a specific communication channel group.

- Example: Channel 1 of group A is adjacent to group B, channel 17 is adjacent to groups E and I, channel 34 is adjacent to groups D, F, L, and M, channel 19 is adjacent to groups E, I, J, and M, and channel 38 is adjacent to groups B, H, and N.

(4) When 3 channels (basic channels) are used, the same channels shall not be shared with other communication channel groups.

- Example: Channels 1, 17, and 34 of group A are not used by other groups as 3 channels.

(5) When 5 channels (basic channels + additional channels) are used, they shall not be shared with a specific communication channel group.

- Example: Channel 17 of group A is shared with group I, channel 34 is shared with group G, channel 18 is shared with group B, and channel 38 is shared with group M.

The standard frequency of communication shall be as follows under the condition that the one-time communication time is 1.5 sec., the number of radio systems for which radio interference is supposed is 200, and the probability of wait for transmission is 0.1% or less:

- When using 3 channels: Once or less for about 70 minutes
- When using 5 channels: Once or less for about 15 seconds

As the number of channels to be used increases, the frequency of communication becomes higher but the number of channel selections for wait on the receiving side increases. Therefore, the one-time transmission time on the transmitting side becomes longer.

The channel priority for communication shall be as follows when 5 channels are used:

(1) Additional channel (For example, channels 19 and 38 in group A)

(2) Channels to be shared with other groups out of the basic channels (For example, channels 17 and 34 in group A)

(3) Channels to be used exclusively by the self-group out of the basic channels (For example, channel 1 of group A)

When 3 channels are used, the above (1) shall not be used but the priority is (2) (3), in this order.

In addition, when the ACK signal is transmitted, the channel that received the previous communication (information transmitting signal and ACK signal) shall have top priority. For resend processing, the transmitting channel shall be changed each time.

(C) Setting the operating frequency, communication channel groups, and number of channels

At the initial settings for the radio system, the operating frequency, communication channel groups, and number of channels are set and stored in the non-volatile RAM.

Set the operating frequency according to the use of the radio system and the frequency characteristics of the radio transmitter/receiver circuit.

It is desirable that the communication channel groups should be adjusted to the radio system existing nearby. As the default, you may determine communication channel groups by a different radio system identification code for each radio system. It is desirable to adjust the number of channels in accordance with the communication volume of the radio system.

As the default, the use of 3 channels is selectable. However, to provide for an increase of communication volume in future, the setting must be changeable to 5 channel use.

For setting communication channel groups and the number of channels by using radio communication, this communication shall use the channel for system setup. It is also possible to use wire telecommunication or perform individual settings by switch for each device instead.

4.4 Logical Specifications

(1) Transmission control system

CSMA (Carrier Sense Multiple Access) system using multi-channel

(2) Carrier sense

When a radio wave of another radio system is detected by executing carrier sense before transmission, no transmission is performed. A shift is made to another communication channel and carrier sense is executed. After that, transmission is performed. Or transmission is performed after completion of another radio wave.

(3) Transmission time limit and transmission pause time

- Transmission time limit: 429 MHz band 40 sec. max.; 426 MHz band 3 sec. max.
- Transmission pause time: 2 sec. or more

(4) Wait for reception

Continuous wait for reception, which gives priority to communication efficiency, and intermittent wait for reception, which gives priority to low power consumption at wait for reception, are available. In consideration of the transmission time limit, these are specified as follows:

- Continuous wait for reception: Available for both 429 MHz band and 426 MHz band
- Intermittent wait for reception:
  429 MHz band; 6 types of 0.5 sec., 3 sec., 5 sec., 15 sec., 25 sec., and 35 sec. intervals
  426 MHz band; 4 types of 0.5 sec., 1 sec., 1.5 sec., and 2 sec. intervals

An intermittent cycle shall be set and registered for each communication destination at the initial settings of devices so that the interval of wait for reception (intermittent cycle) may be differentiated for each device. The transmitting side switches part of the transmit signal in accordance with the intermittent cycle of the communication destination and then transmits it (See Section 4.4.2.).

This Standard provides a communication procedure to boost communication efficiency by switching over to continuous wait for reception only at communication in the devices that make an intermittent wait for reception. (See Section 4.4.4.)

4.4.1 Data structure

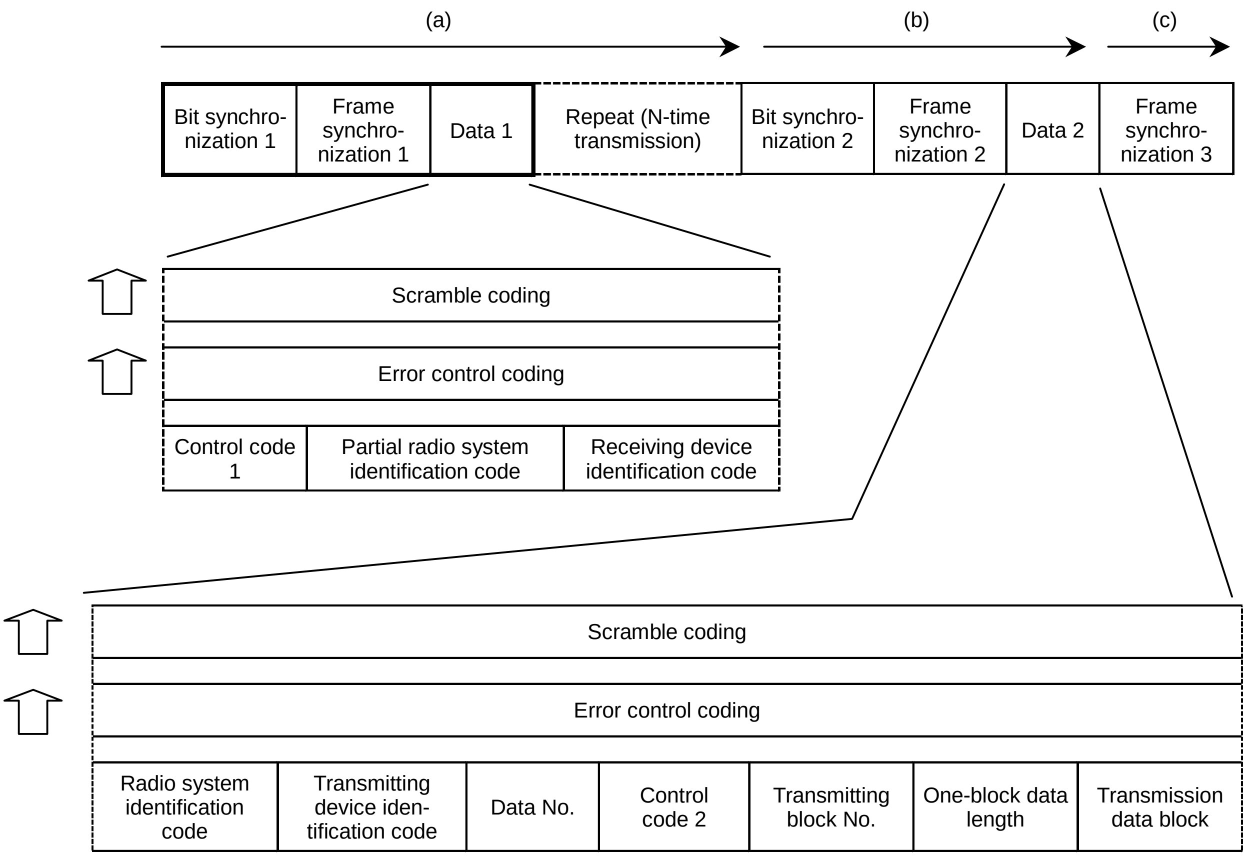
The data format to be used for radio communication is classified into the information transmitting signal for information transmission and the ACK signal that is a response for acknowledgement of reception. The data format for these shall be as common as possible.

The data format consists of the three parts shown below. As described later, data 1 and data 2 undergo error control coding and then scramble coding. When each byte is transmitted, it is output starting with the high-order bit (MSB).

(a) Repeat division specifying bit synchronization 2, frame synchronization 1, and data 1 as one unit. After synchronization establishment of bit synchronization and frame synchronization 1, the receiving side confirms the opposite party of communication with data 1.

(b) This division consists of bit synchronization 1, frame synchronization 2, and data 2. After synchronization establishment of bit synchronization 2 and frame synchronization 2, the receiving side confirms the opposite party of communication with data 2 and receives the data to be transmitted.

(c) Repeat division of frame synchronization 3. When the ACK signal is transmitted from the receiving side, the transmitting side secures a communication channel.



4.4.2 Layer 1

Bit synchro-nization 1	Frame synchro-nization 1	Data 1	Repeat (N-time transmission)	Bit synchro-nization 2	Frame synchro-nization 2	Data 2	Frame synchro-nization 3

(A) Bit synchronization 1

- A signal for synchronizing the bit timing of the receiving side with the bit timing of the transmitting side in order to receive frame synchronization 1 to data 1.
- 41 bits of “0101 ... 10”.

(B) Frame synchronization 1

- A signal for confirming the data format position on the receiving side.
- 31-bit M series code “1110010001010111101101001100000”.

(C) Data 1

- Includes the information of the opposite party of communication. (Details are provided in Section 4.4.3.)
- Error control coding for error detection/correction is performed (details are provided in Section 4.4.3), and then scramble code conversion for limiting the number of continuous same bits is performed (details are provided below in item (2) Scramble code conversion).
- 64 bits (after coding)

(D) Bit synchronization 2

- A signal for synchronizing the bit timing of the receiving side with the bit timing of the transmitting side in order to receive frame synchronization 2 to data 2.
- 65 bits of “1010 ... 01”.

(E) Frame synchronization 2

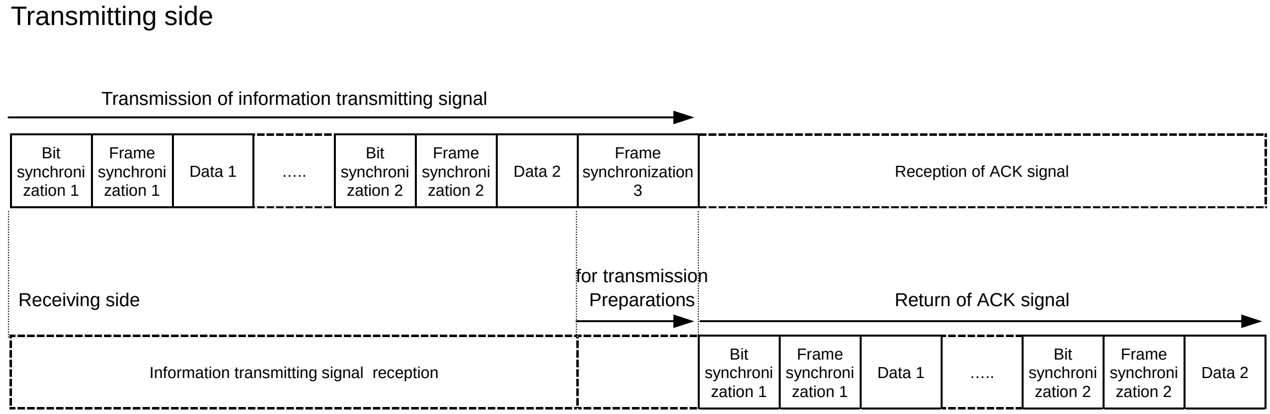
- A signal for confirming the data format position on the receiving side.
- To distinguish frame synchronization 2 from frame synchronization 1, this shall be a bit-inverted code.
- 31-bit M series code “0001101110101000010010110011111”.

(F) Data 2

- Includes information about the opposite party of communication, data to be transmitted, etc. (Details are provided in Section 4.4.3.)
- Error control coding for error detection/correction is performed (details are provided in Section 4.4.3), and then scramble code conversion for limiting the number of continuous same bits is performed (details are provided below in item (2) Scramble code conversion).
- If the number of bits of data 2 including the error control code exceeds 2240, bit synchronization 2 and frame synchronization 2 are inserted halfway so that re-synchronization may be performed on the receiving side (Details are provided below in item (3) Block division of data 2).

(G) Frame synchronization 3

- When a return of the ACK signal is required, this signal is used to secure the communication channel already used on the transmitting side while the receiving side makes preparations for transmitting the ACK signal.
- When a return of the ACK signal is not required, the transmitting side does not add frame synchronization 3 to the information transmitting signal.
- The ACK signal is returned when the receiving side has attained normal reception. The ACK signal returning side receives data 2, makes preparations for transmitting the ACK signal, checks the completion of frame synchronization 3 by carrier sense, and transmits the ACK signal.
- Only when data 2 is divided into blocks for transmission does the receiving side make a request to resend by transmitting the ACK signal, even if a receive error occurs in the process of data 2 reception of the information transmitting signal (details are provided in Section 4.4.3, item (8)). At this time, the ACK signal returning side calculates the ending time of data 2 on the basis of the transmitting block No. in received data 2 (details are provided in Section 4.4.3, item (6)), checks the completion of frame synchronization 3 by carrier sense, and transmits the ACK signal.
- Frame synchronization 3 is a 32-bit code repeat signal with “1” added to the beginning of the 31-bit M series code “0001101110101000010010110011111” that is equal to frame synchronization 2.
- The repeat count shall be 4.



(1) Receiving cycle and repeat transmission count

- The transmitting side transmits the repeat transmission division in accordance with the intermittent cycle of the receiving side. The repeat transmission division is repeated N times specifying bit synchronization 1 - frame synchronization 1 - data 1 as one unit (136 bits).
- The repeat transmission count N takes into consideration the factors shown below. Accordingly, at transmission, the repeat transmission count is selected based on the opposite party of communication.

  Repeat transmission count N = (a) Count required for a wait for intermittent reception + (b) Repeat count required for identifying the opposite party of communication

  (a) Count required for a wait for intermittent reception: Differs depending on the receiving cycle and modulation rate.
  (b) Repeat count required for identifying the opposite party of communication: Differs depending on the number of channels to be used.

- The repeat transmission count N is shown in the following table. For reference, the transmission time of the repeat transmission division is shown.

When using 3 channels

Intermittent cycle (sec.)	4800bps		2400bps	
	Repeat transmission count (times)	Repeat transmission time (sec.)	Repeat transmission count (times)	Repeat transmission time (sec.)
0 (continuous)	12	0.4	9	0.5
0.5	30	0.9	18	1.0
1.0	55	1.6	32	1.8
1.5	72	2.1	41	2.3
2.0	90	2.6	50	2.8
3.0	125	3.5	67	3.8
5.0	196	5.6	103	5.8
15.0	549	15.6	279	15.8
25.0	902	25.6	456	25.8
35.0	1,255	35.6	632	35.8

When using 5 channels

Intermittent cycle (sec.)	4800bps		2400bps	
	Repeat transmission count (times)	Repeat transmission time (sec.)	Repeat transmission count (times)	Repeat transmission time (sec.)
0 (continuous)	19	0.5	15	0.9
0.5	37	1.1	24	1.4
1.0	65	1.9	40	2.3
1.5	83	2.4	49	2.8
2.0	100	2.8	58	3.3
3.0	135	3.8	75	4.3
5.0	206	5.8	111	6.3
15.0	559	15.8	287	16.3
25.0	912	25.8	464	26.3
35.0	1,265	35.8	640	36.3

(2) Scramble code conversion

- For data 1 and data 2, data having continuous same bits (for example, 0×00 and 0×FF) is often used. Because tens of bits to hundreds of bits having continuous “0” and “1” are not desirable as radio communication characteristics, scramble conversion is performed for diffusion.
- For scramble code conversion, an XOR (exclusive OR) with a pseudo random code (M series code) is used.
- At transmission, an error control code is added and XOR is performed with the scramble code. At reception, XOR is performed with the scramble code, and then error control is exerted.

- Error detection/correction (details are provided in Section 4.4.3) is performed in units of 32 bits. Accordingly, the scramble code conversion shall be in units of 32 bits.

Example of scramble code conversion

Transmitting side

[Data with an error control code (a)] → [Data that has undergone scramble processing (c)] → Transmit processing

(a) Data with an error control code : **00000000000000001111111111111111**
(b) Scramble code : **11011010011000001110010001010110**
(c) Data that has undergone scramble processing : **11011010011000000001101110101001**
(c) = (a) XOR (b)

Transmission → Reception

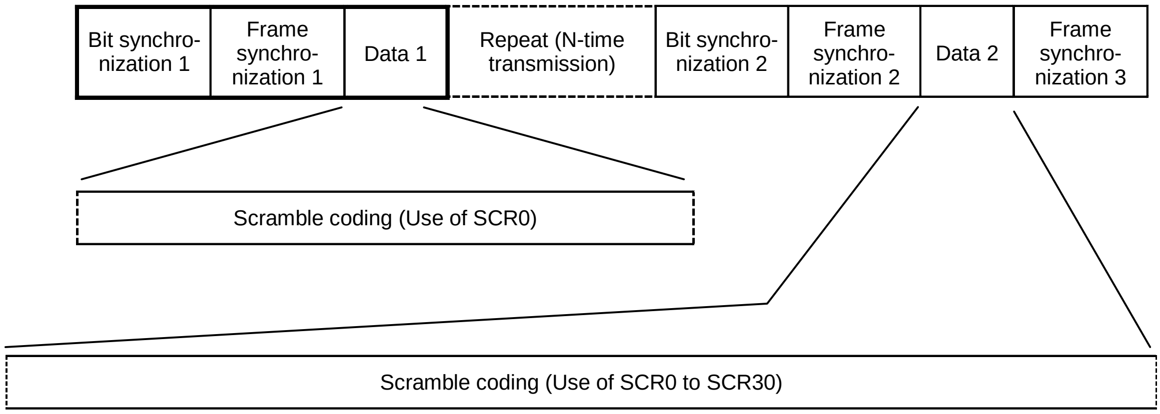
Receiving side

[Received data (d)] → [Data that has undergone scramble processing (f)] → Received contents analyze processing

(d) Received data : **11011010011000000001101110101001**
(e) Scramble code : **11011010011000001110010001010110**
(f) Data that has undergone scramble processing : **00000000000000001111111111111111**

(f) = (d) XOR (e) = (a) holds.

- The scramble code shall be of 32 bits or 31-bit pseudo random code + 1 bit “0”, as shown in the table below. There are 31 different scramble codes with different 31-bit pseudo random code divisions.
- Usually, the common scramble code SCR0 is used for all radio systems. If required, it is possible to select a different scramble code for each radio system from SCR1 to SCR30. At this time, if the same scramble code is not available between the transmitting device and the receiving device, the contents of communication are confidential.
- Set a different scramble code for each radio system in the initial settings for the radio system. The default shall be SRC0.
- The data 1 division shall use the scramble code SCR0 and the data 2 division shall use one scramble code selected from the scramble codes SCR0 to SCR30. For communication by the channel for system setup, only SCR0 shall be used as the scramble code.



Scramble Code List

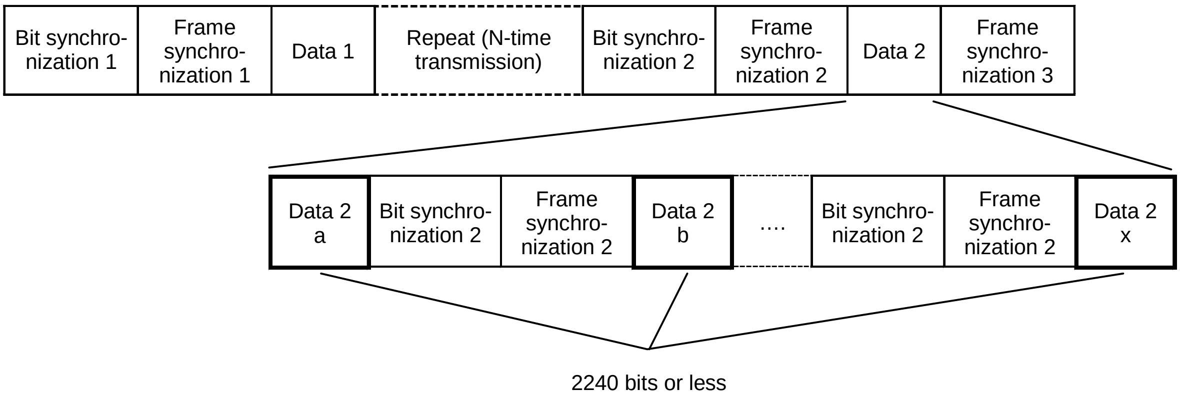
	High-order Lower-layer
SCR0	1101101001100000111001000101010110
SCR1	1110110100110000011100100010101010
SCR2	1111011010011000001110010001010100
SCR3	0111101101001100000111001000101010
SCR4	1011111011010011000001110010001000100
SCR5	0101111101101001100000111001000100010
SCR6	1010111110110100110000011100100010000
SCR7	0101011111011010011000001110010001000
SCR8	0010101111101101001100000111001000100
SCR9	0001010111110110100110000011100100010
SCR10	1000101011111011010011000001110001000
SCR11	0100010101111101101001100000111000100
SCR12	0010001010111110110100110000011100010
SCR13	1001000101011111011010011000001100010
SCR14	1100100010101111101101001100000100010
SCR15	1110010001010111110110100110000000000
SCR16	0111001000101011111011010011000000000
SCR17	0011100100010101111101101001100000000
SCR18	0001110010001010111110110100110000000
SCR19	0000111001000101011111011010011000000
SCR20	0000011100100010101111101101001100000
SCR21	1000001110010001010111110110100100000
SCR22	1100000111001000101011111011010000000
SCR23	0110000011100100010101111101101000000
SCR24	0011000001110010001010111110110100000
SCR25	1001100000111001000101011111011000000
SCR26	0100110000011100100010101111101100000
SCR27	1010011000001110010001010111110100000
SCR28	1101001100000111001000101011111000000
SCR29	0110100110000011100100010101111100000
SCR30	1011010011000001110010001010111100000

(3) Block division of data 2

When the data to be received is long, the receiving side must perform re-synchronization halfway to correct synchronization error.

If the allowable deviation of the modulation rate is 200 × 10^(-6), the data length that can be received by a single synchronization is about 500 bits.

In this Standard, when data 2 exceeds 2240 bits (number of bits with an added error control code), data 2 shall be divided into multiple blocks. Bit synchronization 2 and frame synchronization 2 shall be inserted between blocks.



4.4.3 Layer 2

(1) Radio system identification code

There is a unique identification code for each radio system. Radio communication is not performed between radio systems with a different identification code. For example, there may be multiple radio system identification codes in one house. When the ECHONET SUBNET is different, the radio system identification code is also different.

An optional node in the SUBNET is specified as a master node, and the radio system identification code of the master node is specified as the radio system identification code of the SUBNET. All the slave nodes are unified to the radio system identification code of the master node.

Regarding radio system identification codes, previously specified high-order bits are assigned to individual manufacturers, and the remaining bits are managed by the manufacturers to avoid duplication. The manufacturers store radio system identification codes in ROM before delivering devices with the master node function. Devices with the master node function shall also offer the slave node function by switch selection. Some devices come with only a slave node function.

To add new slave nodes to the existing radio communication system, manually write the radio system identification code of the master node into the non-volatile RAM of the slave node. When the radio system identification code has been written, the device identification code is cleared to the unset status.

For manual setting, you may use radio communication (use the channel for system setup) or wire communication for setting in addition to individual setting by using a switch for each device. The information to be set includes the radio system identification code, communication channel groups, number of channels, scramble code, and master node receiving cycle information.

For a master node change, change the radio system identification codes written in all the slave nodes in the SUBNET to the radio system identification codes owned by the new master node.

(2) Device identification code

There is a unique identification code (MAC address) for each device comprising the radio system. In the same radio system, no duplication of device identification codes is allowed. The master node manages device identification codes.

The device identification code of the master node shall be 0×01. The master node assigns 0×02 to 0×7F codes to slave nodes. However, codes 0×80 to 0×FF are already stored as provisional device identification codes in the slave nodes in the unset status. The provisional device identification codes are assigned at random on delivery from the factory.

(Setting method)

- When a device identification code is not yet set, a slave node transmits the data flag for radio system setup shown in Control code 2 in Section 4.4.3 to the master node by using the provisional device identification code as the self-office address and setting this flag under “Transmission data: None”. As a transmission channel, the ordinary channel of the communication channel group is used.
- When receiving the provisional device identification code, the master node refers to the self-domain table and issues a free device identification code.
- The master node specifies the provisional device identification code as the opposite party’s address, puts the previously issued device identification code in the data division, sets the data flag for radio system setup, and transmits it to the slave node.
- The basic communication procedure shown in Fig. 4.1 in Section 4.4.4 or the communication procedure using link connection shown in Figs. 4.2 to 4.4 is available as a communication procedure.
- The slave node that completed transmission by using the provisional device identification code receives the device identification code issued by the master node and stores it in non-volatile RAM.

(3) Identification code and broadcast communication or individual communication

The receiver checks that the received radio system identification code matches the self radio system identification code. In addition, the receiver checks that the received device identification code matches the self device identification code. In the case of a mismatch, the reception is suspended.

The identification codes requiring a match check differ depending on each communication method as shown in the following table. The information to specify either broadcast communication or individual communication for the receiver is included in control code 1 in data 1.

Communication method	Radio system identification code (48 bits)	Receiving device identification code (8 bits)
Broadcast communication	Match check	Partial match check
Individual communication	Match check	Match check

Address Setting for Broadcast Communication

Broadcast group	Device identification code on the receiving side	Information of broadcast specification to be inserted in the receiving device identification code division at transmission
0	**** 0000	**** ***1
	**** 1000	**** ***1
1	**** 0100	**** **1*
	**** 1100	**** **1*
2	**** 0010	**** *1**
	**** 1010	**** *1**
3	**** 0110	**** 1***
	**** 1110	**** 1***
4	**** 0001	***1 ****
	**** 1001	***1 ****
5	**** 0101	**1* ****
	**** 1101	**1* ****
6	**** 0011	*1** ****
	**** 1011	*1** ****
7	**** 0111	1*** ****
	**** 1111	1*** ****
Simultaneous broadcast to all groups		1111 1111

- In broadcast communication, the transmission count N of the repeat transmission division is determined by the longest intermittent cycle of the device on the receiving side in the broadcast group.

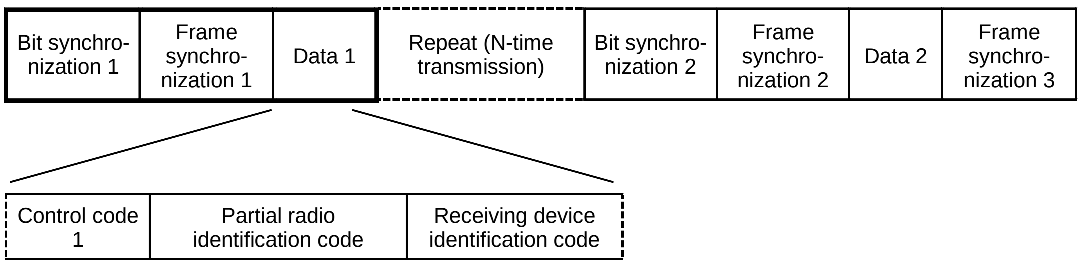
(4) Error detection/correction

- Error control is exerted in data 1 and data 2.
- BCH (31, 16) is used for error control. To a 16-bit transmit signal, a 15-bit BHC error control code and a 1-bit even parity code are given.
- Error detection capability: Error detection can be performed for up to 5 bits out of 32 bits.
- Error correction capability: Error correction can be performed for up to 2 bits out of 32 bits.
- When received data corresponds to “error detection available” and “error correction enable”, it is received and error correction is performed. If received data corresponds to “error detection available” and “error correction disable”, the reception is suspended.

Transmit signal 16 bits	BCH error control code 15 bits	Even parity code 1 bit

(5) Data 1 structure

- 32-bit information + 32-bit error control code = 64 bits



(A) Control code 1

- 8-bit information
- Provided with the following flags

(1) Flag to indicate broadcast communication or individual communication (2 bits)

	High-order Low-order
- Broadcast communication	：1 0＊＊＊＊＊＊
- Individual communication (information transmitting signal)	：0 0＊＊＊＊＊＊
- Individual communication (ACK signal)	：0 1＊＊＊＊＊＊

(2) Flag to indicate the contents of the following partial radio system identification code (2 bits)

16 high-order bits/16 medium-order bits/16 low-order bits of 48 bits of radio system identification code. Detailed usage is described below in item (B) Partial radio system identification code.

- 16 high-order bits : ＊＊１１＊＊＊＊
- 16 medium-order bits : ＊＊１０＊＊＊＊
- 16 low-order bits : ＊＊０１＊＊＊＊

(3) Flag to indicate transmitting channel No. (3 bits)

The receiving side checks that the received channel No. matches the actual receiving channel. In the case of a mismatch, reception is suspended.

- Channel No. : ＊＊＊＊００１＊～＊＊＊＊１０１＊

429 MHz band

Channel No.	'001'	'010'	'011'	'100'	'101'
Communication channel group	Basic channel			Additional channel	
Group A	1ch	8ch	20ch	35ch	44ch
Group B	2ch	14ch	29ch	38ch	41ch
Group C	3ch	10ch	22ch	34ch	37ch
Group D	4ch	16ch	31ch	40ch	43ch
Group E	5ch	12ch	24ch	36ch	39ch
Group F	6ch	18ch	33ch	42ch	45ch
For system setup	6ch	26ch	46ch	–	–

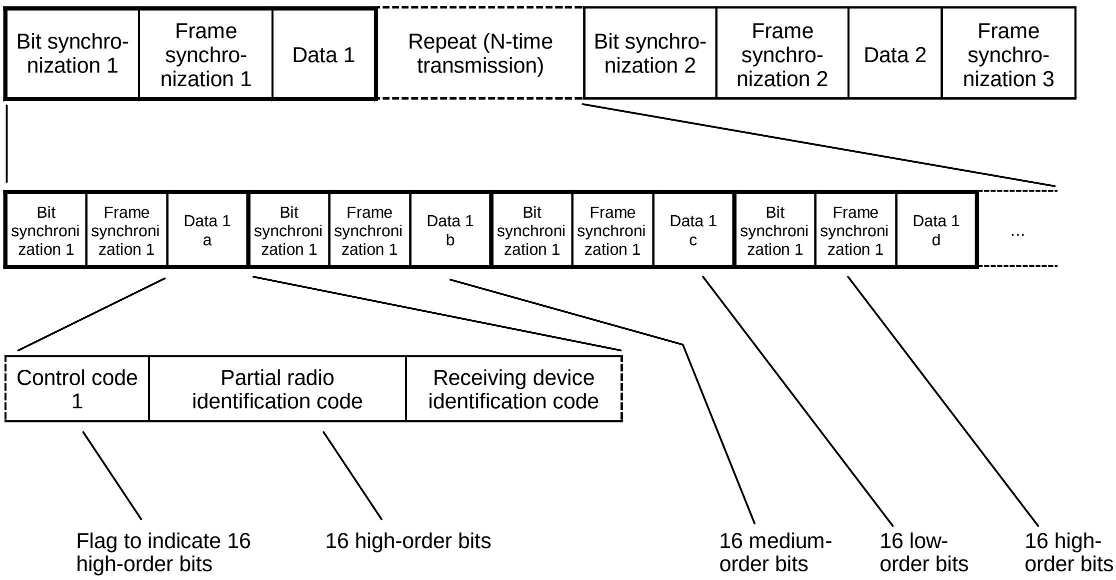
426 MHz band

Channel No.	'001'	'010'	'011'	'100'	'101'
Communication channel group	Basic channel			Additional channel	
Group A	1ch	17ch	34ch	19ch	38ch
Group B	2ch	19ch	37ch	23ch	41ch
Group C	3ch	21ch	40ch	27ch	42ch
Group D	4ch	23ch	43ch	31ch	35ch
Group E	5ch	25ch	46ch	18ch	40ch
Group F	6ch	27ch	33ch	22ch	45ch
Group G	7ch	29ch	36ch	26ch	34ch
Group H	8ch	31ch	39ch	30ch	37ch
Group I	9ch	18ch	42ch	17ch	44ch
Group J	10ch	20ch	45ch	21ch	36ch
Group K	11ch	22ch	48ch	25ch	43ch
Group L	12ch	24ch	35ch	29ch	48ch
Group M	13ch	26ch	38ch	20ch	33ch
Group N	14ch	28ch	41ch	24ch	39ch
Group O	15ch	30ch	44ch	28ch	46ch
For system setup	16ch	32ch	47ch	–	–

(4) The low-order bit of control code 1 shall be 0.

(B) Partial radio system identification code

- 16-bit information
- The transmitting side transmits 48 bits of radio system identification code divided as follows: 16 high-order bits, 16 medium-order bits, and 16 low-order bits. (Partial radio system identification code)
- In repeat transmission, transmission is performed by switching between high-order → medium-order → lower-layer → high-order → etc., (or lower-layer → medium-order → high-order → lower-layer → etc.) and the partial radio system identification code.
- With received control code 1, the receiving side judges whether the partial radio system identification code is high-order/medium-order/lower-layer or not and checks that it matches the corresponding portion of the radio system identification code owned by it. In the case of a mismatch, reception is suspended.



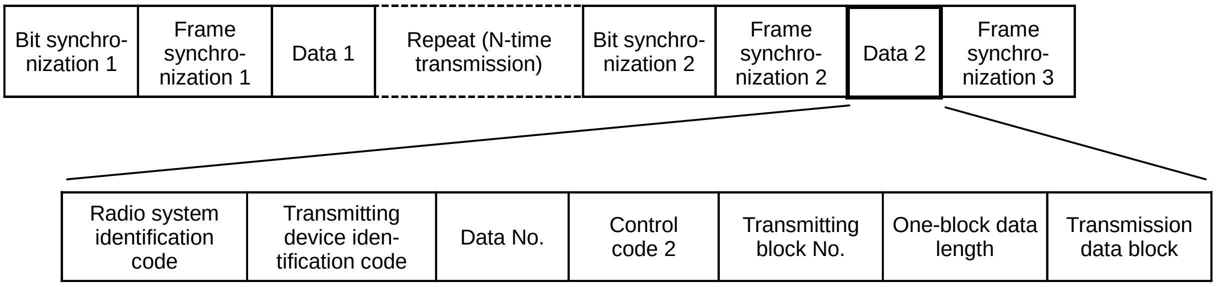
(C) Receiving device identification code

- 8-bit information
- The transmitting side sends the device identification code of the opposite party of communication.
- In individual communication, the receiving side checks that the received receiving device identification code matches the device identification code owned by it. In the case of a mismatch, reception is suspended.

- In broadcast communication, the receiving side checks that the received receiving device identification code specification matches the 4 low-order bits of the device identification code owned by it. In the case of a mismatch, reception is suspended.

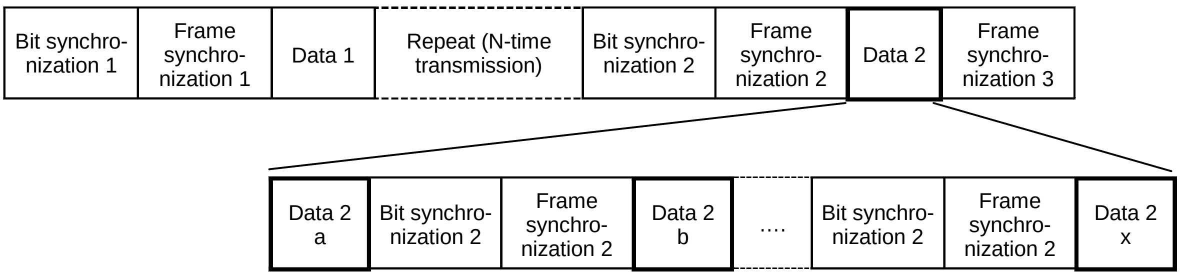
(6) Data 2 structure

- Information of up to 1120 bits + Error control code of up to 1120 bits = 2240 bits max.
- The data structure differs for lump transmission of information transmitting signal, block-divided transmission of information transmitting signal, and ACK signal.
- Lump transmission of information transmitting signal



- Block-divided transmission of information transmitting signal

  When the signal is divided into blocks, data 2 of the beginning block is the same as lump transmission. In and after the second block, the radio system identification code, transmitting device identification code, data No., and control code 2 are omitted.



Data 2a

Radio system identification code	Transmitting device identification code	Data No.	Control code 2	Transmitting block No.	One-block data length	Transmission data block

Data 2b to data 2x

Transmitting block No.	One-block data length	Transmission data block

- ACK signal

  Basically, this is the same as lump transmission. The ACK data has a fixed length, so "One-block data length" is omitted. Instead of transmitting block No., a resend request block is included and used for block-divided transmission.

Bit synchronization 1	Frame synchronization 1	Data 1	Repeat (N-time transmission)	Bit synchronization 2	Frame synchronization 2	Data 2

Data 2:

Radio system identification code	Transmitting device identification code	Data No.	Control code 2	Resend request block No.	ACK data

(A) Radio system identification code
- 48-bit information
- The transmitting side sends its 48 bits of radio system identification code.
- The receiving side checks that the received radio system identification code matches the radio system identification code owned by it. In the case of a mismatch, reception is suspended.

(B) Transmitting device identification code
- 8-bit information
- The transmitting side sends its device identification code.
- The receiving side obtains the information transmitting signal or the identification code of the device that transmitted the ACK signal.

(C) Data No.

- 8-bit information
- The receiving side checks duplicate reception at re-transmission by the data No. If the same data No. is received from the same opposite party of communication in succession, the received data is not notified to the high-order layer (higher than the lower-layer communications software in the communication layers).
- The transmitting side changes the data No. each time new transmission data is transmitted. For example, suppose that the previously transmitted or received data number is +1. The data number for re-transmission shall be the same as that previously transmitted.
- When the data No. exceeds 0×FF, it is returned to 0×00.

(D) Control code 2

- 16-bit information
- Provided with the following flags. For detailed usage, see Section 4.4.4.

(1) Flag to indicate whether a request for link connection exists or not in the communication procedure (2 bits)

	High-order Low-order
- Link connection data	: ＊＊＊＊＊＊＊＊＊＊1 0＊＊＊＊＊
- Link disconnection data	: ＊＊＊＊＊＊＊＊＊＊0 1＊＊＊＊＊
- Linking data	: ＊＊＊＊＊＊＊＊＊＊0 0＊＊＊＊＊
- Single-shot data (without link)	: ＊＊＊＊＊＊＊＊＊＊1 1＊＊＊＊＊

(2) Flag to indicate whether the request for the return of the ACK signal is made to the receiving side (1 bit)

- Request for ACK signal : ＊＊＊＊＊＊＊＊＊＊＊＊1＊＊＊＊
- No request for ACK signal : ＊＊＊＊＊＊＊＊＊＊＊＊0＊＊＊＊

(3) Flag to indicate whether the request for a return of the information transmitting signal is made to the receiving side

- Request for a return : ＊＊＊＊＊＊＊＊＊＊＊＊1＊＊＊＊
- No request for a return : ＊＊＊＊＊＊＊＊＊＊＊＊1＊＊＊＊

(4) Flag to indicate the contents of the information transmitting signal

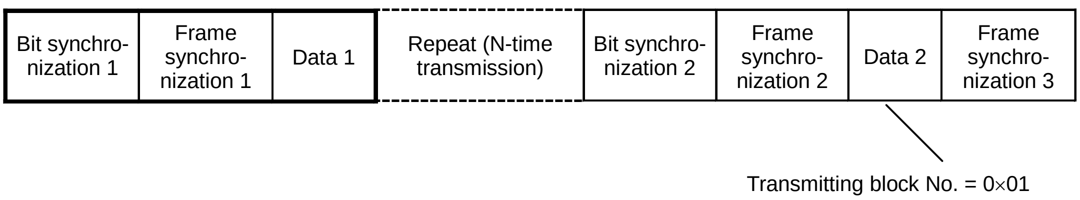
- ECHONET data : ＊＊＊＊＊＊＊＊＊＊＊＊0＊＊＊＊
- Data for radio system setup : ＊＊＊＊＊＊＊＊＊＊＊＊1＊＊＊＊

(5) Other bits shall be reserved and set to 0.

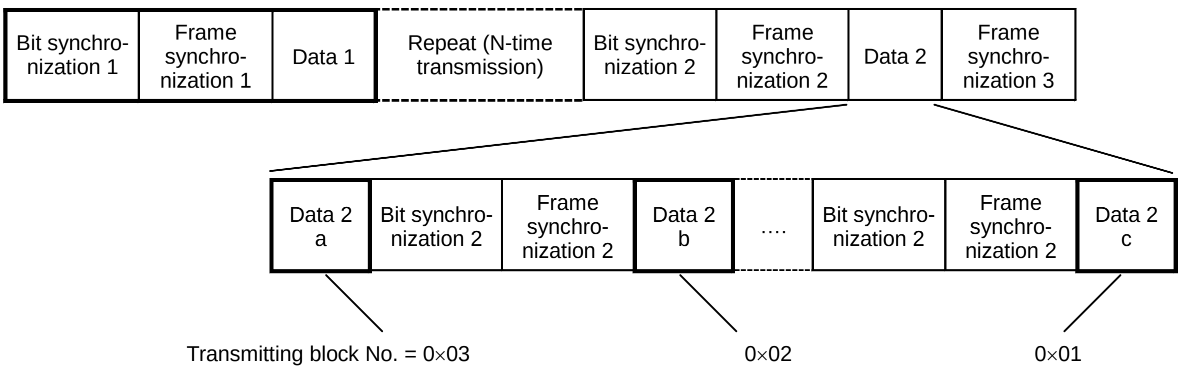
(E) Transmitting block No.

- 8-bit information
- The transmitting block No. indicates the number of remaining transmission data blocks to be received.
- 0×01 for lump transmission of data 2
- For block-divided transmission of data 2, the number becomes a decrement value during transmission, as shown in the figure below, and the last transmission data block is 0×01.
- To prevent endless reception, it is desirable that the receiving side check the decrement value of the transmitting block No. and suspend reception if the check result is not normal.

<Example 1> When transmitting data 2 in a lump transmission



<Example 2> When transmitting data 2 in 3-divided form



(F) One-block data length

- 8-bit information
- The transmission data length (not including the error control code) in the next transmitting data block is included in units of bytes for transmission.
- The data length of one block is 1 byte to 128 bytes.
- When “0×00” is set in a one-block data length, the subsequent transmission data block does not exist.

(G) Transmission data block

- 2024 bits (256 bytes) max.
- The information volume to be transmitted by the high-order layer (higher than the lower-layer communications software in the communication layers) shall be in units of 8 bits and the transmission data block shall be up to 1024 (128 bytes).
- To each 8-bit transmission data x 2 units (= 16 bits), a 16-bit error control code shall be added.
- When the transmission data is of an odd number of bytes, [0] of 8 bits is added to the end into 16 bits for transmission. The receiving side judges this depending on whether the data length of one block is odd or even.

(H) Resend request block No.

- 8-bit information
- 0×00 for no receive error.
- In the ACK signal during block-divided transmission, the beginning number of the transmission data block for the resend request shall be sent.
  0×00 for no receive error.
- The receiving side that received the resend request by the ACK signal resends the transmission data blocks subsequent to the resend request block No. Details are provided below in item (7) Transmitting block No. and resend request block No.

(I) ACK data

- 8-bit information
- 0×06 for normal reception. (ACK)
- 0×15 upon occurrence of a receive error at block-divided transmission. (NAK)

(7) Duplication check for radio system identification code and device identification code

To make a duplication check for radio system identification code and device identification code, we recommend that in broadcast communication, the receiving side check that the received transmitting device identification code matches its own device identification code and reports it by some means.

(8) Transmitting block No. and resend request block No.

Usually, when the received information transmitting signal corresponds to “error detection available” and “error correction disable”, the receiving side does not send back the ACK signal but waits for re-transmission from the transmitting side. However, if the transmission data volume is substantial and block-divided transmission must be performed, the following ACK signal shall be transmitted to shorten the data to be resent under “error detection available” and “error correction disable”.

The receiving side of the information transmitting signal sends the resend request block No. of the data transmitting block, together with the resend request block No. in the ACK signal to be resent to the transmitting side. If no resend request is made, the block No. is 0×00.

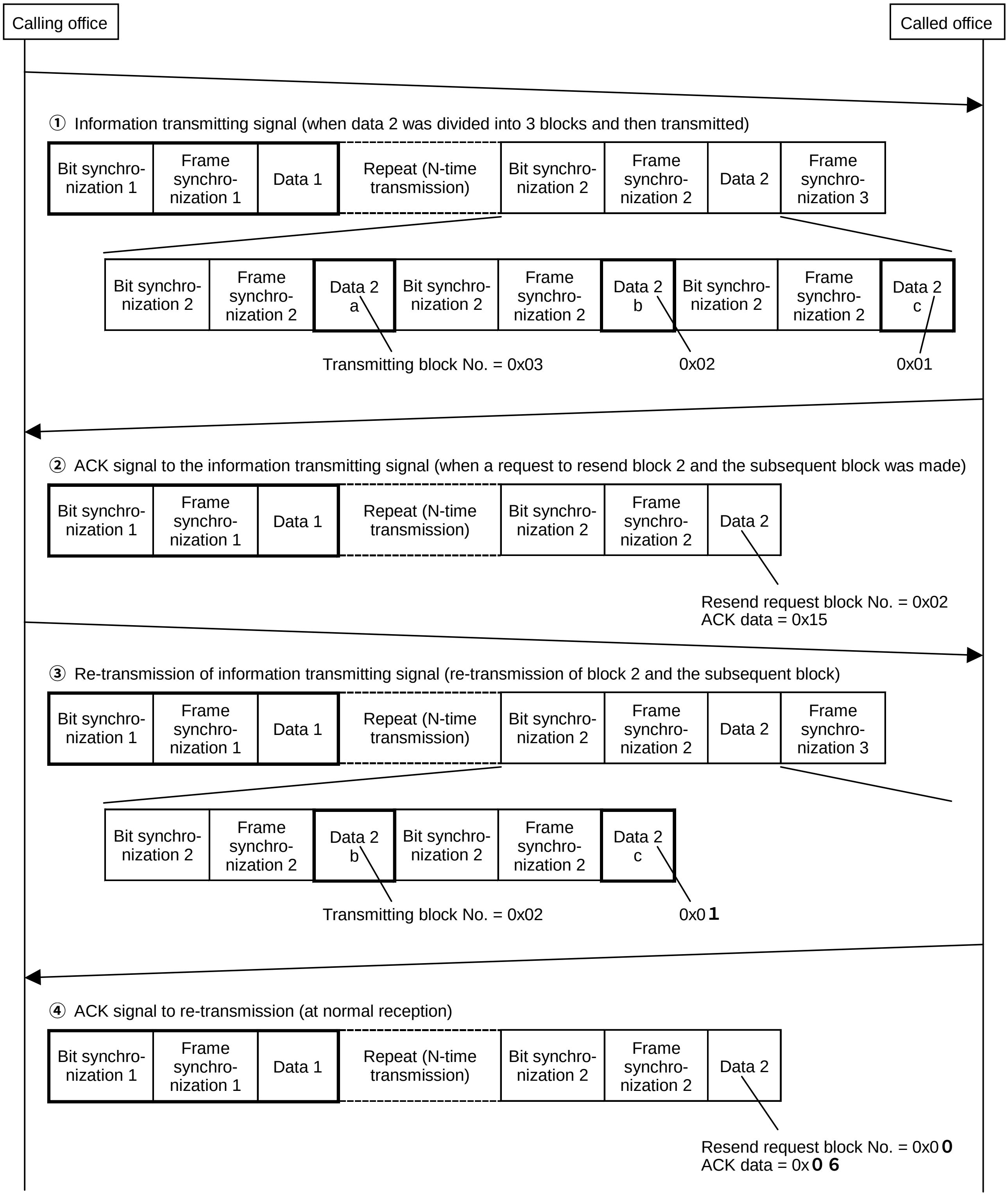
The transmitting side of the information transmitting signal that received this ACK signal resends the data transmitting blocks subsequent to the resent request block No. in the ACK signal.

The receiving side of the information transmitting signal receives this re-transmission and integrates it with the previous received contents on the basis of the data transmitting block No.

However, even in block-divided transmission, if the first block corresponds to “error detection available” and “error correction disable”, the receiving side does not send back the ACK signal but waits for re-transmission.

The re-transmission of the information transmitting signal to the ACK signal of the resend request is the same as ordinary resend processing. In this case, the data No. shall be the same as the data No. that was previously transmitted.

<Example> Data 2 was divided into 3 blocks and then transmitted. A request to resend block 2 and the subsequent block was made. As a result of re-transmission, all 3 blocks have been received.



(8) Communication time and transmission data volume (for reference)

The reference values for the data (transmission data) volume to be transmitted by the high-order layer (higher than the lower-layer communications software in the communication layers) and transmission time are shown below. The transmission time includes the repeat transmission time of bit synchronization 1 to data 1, so that it differs depending on the intermittent cycle and number of channels used on the receiving side.

In the STD-16 and STD-30, there is a limit on the transmission time, thereby limiting the volume of information that can be sent in a single transmission.

As an example, the transmission time for a case in which the transmission data is 16 bytes and 256 bytes is shown below.

(A) 429 MHz band

Transmission Time for Transmission of 16-byte Transmission Data (sec.)

Intermittent cycle (sec.)	4800bps		2400bps	
	When using 3 channels	When using 5 channels	When using 3 channels	When using 5 channels
0 (continuous)	0.5	0.7	0.8	1.2
0.5	1.0	1.2	1.3	1.7
:	:	:	:	:
X	X+0.7	X+1.0	X+1.1	X+1.6
:	:	:	:	:
35.0	35.7	36.0	36.1	36.6

X≧1.0 sec.

Transmission Time for Transmission of 256-byte Transmission Data (sec.)

Intermittent cycle (sec.)	4800bps		2400bps	
	When using 3 channels	When using 5 channels	When using 3 channels	When using 5 channels
0 (continuous)	1.3	1.5	2.5	2.8
0.5	1.8	2.0	3.0	3.3
:	:	:	:	:
X	X+1.5	X+1.8	X+2.8	X+3.2
:	:	:	:	:
35.0	36.5	36.8	37.8	38.2

X≧1.0 sec.

(B) 426 MHz band

Transmission Time for Transmission of 16-byte Transmission Data (sec.)

Intermittent cycle (sec.)	4800bps		2400bps	
	When using 3 channels	When using 5 channels	When using 3 channels	When using 5 channels
0 (continuous)	0.5	0.7	0.8	1.2
0.5	1.0	1.2	1.3	1.7
1.0	1.8	2.0	2.1	2.6
1.5	2.3	2.5	2.7	***3.1***
2.0	2.8	3.0	***3.2***	***3.6***

Because the oblique font part exceeds the transmission time limit, 16 bytes cannot be transmitted.

Transmission Time for Transmission of 256-byte Transmission Data (sec.)

Intermittent cycle (sec.)	4800bps		2400bps	
	When using 3 channels	When using 5 channels	When using 3 channels	When using 5 channels
0 (continuous)	1.3	1.5	2.5	2.8
0.5	1.8	2.0	3.0	***3.3***
1.0	2.6	2.8	***3.8***	***4.2***

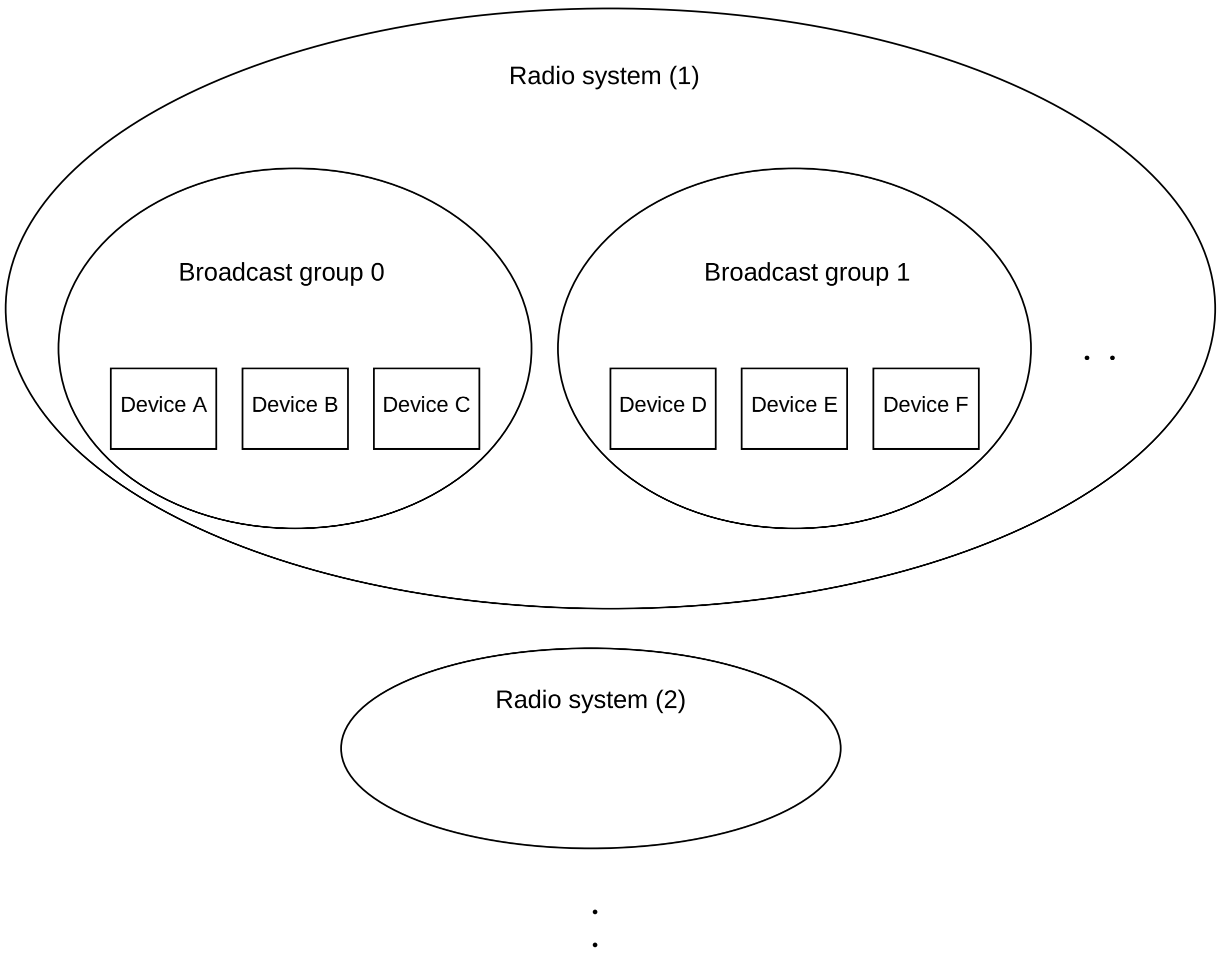
Because the oblique font part exceeds the transmission time limit, 256 bytes cannot be transmitted.

(9) Overall system configuration

In the radio system, the system identification code, communication channel groups, number of channels, and scramble code to be provided by each device shall be common. Using simultaneous broadcast communication enables the devices in the same radio system to receive data simultaneously.

Groups sharing the 3 low-order bits of the device identification code shall be specified as broadcast groups. Using group broadcast communication enables the devices in a specified broadcast group to receive data simultaneously.

In the case of radio devices, the device identification code to be prepared for each device differs with the device. The receiving cycle can be different for each device. Using individual communication enables only a specified device to receive data.



4.4.4 Layer 3

(1) Individual communication

(A) Basic procedure

When communication is performed between a calling office and a called office in 1:1 form, this is called individual communication. Fig. 4.1 shows a basic communication procedure. In this figure, “high-order” means higher than the lower-layer communications software in the communication layers. This corresponds to the portion that is higher than the ECHONET communications middleware. The numbers ((1) (2) ...) described in the data in the radio communication section indicates the data number (see Section 4.4.3). The data number is given as an example only.

The data to be transmitted is created by the high-order portion. The low-power radio unit on the calling office side transmits the created data according to the request to send (a) and notifies the high-order portion whether the transmission has been successful ((1) Information transmission in the figure). ((b) Notice of transmission.)

When receiving the transmitted signal correctly, the low-power radio unit on the called office side informs the high-order portion of the received contents ((c) Notice of received contents) and also transmits the ACK signal to the calling office ((2) ACK signal). In Fig. 4.1, (2) ACK signal is transmitted after (c) Notice of received contents. However, this order may be reversed. The calling office side receives the ACK signal transmitted from the called office side, transfers (d) Notice of reception to the high-order portion, and informs the high-order portion that the called office side received the data.

The data ((1) Information transmission) transmitted from the calling office side includes frame synchronization 3, and the corresponding channel is secured while the receiving side prepares for the ACK signal (see Section 4.4.2). In the transmitting operation for a return of the ACK signal, the same channel as the data (1) transmitted from the calling office has priority, and carrier sense is executed for transmission.

Single data transmission is completed according to the above procedure.

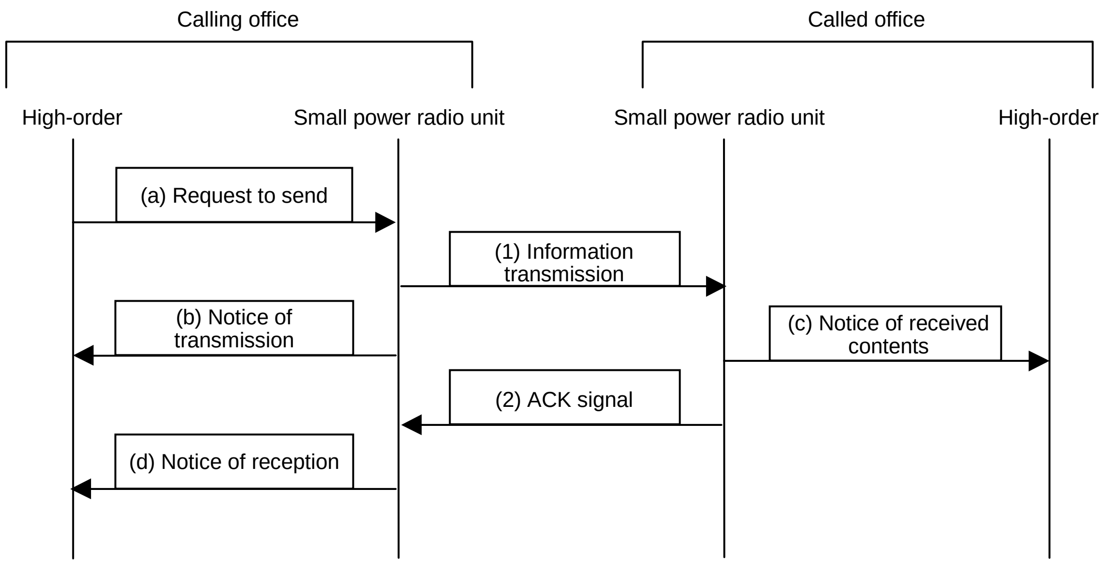


Fig. 4.1 Basic Communication Procedure

(B) Link connection

When continuous multiple communications are performed in the form of 1 calling office:1 called office, link establishment shall be enabled between the calling office and the called office to increase communication efficiency. This link establishment means that (1) Opposite party of communication is fixed by the low-power radio unit, and (2)Switching is performed to a wait for continuous reception at wait for intermittent reception. In particular, at a wait for intermittent reception, the frequency of the repeat transmission division is raised and the data length increased by the data of the basic procedure. Link establishment can minimize the frequency of the repeat transmission division.

For link establishment, a link connection is made between the calling office and the called office. Fig. 4.2 shows a communication procedure at a link connection. In the data in the radio communication section in Fig. 4.2, “Link connection: Yes”, “ACK request: No”, etc. are described in a shortened form of flag information in control code 2 in data 2.

For example:

“Link connection: Yes” means “In control code 2, the flag to indicate the request for radio link connection is set to Yes”.

“ACK request: No” means “In control code 2, the flag to indicate the request for ACK signal transmission is set to No”.

“Transmission data: No” means that the transmission is performed with a one-block data length of “0x00” (see Section 4.4.3).

As shown in Fig. 4.2, the ACK signal is not sent back to link connection data (1). Usually, after link establishment, the calling side transmits information according to the communication procedure shown in Fig. 4.3.

(C) Link establishment

In the link establishment status, communication is performed according to the procedure shown in (A) Basic procedure. The communication procedure in the link establishment status is shown in Fig. 4.3. In the link establishment status, efficient communication can be performed because of a wait for continuous reception.

(D) Link disconnection

To terminate link establishment, link disconnection is performed between the calling office and the called office. The communication procedure at link disconnection is shown in Fig. 4.4. As a result of link disconnection, the low-power radio unit clears the fixed status of the opposite party of communication and returns the cycle of wait for reception to the cycle previous to the link establishment.

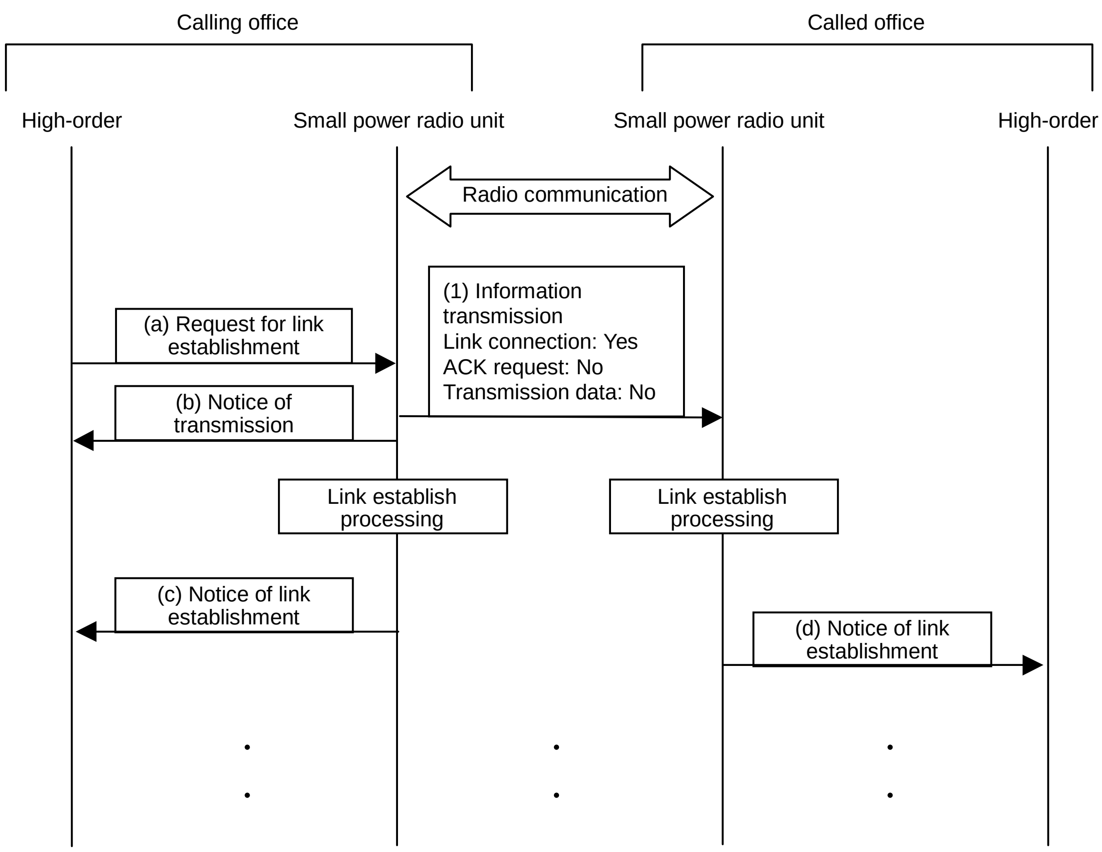


Fig. 4.2 Communication Procedure at Link Connection

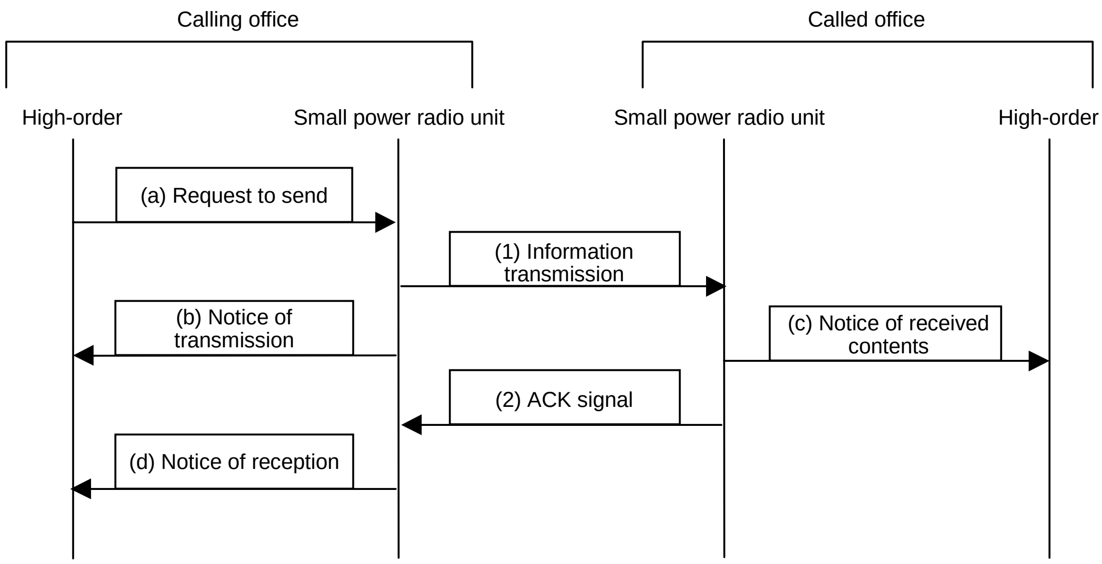


Fig. 4.3 Communication Procedure in the Link Establishment Status

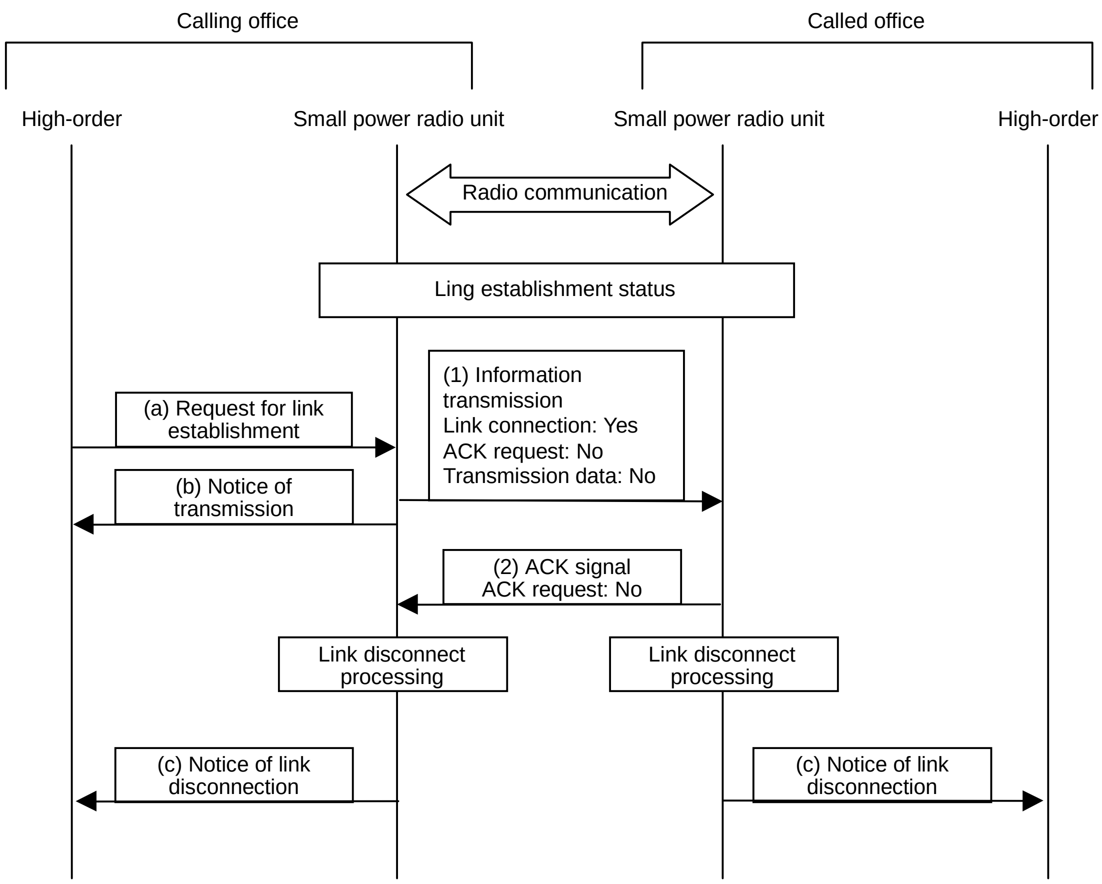


Fig. 4.4 Communication Procedure at Link Disconnection

(2) Broadcast communication

When communication is performed between a calling office and called offices in the form of 1:N, this is called broadcast communication. Fig. 4.5 shows a communication procedure.

The control codes for the data to be transmitted from the calling office are set as follows:

Control code 1:

Opposite party classification: Broadcast communication

Control code 2:

Flag to indicate the request for ACK signal transmission: No

Flag to indicate the request for a return of information transmitting signal: No

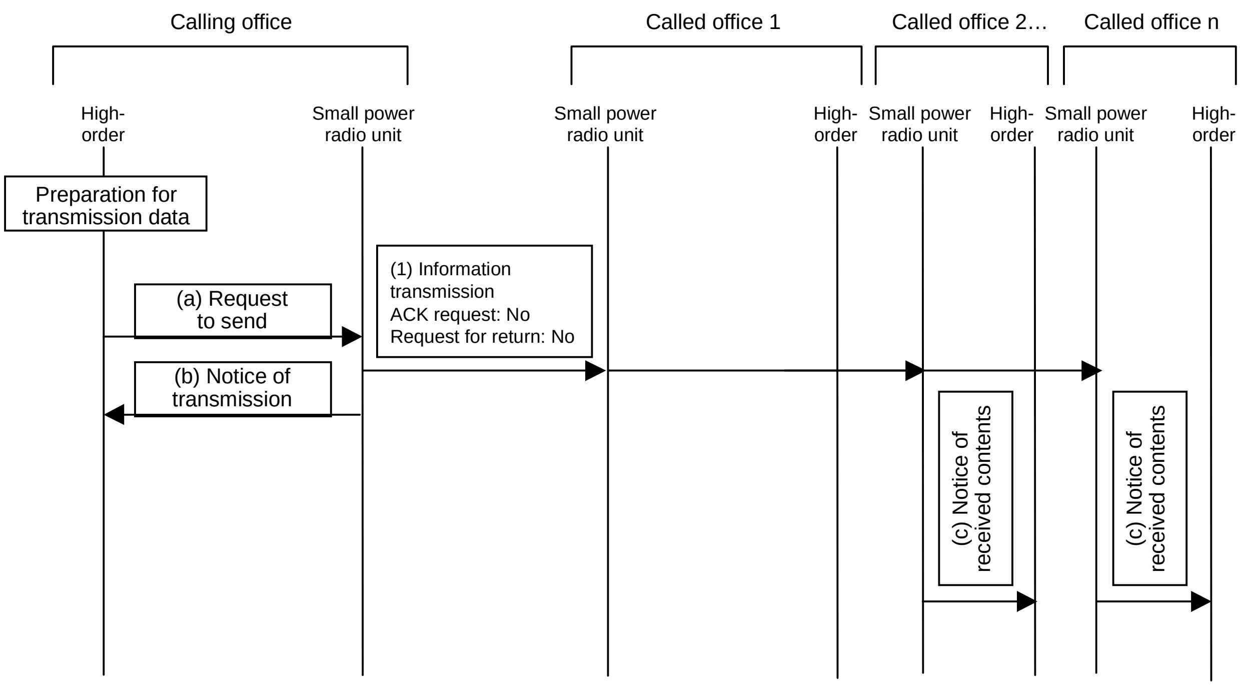


Fig. 4.5 Broadcast Communication

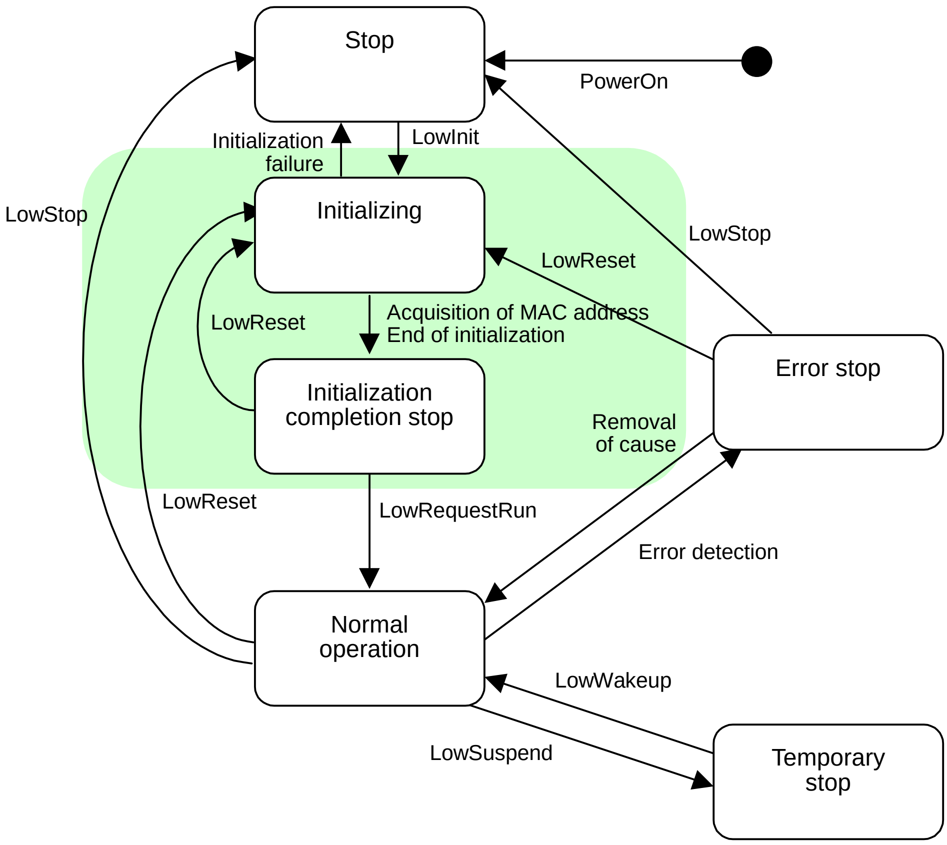
4.5 Basic Sequence

4.5.1 Basic concept

This subsection classifies the discrete lower-layer communications software status as shown below, and describes an outline of the sequence in each status.

① Stop status
② Initialize processing status
③ Normal operation status
④ Error stop status

The following figure shows the state transition diagram for each status.



4.5.2 Stop Status

The stop status signifies a status where no lower-layer communications software operations are performed. This status is provided immediately after Power On. An outline of processing immediately after state transition and an outline of Individual Lower-layer Communication Interface services that the stop status receives and its processing are described below.

(1) Trigger and action

Waits for a Individual Lower-layer Communication Interface service.

(2) Status acquisition service (LowGetStatus)

Returns LOW_STS_STOP as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)

Sends back the stop status as status.

The following is a trigger to perform state transition.

(1) Transition trigger to the initialize processing status

Transition is caused by an initialization service (LowInit).

4.5.3 Initialize processing status

The initialize processing status signifies that the lower-layer communications software is initialized.

An outline of processing immediately after state transition and an outline of Individual Lower-layer Communication Interface services that the initialize processing status receives and its processing are described below.

(1) Trigger and action

① Initializes the transceiver.

② Obtains a unique MAC address in the SUBNET.

③ Obtains a radio system identification code.

(2) Status acquisition service (LowGetStatus)

Return LOW_STS_INIT as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)

Return the operating status as status.

The trigger for state transition is shown below.

(1) Transition trigger to the initialization completion stop status

Transition is caused by initializing the transceiver, getting a MAC address, and getting a radio system identification code.

4.5.4 Initialization completion stop status

The initialization completion stop status signifies a status waiting for a request for operation start from the communications middleware after the lower-layer communications software is initialized. An outline of processing immediately after state transition and an outline of Individual Lower-layer Communication Interface services that the initialization completion stop status receives and its processing are described below.

(1) Trigger and action

Waits for Individual Lower-layer Communication Interface service.

(2) Status acquisition service (LowGetStatus)

Returns LOW_STS_INIT as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)

Returns the operating status as status.

(4) Physical address acquisition service (LowGetMacAddress)

Returns a MAC address.

(5) Profile data acquisition service (LowGetProData)

Returns profile data.

The trigger to perform state transition is shown below.

(1) Transition trigger to the normal operation status

Transition is caused by the operation start instruction service (LowRequestRun).

4.5.5 Normal operation status

The normal operation status signifies a status where data is transmitted to or received from a transmission medium as the primary function of the lower-layer communications software. An outline of processing immediately after state transition and an outline of the Individual Lower-layer Communication Interface services that the normal operation status receives and its processing are described below.

(1) Trigger and action

Waits for the Individual Lower-layer Communication Interface service.

(2) Status acquisition service (LowGetStatus)

Returns LOW_STS_RUN as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)

Returns the operating status as status.

(4) Physical address acquisition service (LowGetMacAddress)

Returns a MAC address.

(5) Profile data acquisition service (LowGetProData)

Returns profile data.

(6) Data transmission service (LowSendData)

Translates the received protocol difference absorption processing block data into lower-layer communications software data and outputs it to the transmission medium.

(7) Data reception service (LowRecvData)

Translates the lower-layer communications software data received from the transmission medium into the protocol difference absorption processing block data and outputs it to the protocol difference absorption processing block.

The following are triggers to perform state transition.

(1) Transition trigger to the stop status

Transition is caused by the end service (LowReset).

(2) Transition trigger to the initialize processing status

Transition is caused by the reset instruction service (LowReset).

(3) Transition trigger to the error stop status

Transition is caused by the occurrence of an error.

4.5.6 Error stop status

The error stop status signifies a status where operation is stopped by the occurrence of an error. An outline of processing immediately after state transition and an outline of the Individual Lower-layer Communication Interface services that the error stop status receives and its processing are described below.

(1) Trigger and action
Performs error processing.

(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_SUSPEND as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)
Returns the stop status as status.

The following are triggers to perform state transition.

(1) Transition trigger to the stop status
Transition is caused by the end service (LowStop).

(2) Transition trigger to the initialize processing status
Transition is caused by the reset instruction service (LowReset).

(3) Transition trigger to the normal operation status
Transition is caused by removing the cause of the error.

4.5.7 Suspension status

The suspension status signifies a status where operation is paused by an instruction from the communications middleware. An outline of processing immediately after state transition and an outline of the Individual Lower-layer Communication Interface services and its processing are described below.

(1) Trigger and action
Stops the operation of the lower-layer communications software.

(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_SUSPEND as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)
Returns the stop status as status.

The following are triggers to perform state transition.

(1) Transition trigger to the normal operation status
Transition is caused by the operation restart service (LowWakeUp).

Chapter 5 Extended HBS Communication Protocol Specification

5.1 System Overview

This specification provides the extended HBS communication protocol for pair cable as an ECHONET transmission medium. The specification of the communication protocol to be used for this medium was already established in 1988 as “ET-2101 Home Bus System (HBS)” by the Electronic Industries Association of Japan (EIAJ). After that, “Addresses and Commands related to AVC Service of the ET-2012 Home Bus System” was released in January 1990, and “ET-2101-1 Home Bus System (Supplement)” was published in November 1990. The EIAJ standard specifies “Twisted pair cable” and “Coaxial cable” as transmission media.

As the basic policy, if standards established in the past are available and still effective, ECHONET uses them where applicable. The EIAJ standard includes layers 1 to 7 in respect of the OSI communication layer configuration as well as multiple information channels for the transmission of AV video and audio, in addition to equipment control channels. We have decided to adopt the lower-layer layers (layers 1 to 3) and provisions on control channels and part of the provisions of layer 7 as the pair cable protocol for ECHONET. However, the ET-2101 standard relates to specifications of the lower-layer medium specifying the co-existence of both CT and AVC systems (as concrete examples, the mounting of four sets of twisted pair cables, the use of an 8-pin modular jack as a connector, etc.) and includes some excessive specifications for actual system construction that limits the equipment system. When adopting the ECHONET Standard, new provisions have been added for these portions, and additional provisions have been specified for insufficient portions.

In the following sections in this Chapter, the applicable portions have been extracted from the ET-2101 Standard, and new portions have been added. The principal differences from the ET-2101 are mentioned below.

(1) Regarding the number of pairs of twisted pair cable, one pair is allowed.

(2) On the information regarding socket shape, a screw-fixing specification has been added in addition to the 8-pin modular jack.

(3) The allowable transmission distance (cable length) for pair cables is 1 km, and specifications for the related signal levels have been added.

(4) The data area specifications, including command specifications (related to layer 7), are newly provided as the extended HBS. However, as the basic concept, ET-2101 specifications are followed whenever possible.

(5) New specifications are added for address redundancy detection.

5.2 Mechanical and Physical Characteristics

The following six items are specified as mechanical and physical specifications for the extended HBS. For specifications 3) and 5), the EIAJ ET-2101 Standard (HBS standard) shall be fully applied. In and after this section, the applicable specifications are shown.

Note: Principal differences from the ET-2101 Standard

1) In the specifications for pair cables, one pair shall also be allowed.
2) In consideration of medium and small buildings, a maximum length of 1 km shall be allowed.
5) Because a specification for the number of pairs of pair cables has been added, a specification for information sockets corresponding to the addition has also been added.

1) Transmission media and number of transmission pairs
   - The ET-2101 Standard "3.1.1 Transmission media and number of transmission pairs" is applied, and a part is additionally specified.
   - The details shall be specified in "7.2.1 Transmission media and number of transmission pairs".

2) Cable length
   - The ET-2101 Standard "3.12 Cable length" is applied and a part is additionally specified.
   - The details are specified in "7.2.2 Cable length".

3) Topology
   - The ET-2101 Standard "3.1.3 Topology" is applied.

4) Information socket shape (including compatibility with signals)
   - The ET-1201 Standard "3.1.4 Information socket shape" and "3.1.6 Compatibility between information sockets and signals" are applied. A part is additionally specified.
   - The details are specified in "7.2.3 Information socket shape (including compatibility with signals)".

5) Number of information sockets
   - The ET-2101 Standard "3.15 Number of information sockets" is applied.

5.2.1 Transmission media and number of transmission pairs

(1) Cable type: Twisted pair cable

(2) Number of pairs: 1 pair (1 pair for control and 3 pairs for information in the case of HBS)

5.2.2 Cable length

The maximum cable length shall be 1 km per cluster. However, the applicable cable diameter is specified as follows.

Twisted pair cable length: 1 km max.	However, when the cable length is 200 m or less, the cable diameter shall be 0.65 mm. When the cable length exceeds 200 m but does not exceed 1 km, the cable diameter shall be 1.2 mm.

5.2.3 Topology

Bus system

5.2.4 Number of terminals to be connected

When the cable length is 200 m, the number of terminals to be connected shall be 64 per cluster.

When the cable length exceeds 200 m but does not exceed 1 km, the number of terminals to be connected shall be 128 per cluster. Logically, the maximum number in one system shall be 256.

5.2.5 Information socket shape (including compatibility with signals)

The ET-2101 Standards “3.1.4 Information socket shape” and “3.1.6 Compatibility between information sockets and signals” are applied. In the case of one pair of twisted pair cable, screw fixing shall be allowed.

5.2.6 Compatibility between information sockets and signals

The ET-2101 Standard “3.1.6 Compatibility between information sockets and signals” is applied.

5.3 Electrical Characteristics

With the exception of “Load resistance of control channel cable”, the ET-2101 Standard “3.2 Electrical Characteristics” is applied. In this section, regarding “Load resistance of control channel cable” to be additionally specified, the specification for the cable diameters specified in “7.2.2 Cable length” in this Section is also provided.

5.3.1 Characteristic impedance of cable

Short-conductor cable with a cable diameter of 0.65 mm:	300Ω
Short-conductor cable with a cable diameter of 1.2 mm:	150Ω
Stranded cable with a nominal sectional area of 0.75 mm^2:	200Ω

However, when the cable diameter is 1.2 mm and the nominal sectional area is 0.75 mm^2, the transmission distance shall be above 200 m up to 1 km inclusive.

5.3.2 Load resistance of control channel cable

The processing method for the load to be applied to the cable shall be as outlined below. For the load resistance, a condenser is connected in series and the direct current is cut in consideration of power feed.

(1) For a cable length of 200 m or less

A 75Ω resistor or a 39Ω load resistance is connected to the terminal.

(2) For a cable length of more than 200 m up to 1000 m inclusive

A 100Ω resistor is connected to each terminal.

5.3.3 Transmission rate of control signal

9.60kbps ± 0.13%

5.3.4 Transmission system and transmission waveform of control signal

(1) Transmission system: Base-band transmission

(2) Transmission waveform: AMI (Alternate Mark Inversion) shown in Fig. 7.1 and negative logic with a duty ratio of 50%.

The start bit of each byte shall be transmitted from the 0 (+) side for collision detection.

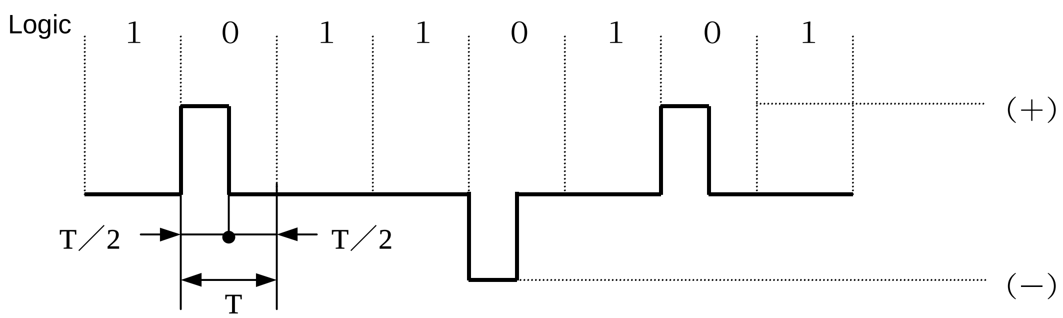


Fig. 7.1 Transmission Waveform of Control Signal

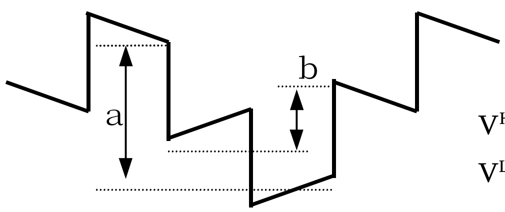
5.3.5 Transmitting/receiving level of control signal

The transmitting/receiving level of the control signal shall be as shown in Table 7.1.

Table 7.1 Transmitting/Receiving Level of Control Signal

Logic	Receiving level	Transmitting level
1	V^{LL} = 0.6 V or less	V^{LL} = 0.6 V or less
0	V^{HH} = 1.4 V or more	V^{HH} = 2.5 V or more

Note: The voltage represents the control signal level on the cable.



$V^{HH} = a/2$
$V^{LL} = b/2$

5.3.6 Impedance and power feed voltage of terminals to be connected

(1) Input impedance: 10 kΩ or more for a frequency of 5 kHz
(2) Output impedance: 40Ω or less for a frequency of 5 kHz

Remarks: In consideration of power feed, a condenser must be connected in series. The above value shall include the condenser for cutting this direct current.

5.3.7 Power feed voltage of control channel

Power feed is allowed. The maximum power feed voltage shall be 36 V DC.

5.4 Logical Layers (Layer 1 Specifications)

This section provides the logical specifications for layer 1 of the pair cable communication protocol.

As logical specifications for layer 1, the following eight items are specified. For all of these items, the EIAJ ET-2101 Standard (HBS Standard) is fully applied. An outline of the specifications is described below. (For details, see “ET-2101”.)

1) Control system
2) Synchronization system
3) Basic format of control signal
4) Pause time and pause period
5) Packet priority
6) Collision detection procedure
7) Synchronization recovery procedure
8) Short data interruption procedure

5.4.1 Control System

Survival type CSMA/CD (Carrier Sense Multiple Access with Collision Detection)

5.4.2 Synchronization system

Start-stop synchronization. The configuration shall be as follows:

(1) Character configuration: 11-bit configuration, namely, start bit (1 bit), data (8 bits), parity (1 bit), and stop bit (1 bit). The parity shall be even parity (see Fig. 7.2).
(2) Start bit transmission: (+) side
(3) Data transmission: LSB first (negative logic)
(4) Parity: Even parity
(5) Character spacing: No spacing between the stop bit and the next character

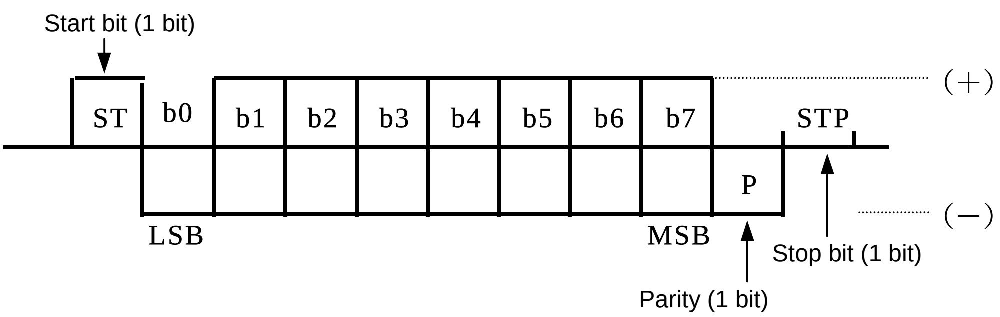
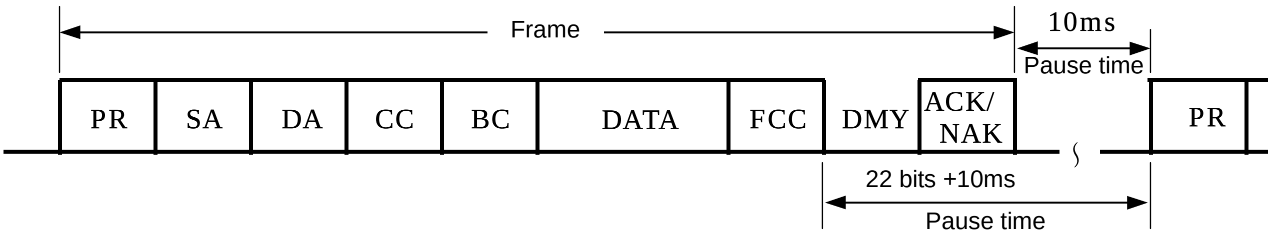


Fig. 7.2 Character Configuration

5.4.3 Basic format of control signal

Fig. 7.3 shows the basic format of the control signal.



PR(Priority)	: Priority code	(11bit)
SA(Source Address)	: Self code	(11bit)
DA(Destination Address)	: Destination code	(11bit)
CC(Control Code)	: Control code	(11bit)
BC(Byte Count)	: Data length code	(11bit)
DATA(Data Field)	: Data field	(11bit＊Max.256)
FCC(Frame Check Code)	: Frame check code	(11bit)
DMY(Dummy Code)	: Dummy	(11bit)
ACK/NAK(ACK/NAK Code)	: ACK/NAK code	(11bit)

Fig. 7.3 Basic Format of Control Signal

5.4.4 Pause time and pause period

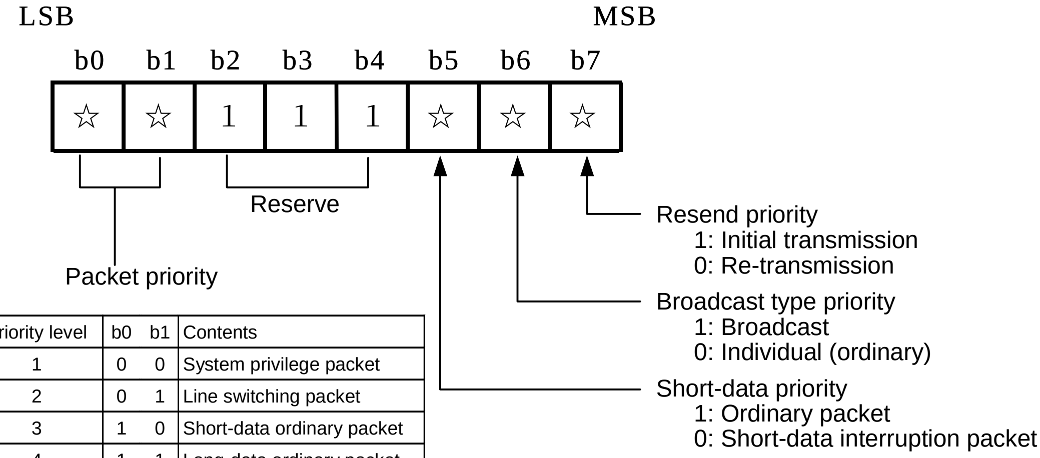
(1) Pause time: 10 ms (96-bit time) from the end of the stop bit of the ACK/NAK code

(2) Pause period: 10 ms + 22-bit time from the end of the stop bit of the check code

Note: The terminal that intends to transmit new data monitors the pause time on the bus and then transmits the data according to the synchronization recovery procedure.

5.4.5 Packet priority

Packet priority is performed by contention between the priority code PR and the self address SA. Fig. 7.4 shows a bit configuration of the priority code (for details, see ET-2101 “3.3.5 Priority code”).



Priority level	b0	b1	Contents
1	0	0	System privilege packet
2	0	1	Line switching packet
3	1	0	Short-data ordinary packet
4	1	1	Long-data ordinary packet

Fig. 7.4 Priority Code Bit Allocation

5.4.6 Collision detection procedure

Collision detection is performed according to the following procedure to determine a surviving packet (for details, including concrete examples, see ET-2101 “3.3.6 Bit collation at contention and collision detection”).

(1) The terminal that intends to transmit data collates transmit data with receive data in “bit” units (bit collation).

(2) When a mismatch is detected between transmit data and receive data in bit units (at collision detection), the transmission is immediately stopped and reception is started. After that, when transmission is enabled, the data is transmitted again. (At this time, the flags related to re-transmission are not changed.)

(3) Bit data with logic 0 has priority over bit data with logic 1.

(4) As a result of contention of the priority code and the self address division, the terminal with higher priority survives.

(5) Collision detection is performed when 45.5μs have elapsed from the starting time of each bit. (In the case of HBS, it is performed when 26μs have elapsed.)

(6) To reduce collisions in the bus idle status and to detect a collision securely if it occurs, the delay time (Td) from free channel check to start of transmission is defined as the allowable transmission time. At 50% AMI, the Td value shall be 4.0μs or less from the setting of the start bit.

5.4.7 Synchronization recovery procedure

Synchronization between multiple IFUs is recovered according to the following procedure (for details, including figures, see ST-2101 “3.3.7 Synchronization recovery procedure”):

(1) Synchronization recovery: Monitors the bus from the TF time (synchronization recovery monitoring time) ahead of the end of the pause time.

(2) Synchronization recovery monitoring time (TF): Time equivalent to 2 bits (= 1/9600 × 2μs)

(3) Reception: Enters a receive enable status after a lapse of (10 ms - TF) time subsequent to the end of data.

(4) Transmission: If another terminal starts transmission in the TF period, transmission is started in synchronization with it. If no other terminal starts transmission in the TF period, transmission is performed after the pause time (10 ms). In the period of (10 ms - TF) time from the end of data, transmission is inhibited.

(5) Allowable transmission delay time (Td): Delay time from start of transmission by another terminal in the synchronization recovery monitoring time (TF) until start of transmission in synchronization with it, and delay time from a free channel check until start of transmission. 1/8 bit time (13μs) or less after the rise of the start bit.

5.4.8 Short-data interruption procedure

The short-data interruption procedure is as follows:

(1) If a request for short-data frame transmission is made during long-data frame transmission, interruption can result in the data field of the long data.

(2) As a break signal, “logic 0 (+)” is transmitted in synchronization with the stop bit of long data. However, break signal transmission is allowed only within the allowable transmission delay time (Td).

(3) The break enable period is from the end of long data code BC of the long-data frame until the start of the check code FCC.

(4) For processing after a break, as soon as the terminals on the transmitting side and the receiving side that perform long-data communication detect a break signal, they stop transmit and receive processing and enter the pause time (10 ms + 22 bits) from the end of the break signal.

(5) The terminal that transmitted a break signal and has a request for short-data frame transmission transmits a short-data frame after the pause period.

(6) The terminal that stopped transmitting long data by the break signal does not count up the control code re-transmission count after the pause time, but transmits the long-data frame again that was at a break.

(7) After the pause period, a short-data frame and a long-data frame are transmitted simultaneously. However, the short-data frame is transmitted with priority because of contention by the priority bit of the priority code.

(8) After completion of transmission of the short-data frame that survived as a result of contention, the long-data frame is transmitted again in or after the pause period.

5.5 Logical Specifications (Layer 2 Specifications)

For layer 2 specifications, the eight items below are specified . For specifications 2), 6) and 7), the EIAJ ET-2101 Standard (HBS Standard) is fully applied.

Note: The principal differences from the standard are listed as follows:

1) A specification for the address area of the router is additionally provided.
3) Bit settings for application to ECHONET are specified.
4) The size specified for short data is changed from 16 bytes to 32 bytes in the specification.
5) The specifications for starting the lower-layer transmission media and using the commands for maintenance are provided.
8) The contents of error detection and NAK code are additionally specified.

1) Address
2) Broadcast, simultaneous broadcast, group broadcast
3) Control code
4) Long-data code
5) Data area
6) Check code
7) Dummy
8) Error detection and error control

5.5.1 Address

The size of the self address (SA) and the destination address (DA) shall be 1 byte and conform to Table 7.2 Address Code Allocation Table. Regarding the priority of the address code, the 4 low-order bits have the same priority at collision as the 4 high-order bits. Since bit transmission is started from the low-order bits, the 4 low-order bits have priority over the 4 high-order bits.

Table 7.2 Address Code Allocation Table

4 high-order bits / 4 low-order bits	0,8,4,C,2,A,6,E,1,9,5,D,3,B,7,F (Order of descending priorities from the left at collision)
0	For router, GW
8, 4. C	For security device
Others	For devices other than the above

5.5.2 Broadcast, simultaneous broadcast, and group broadcast

Broadcast shall be performed according to the procedure shown below. In this case, the address code shall be as shown in Fig. 7.5.

(1) Simultaneous broadcast (transmission to all terminals connected to the transmission line)
- Set b6 of the priority code (PR) to 1 and all the bits of the destination address (DA) to 1, and specify all groups.

(2) Group broadcast (transmission to a part of address groups)
- Set b6 of the priority code to 1 and specify a group (0 to 7) specified in each bit of the destination address (DA). (See Fig. 7.5.)

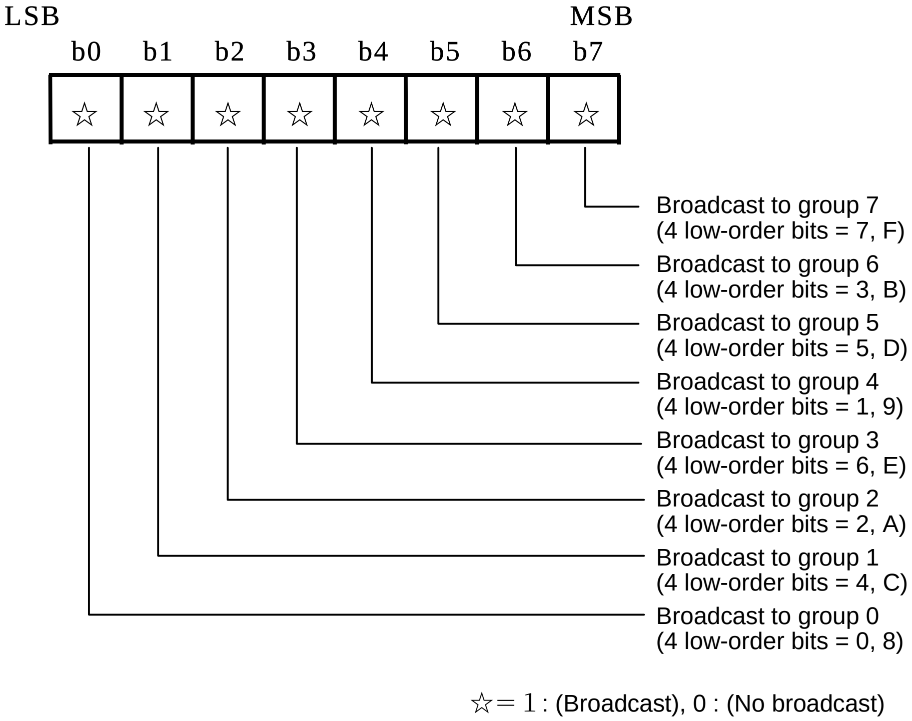


Fig. 7.5 Bit Specification for Group Broadcast

5.5.3 Control code

The allocation of the control code shall be as shown in Fig. 7.6. The ET-2101 specifies that bits (b2 to b5) specified for protocol expansion are positioned for protocol specification, and both ECHONET data and extended HBS can be set in the DATA area. For detailed specifications of b0, b1, b6, and b7, see ET-2101 “3.3.11 Control code (CC)”.

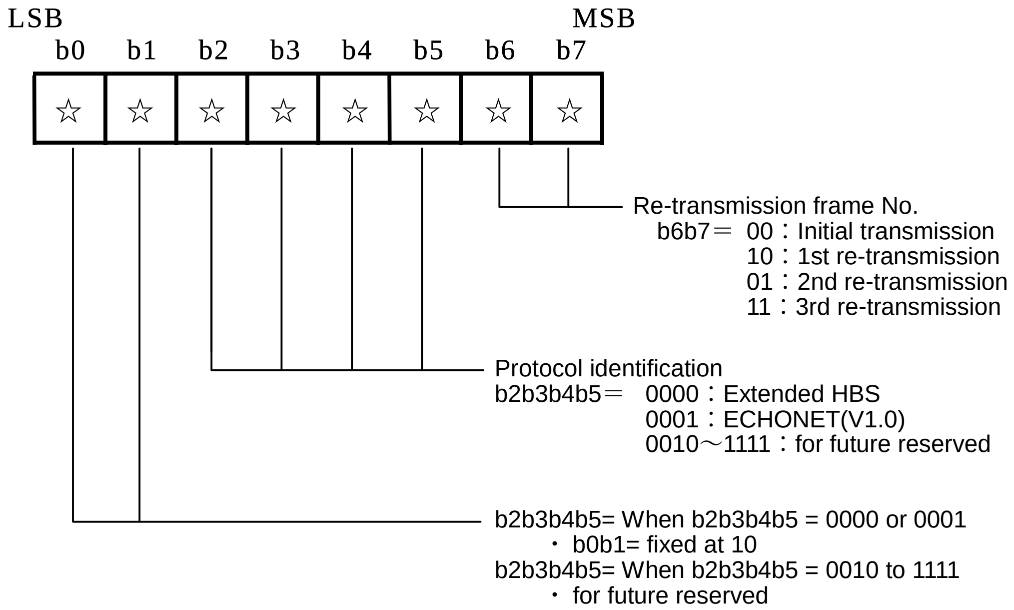


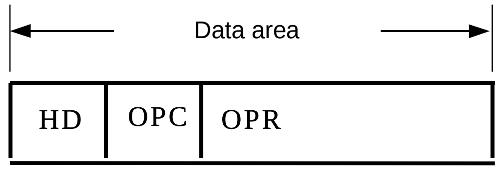
Fig. 7.6 Control Code Bit Allocation

5.5.4 Data length code

The data length code indicates the number of characters in the data field. The data length code x ‘01’ to x ‘FF’ indicates 1 to 255 characters. The data length code x ‘00’ indicates 256 characters. In this extended HBS Standard, when the data field length is 32 characters or less, it is specified as short data, and the others are specified as long data.

5.5.5 Data area

The data area structure depends on the values of b2 to b5 in the control code. This Standard specifies both the extended HBS specification (control code b2:b3:b4:b5 = 1:1:1:0 specification) and the ECHONET V1.0 specification (control code b2:b3:b4:b5 = 1:1:0:1 specification). In the ECHONET specification, the data area adopts the data structure specified in the communications middleware specification (see Part 2). Fig. 7.7 shows a data area structure in the extended HBS specification.



HD (extend Heder) : Header code 1 (11bit)
OPC (extend Operation Code) : Operation code (11bit)
OPR (extend Operand Code) : Operand code (11bit*Max.30)

Note: Details of each code are specified in the layer 3 specification.

Fig. 7.7 Data Area Structure at Extended HBS Specification

5.5.6 Check Code

For frame transmission error detection, a 2's complement value of the sum from the self address to the last character of the data area is transmitted at the end of the frame. However, the check code is a value of 1 low-order byte obtained by the aforementioned calculation.

5.5.7 Dummy code

For the dummy code, one character is assigned as an error check calculation time. In this period, the bus idle status is continued without data and characters. The receiving device calculates the check code of the received frame in this period, and performs one-byte response processing after a lapse of 11 bits.

5.5.8 Error detection and error control (ACK/NAK response)

"Error detection" is executed to increase the reliability of a received frame by providing one bit as parity for each byte or one byte as the check code for the whole frame to detect a transmission error due to data change or a lack of data. The parity shall be even parity.

The ACK/NAK response processing shall be as follows:

(1) Regarding the data addressed to the self address that does not correspond to simultaneous broadcast or broadcast, one byte of ACK/NAK code is transmitted as a response after the dummy code. However, on detection of the following address redundancy, a code to indicate address redundancy is transmitted as the ACK/NAK code even if the data is not addressed to the self address.

(2) The transmitting terminal transmits the control signal frame (from priority code PR to check code FCC) and the receiving terminal side performs this signal frame error detection. When the control signal is received correctly, the receiving terminal side transmits the ACK signal to the transmitting terminal side.

(3) When the control signal cannot be received correctly, the receiving terminal side transmits the NAK signal to the transmitting terminal side.

(4) At data transmission other than broadcast, if the data transmitting side received the NAK response after the dummy code, it resends the frame after the pause period. At this time, the re-transmission frame number (b6, b7) of the control code is changed based on the re-transmission count. The maximum re-transmission count shall be 3.

(5) When a code other than the ACK/NAK code is received after the dummy code, it is always regarded as NAK. No response at data transmission except broadcast is also regarded as NAK.

(6) At address redundancy detection, the NAK signal to indicate address redundancy is transmitted even if it is broadcast.

(7) When receiving the NAK signal to indicate address redundancy, the processing to be performed by the transmitting terminal side is specified by the basic sequence in the layer 3 specification.

ACK/NAK code	ACK	: x ‘06’	
	NAK	: x ‘15’	(Parity error or FCC error)
		: x ‘00’	(Address redundancy detection)
		: x ‘11’	(Receiving buffer full)
		: x ‘12’	(Terminal [application] failure)

When errors of the above four types of NAK are detected in redundant form, the code is determined with the following priority and returned (in the order of subsequent priorities):

x ‘15’ → x ‘00’ → x ‘11’ → x ‘12’

When both FCC error and address redundancy detection occur simultaneously, it is indicated that the notice of the FCC error has priority.

5.6 Logical Specifications (Layer 7 Specifications)

The extended HBS does not provide any sub-bus specifications. The extended HBS is intended to specify pair cables as lower-layer transmission media in the ECHONET Standard, and the high-order layer processing is realized as processing in the ECHONET communications middleware. The extended HBS provides the specification that considers maintenance of lower-layer transmission media as the layer 7 specification. The specification shown in this section relates to the contents of data (see Fig. 7.7) and the sequence of the data in the case where the extended HBS standard has been selected. Its items are shown below.

1) Header code (HD)
2) Command (OPC, OPR)
3) Communication sequence

5.6.1 Header code (HD)

The header code allocation shall be as shown in Fig. 7.8.

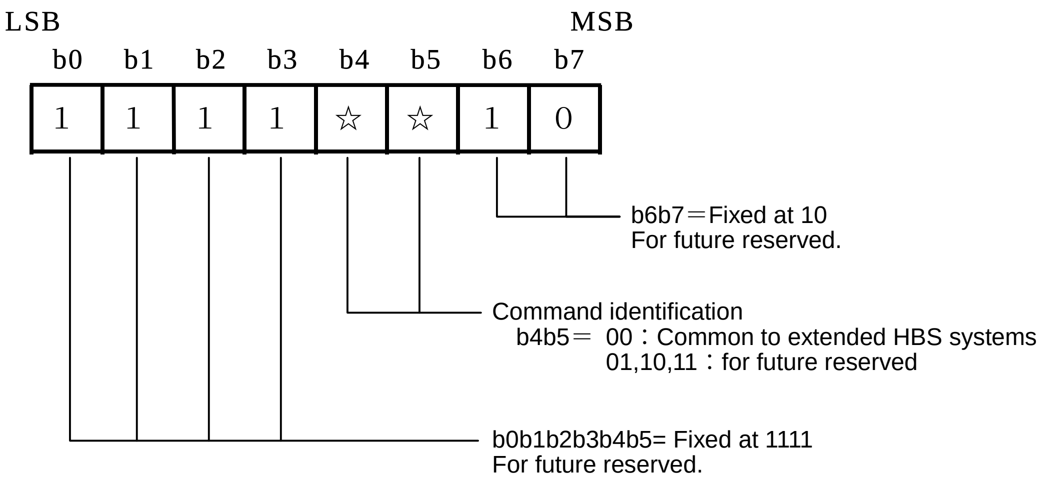


Fig. 7.8 Header Code Bit Allocation

5.6.2 System Common Commands

The system common commands are specified as those commands that are used among devices connected to the extended HBS.

(1) Basic command form

- Structure with OPC (operation code) only
- Structure with OPC and OPR (operand)

(2) OPC (operation code)

The area specified as OPC shall be 128 codes whose 4 high-order bits are 8 to F. The OPC code is classified into 2 types depending on whether an OPR exists.

- 4 high-order bits = 8, 9: OPR does not exist.
- 4 high-order bits = A, B, C, D, E, F: OPR exists.

(3) OPR (operand code)

The area that can obtain an OPR code shall be one whose 4 high-order bits are 9 to 7. The size and meaning of an OPR differs with each OPC.

(4) Meaning of mandatory and free adoption

Transmitting source, mandatory:	Must always transmit.
Transmitting source, free adoption:	May or may not transmit.
Receiving destination, mandatory:	Must not ignore. (Must always perform processing.)
Receiving destination, free adoption:	May ignore.

Table 7.3 shows an OPC code allocation table and Appendix 7.2 of this Section describes the detailed specification of each command including OPR.

Table 7.3 OPC Code Allocation Table

	8	9	A	B	C	D	E	F
0	Reset		Start of startup					
1			Check of startup					
2		OK	Completion of startup					
3		NG						
4		Dummy						
5								
6								
7								
8			Return request					
9			Return response					
A			Version request					
B			Version response					
C	Communication stop request		Maker name request					
D	Communication stop response		Maker name response					
E	Communication start request							
F	Communication start response							

Note: Shaded portions are reserved for future use.

5.6.3 Communication sequence

The communication sequence is described for the following two items:

1) Basic communication sequence
2) Startup communication sequence (physical address acquisition PnP sequence)

(1) Basic communication sequence

The following commands must always respond to requests, and the basic sequence for this is shown in Fig. 7.9. The value in parentheses denotes an OPC code value.

① Communication stop request (8C)/response (8D)
② Communication start request (8E)/response (8F)
③ Loopback request (A8)/response (A9)
④ Communication software version request (AA)/response (AB)

On reception of the request data of ① and ②, response processing shall be based on “free adoption”. In the case of adoption, the communication sequence shown in Fig. 7.9 shall be observed.

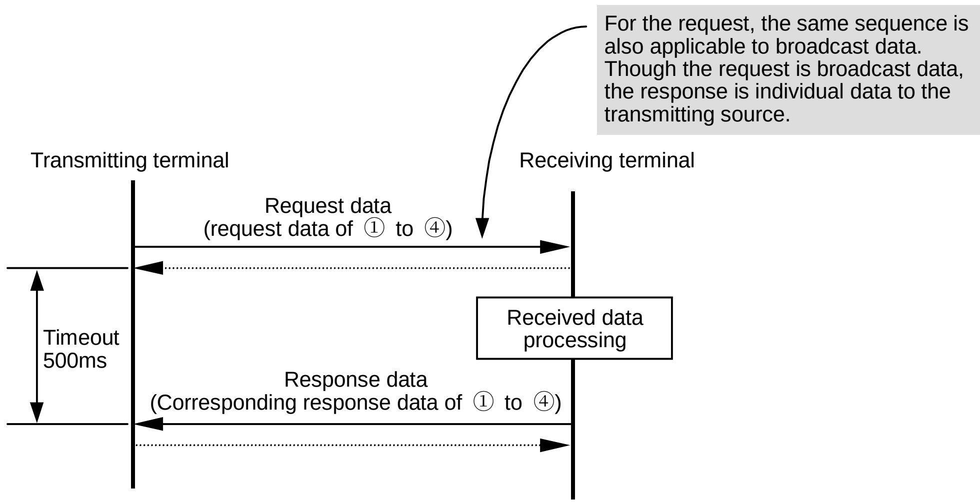


Fig. 7.9 Basic Communication Sequence

(2) Startup communication sequence (physical address acquisition PnP sequence)

For physical address setting at startup, the two commands shown below are used. The value in parentheses denotes an OPC code value. In this sequence, the device conforming to the extended HBS must always hold the youngest physical address among the devices connected to the network.

① Start of startup (A0)

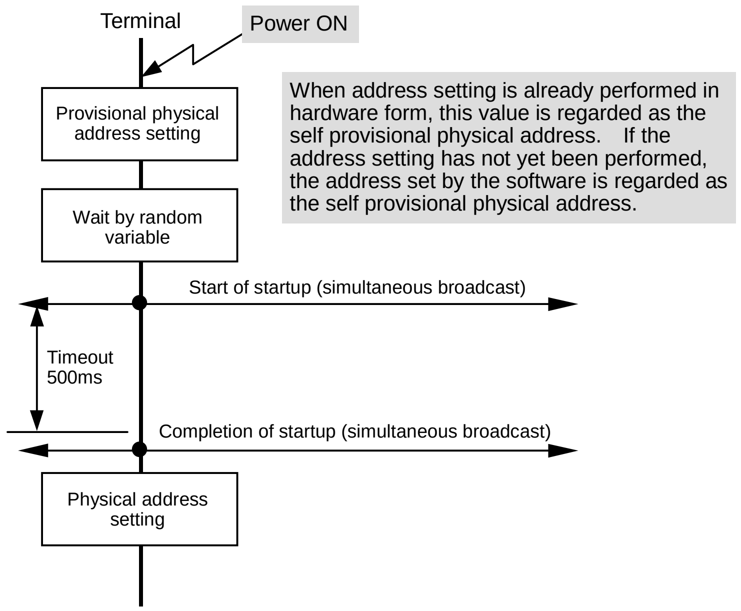
② Check of startup (A1)

③ Completion of startup (A2)

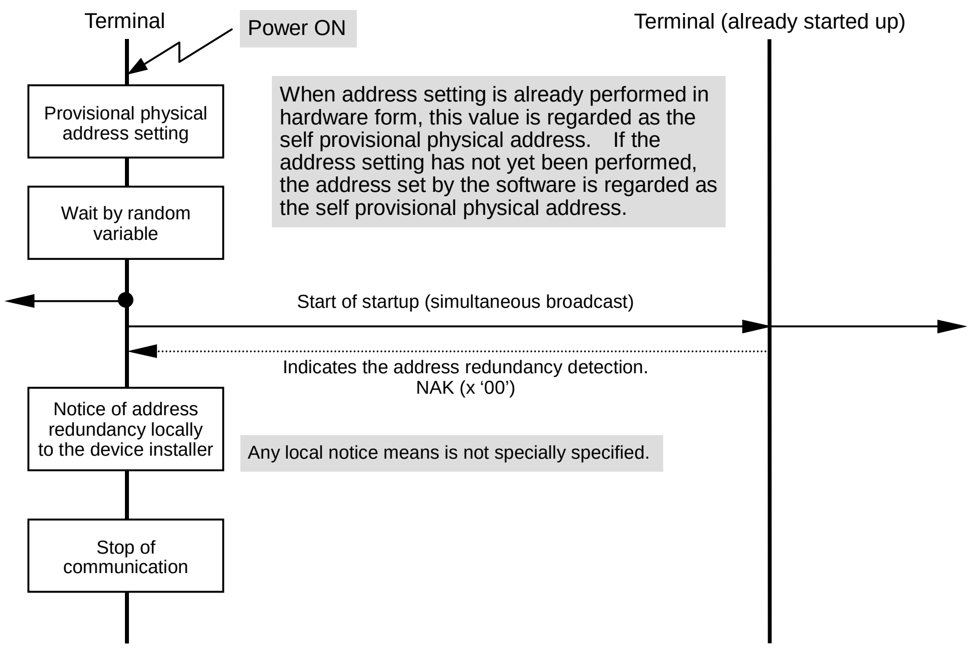
The communication procedure at startup is shown for each case in Fig. 7.10 to Fig. 7.

<CASE 1> ① Other terminals do not exist.

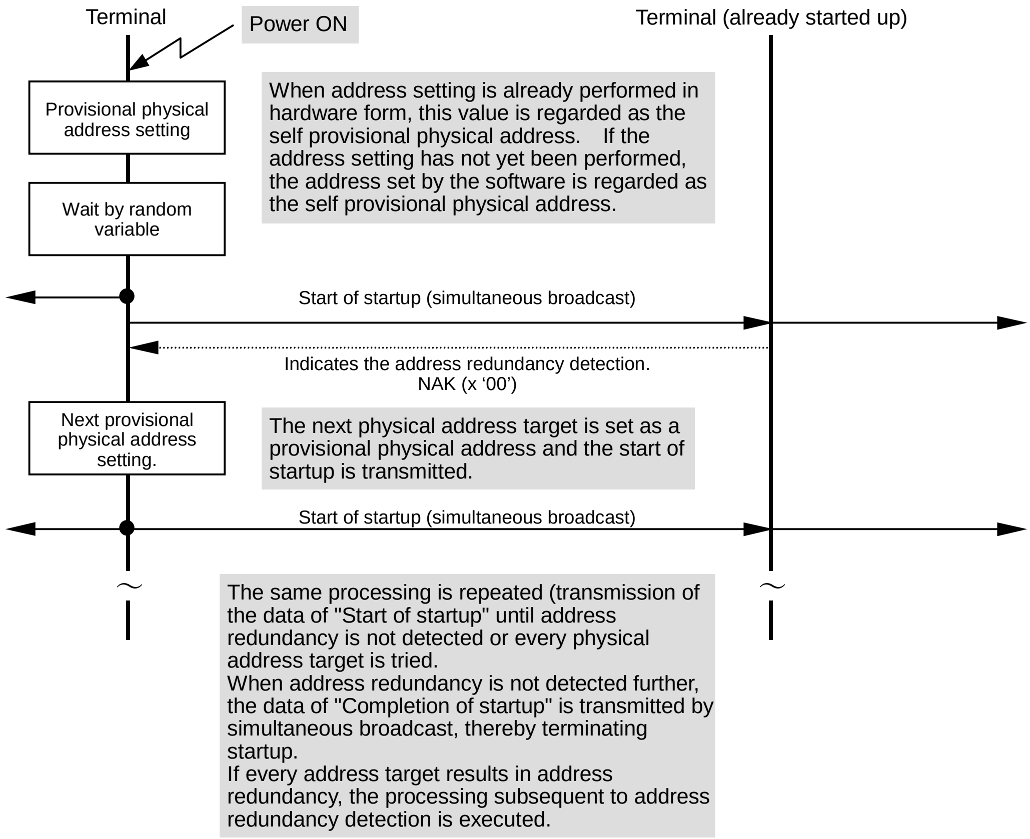
② Other terminals exist but there is no address redundancy.



<CASE 2> ③ Other terminals exist and there is address redundancy, and the address setting is disabled except for the redundant address (fixed by the DIP switch).



<CASE 3> ④ Other terminals exist, there is address redundancy, and the address setting is enabled in software form except for the redundant address.



5.7 Basic Sequence (Software Internal State Transition Specification)

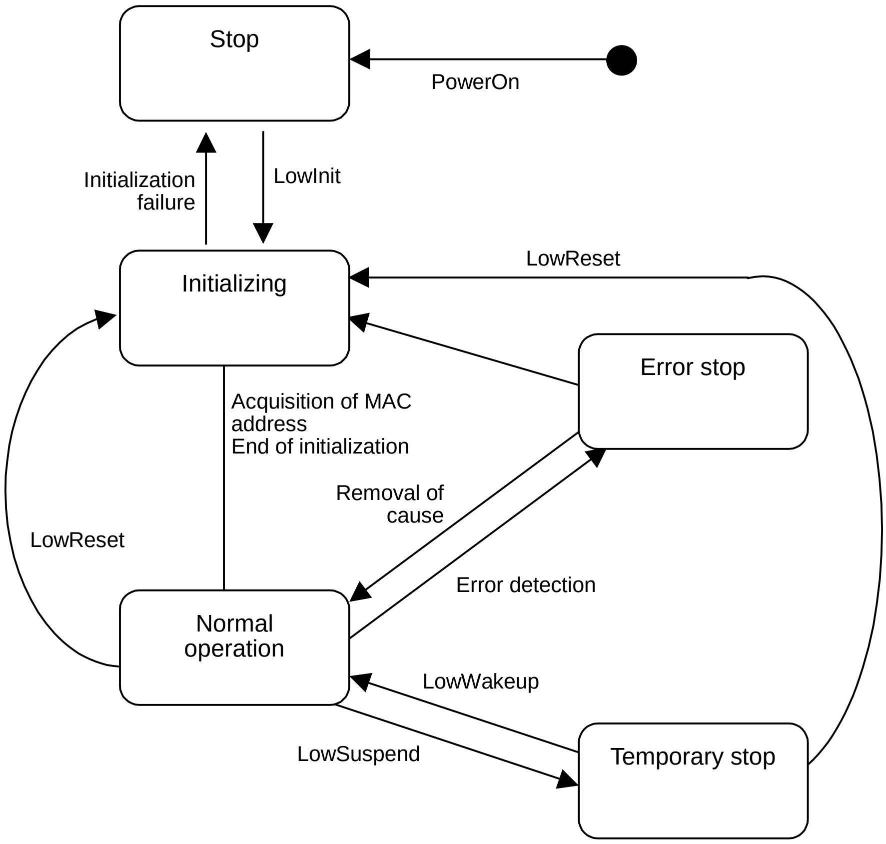
This section describes the basic processing sequence of the lower-layer communications software for extended HBS communication.

5.7.1 Basic concept

This subsection classifies the discrete lower-layer communications software status as shown below, and describes an outline of the sequence for each status.

① Stop status
② Initialize processing status
③ Normal operation status
④ Error stop status

The following figure shows the state transition for each state. In the figure, all English terms other than “PowerOn” are tentative designations for Individual Lower-layer Communication Interface services and are not the official terms.



5.7.2 Stop Status

Stop status signifies a status in which lower-layer communications software operations are not performed. This status is provided immediately after Power On. An outline of processing immediately after state transition and an outline of Individual Lower-layer Communication Interface services that the stop status receives and its processing are described below.

(1) Status acquisition service (LOWGetStatus) acquisition processing

When "Status acquisition service" is called through the Individual Lower-layer Communication Interface, "Stopping" is returned as status.

(2) Initialization acquisition service (LowInit) acquisition processing

When "Initialization service" is called through the Individual Lower-layer Communication Interface, transition is caused to the initialized status. At this time, a response to "Initialization service" is returned immediately or after completion of initialize processing. This is specified in the software mounting specification but not specified here.

5.7.3 Initialize processing status

Initialize processing status signifies that the lower-layer communications software is initialized.

An outline of processing immediately after state transition and an outline of Individual Lower-layer Communication Interface services that the initialize processing status receives and its processing are described below.

(1) Outline of initialize processing

A unique MAC address is obtained in the SUBNET. In particular, when the address is not fixed by the DIP switch as a product, the startup sequence processing specified in "5.6.3 Communication sequence" is executed to get a unique MAC address in the SUBNET.

(2) Status acquisition service (LOWSetStatus) acquisition processing

When "Status acquisition service" is called through the Individual Lower-layer Communication Interface, "Initialize processing" is returned as status.

(3) Transition trigger to the initialization completion stop status

When initializing processing, including necessary buffer clearing after obtaining the MAC address, transition is set to "Normal operation status".

5.7.4 Normal operation status

Normal operation status signifies the status in which data is transmitted to or received from a transmission medium as the primary function of the lower-layer communications software. An outline of processing immediately after state transition and an outline of the Individual Lower-layer Communication Interface service that the normal operation status receives, and its processing, are described below.

(1) Outline of normal operation

Accepts a call for the Individual Lower-layer Communication Interface service from the protocol difference absorption processing block and executes the specified processing, including data transmission. In addition, the data to be exchanged on the transmission line is received, and it is judged whether this data is addressed to the self address or not at the MAC address level. The received data is delivered to the protocol difference absorption processing block through the Individual Lower-layer Communication Interface service.

(2) Status acquisition service (LOWGet Status) acquisition processing

Returns multiple operation status such as “Normally operating”, “Data transmitting”, and “Data receiving” when “Status acquisition service” is called through the Individual Lower-layer Communication Interface. At very least, the above three status types shall be distinguished for a return.

(3) Profile data acquisition service (LOWGetProData) acquisition processing

Executes response processing of the contents of property as the profile information specified in the “discrete lower-layer communications software profile object”. This service is not specified as a discrete service for each property but instead is provided in the lower-layer communications software mounting specification. (However, we recommend that this service conform to the Discrete Lower-Layer Communication Interface Specification in Part 6.)

(4) Data transmission service (LOWSendData) acquisition processing

Executes transmit processing for the delivered data according to the extended HBS communication protocol when “Data transmission service” is called through the Individual Lower-layer Communication Interface. At this time, whether a response should be made in synchronization with the “Data transmission service” or in non-synchronization with the same shall be provided in the software mounting specification but not specially specified here. (However, we recommend that it conform to the Discrete Lower-Layer Communication Interface Specification in Part 6.)

(5) Data reception service (LOWRecvData) acquisition processing

When “Data reception service” is called through the Individual Lower-layer Communication Interface and any received data exists, this data is delivered as a response. If such received data does not exist, “No reception” is returned as a response. However, this lower-layer communications software may notify the reception through the Individual Lower-layer Communication Interface to deliver the data. This shall be provided in the lower-layer communications software mounting specification.

(6) Suspension service (LowSuspend) acquisition processing

When "Suspension service" is called through the Individual Lower-layer Communication Interface and data is being transmitted, processing is stopped after completion of a series of transmit processing, proceeding to the stop status. When data is being received, processing is stopped at once, proceeding to the stop status.

(7) Reset instruction service (LowReset) acquisition processing

When "Reset instruction service" is called through the Individual Lower-layer Communication Interface and data is being transmitted, processing is stopped after completion of a series of transmit processing, proceeding to the initialize processing status. When data is being received, processing is stopped at once, proceeding to the initialize processing status.

(8) Transition trigger to error stop status

If received data remains or stays without being read by the high-order software (protocol difference absorption processing block software) or if an operation error of the high-order communications software is notified, transition is set to error stop status.

5.7.5 Error stop status

Error stop status signifies a status in which a high-order software error is detected or an internal error is detected individually. An outline of processing in the error stop status and an outline of the Individual Lower-layer Communication Interface services that the error stop status receives and its processing are described below.

(1) Outline of error stop status

In the error stop status, an error response is returned for services other than the services (listed below) of the following Individual Lower-layer Communication Interface service from the protocol difference absorption processing block. For data transmission/reception, receive processing is performed but NAK (error existence code) shall be returned as the response of one data and the received data shall be abandoned.

(2) Status acquisition service (LowGetStatus) acquisition processing

When "Status acquisition service" is called through the Individual Lower-layer Communication Interface, "Error stopping" is returned as the status.

(3) Reset instruction service (LowReset) acquisition processing

When "Reset instruction service" is called through the Individual Lower-layer Communication Interface, a response is returned if the processing is possible, proceeding to reset processing.

(4) Transition trigger to normal operation status

When an internally recognized error is removed, a return is made to normal status. Details of error recognition and details of error removal recognition shall be provided in the product specification but not specified here.

5.7.6 Suspension status

Suspension status signifies the status in which lower-layer software operation is suspended. In this status, no service processing is executed except some services (described below) of the Individual Lower-layer Communication Interface, and lower-layer communication processing is not performed at all. An outline of processing in the suspension status and an outline of the Individual Lower-layer Communication Interface services that the suspension status receives and its processing are described below.

(1) Outline of suspension status

In the error stop status, an error response is returned for services other than the services (listed below) of the following Individual Lower-layer Communication Interface from the protocol difference absorption processing block. For data transmission and reception, neither transmit processing nor receive processing is performed.

(2) Status acquisition service (LowGetStatus) acquisition processing

When “Status acquisition service” is called through the Individual Lower-layer Communication Interface, “Suspending” is returned as the status.

(3) Reset instruction service (LowReset) acquisition processing

“When “Reset instruction service” is called through the Individual Lower-layer Communication Interface, a response is returned if processing is possible, proceeding to reset processing.

(4) Operation restart instruction service (LowWakeup) acquisition processing

When “Operation restart instruction service” is called through the Individual Lower-layer Communication Interface, a response is returned, proceeding to the normal operation status.

Appendix 5.1 Documents Cited

(1) "EIAJ ET-2101 Home Bus System" issued by Electronic Industries Association of Japan

Electronic Industries Association of Japan, Technical Department TEL: 03-3213-1075

(2) "EIAJ ET-2101 Home Bus System (Supplement)" issued by Electronic Industries Association of Japan

Electronic Industries Association of Japan, Technical Department TEL: 03-3213-1075

(3) "EIAJ-RC-5202 Information Sockets for Home Bus System" issued by Electronic Industries Association of Japan

Electronic Industries Association of Japan, Technical Department TEL: 03-3213-1075

Appendix 5.2 Details of Command Specifications

1. Reset command
   (1) OPC code: x '80'
   (2) OPR code: None

2. Communication stop request command
   (1) OPC code: x '8C'
   (2) OPR code: None

3. Communication stop response command
   (1) OPC code: x '8D'
   (2) OPR code: None
   (3) Other: Reception and response of the communication stop request command

4. Communication start request command
   (1) OPC code: x '8E'
   (2) OPR code: None

5. Communication start response command
   (1) OPC code: x '8F'
   (2) OPR code: None
   (3) Other: Reception and response of the communication stop request command

6. OK command
   (1) OPC code: x '92'
   (2) OPR code: None

7. MG command
   (1) OPC code: x '93'
   (2) OPR code: None

8. Startup start command
   (1) OPC code: x 'A0'
   (2) OPR code: Self MAC address (1 byte)

9. Startup check command
   (1) OPC code: x 'A1'
   (2) OPR code: MAC address of check destination (1 byte)
   (3) Other: When the controller exists, it receives the startup start command and transmits it.

10. Startup completion command
   (1) OPC code: x 'A2'
   (2) OPR code: MAC address of the self (1 byte)
   (3) Other: The command is transmitted when the startup is completed (completion of MAC address acquisition).

11. Loopback request command
   (1) OPC code: x 'A8'
   (2) OPR code: Optional (254 bytes max)

12. Loopback response command
   (1) OPC code: x 'A9'
   (2) OPR code: Contents set in the OPR of the loop request command
   (3) Other: Response command to the loopback request command

13. Version request command
   (1) OPC code: x 'AA'
   (2) OPR code: None
   (3) Other: Request for the communication driver software version of the lower-layer transmission medium

14. Version response command
   (1) OPC code: x 'AB'
   (2) OPR code: Version information (15 bytes)
   (3) Other: Response command to the version request command

15. Manufacturer name request command
   (1) OPC code: x 'AC'
   (2) OPR code: None
   (3) Other: Request for the manufacturer of the communication driver software of the lower-layer transmission medium

16. Manufacturer name response command
    (1) OPC code: x ‘AD’
    (2) OPR code: Version information (16 bytes)
    (3) Other: Response command to the manufacturer name request command

Chapter 6 IrDA Control Communications Protocol Specification

6.1 System Overview

6.1.1 Overview

This Section specifies the communications protocol using IrDA Control in ECHONET. Unlike conventional systems used for infrared remote control, IrDA Control is quick, responsive and capable of two-way communication. Primarily, this specification provides for two-way communication between PCs specified as hosts and peripheral devices such as a mouse or keyboard. A host can communicate simultaneously with up to eight peripherals.

Regarding the use of IrDA Control in ECHONET, an IrDA device that performs host operations is arranged as an ECHONET router, and devices that communicate with this ECHONET router by using infrared are configured as peripherals.

Fig. 6.1 shows an application example. In this figure, the ECHONET router acts as a router connecting the IrDA Control subnet and another subnet. The peripherals are assumed to be various sensors that transmit detected information to the centralized control unit through the router. Up to eight sensors can be installed.

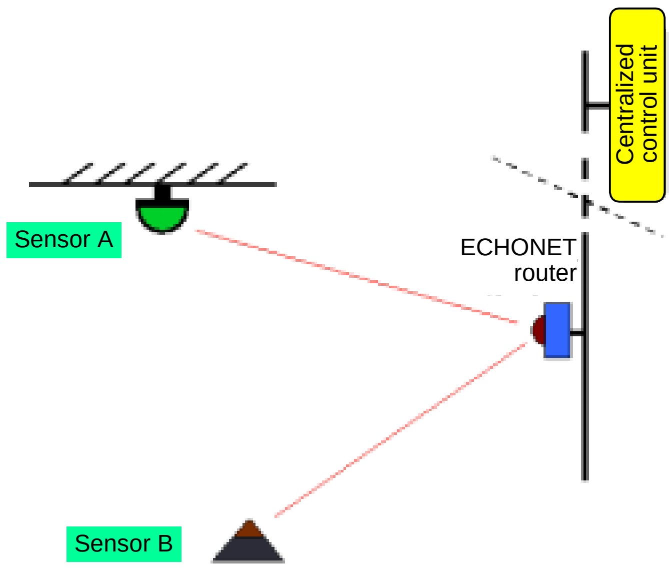


Fig. 6.1 Application Example of IrDA Control

6.1.2 Scope of the specification

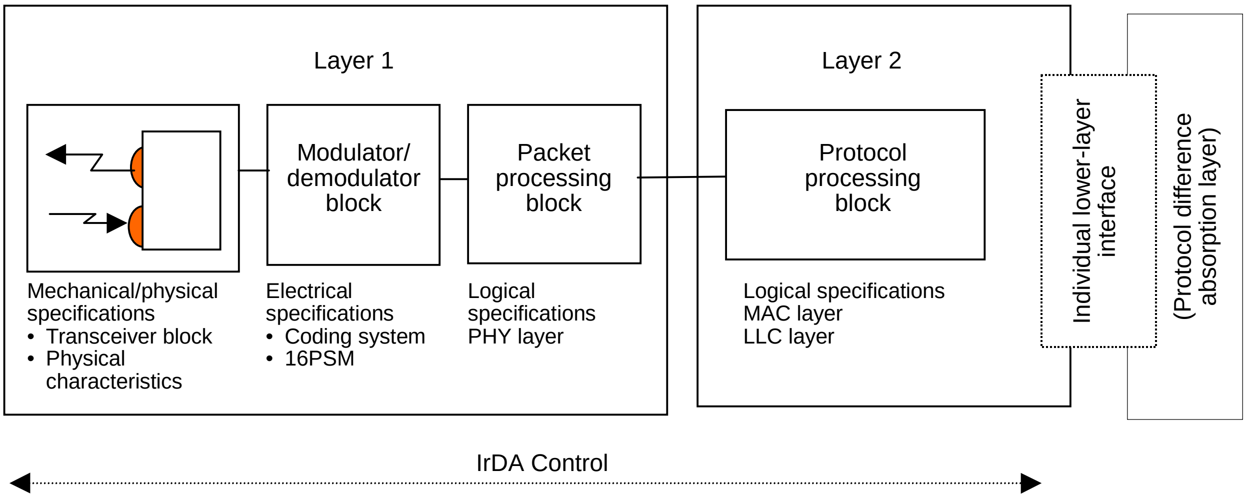


Fig. 6.2 IrDA Control Positioning in ECHONET

Fig. 6.2 is a conceptual diagram that indicates IrDA Control positioning in ECHONET. IrDA Control corresponds to layers 1 and 2 of ECHONET. Layer 1 is a physical layer consisting of a transceiver block, modulator/demodulator block, and packet processing block (logical specifications). Layer 2 is a logical layer consisting of the MAC layer and LLC layer of IrDA Control. The MAC layer (Media Access Control layer) has functions to exchange property information (host address, host ID, and peripheral ID) between the host and peripherals, perform connections (binding: destination device numbering), perform scheduling for communication of 1:N (N = more than one), identify the destination device, and detect errors. The LLC layer (Logical Link Control layer) has functions of detecting missing packets and performing re-transmission. Through data packet numbering and receipt check, the LLC layer provides a high-reliability communication line.

Layers 1 and 2 shall conform to IrDA Control specification.

In addition, solutions for problems (address translation, broadcast processing, etc.) caused by accommodating IrDA Control as an ECHONET transmission medium, have been specified. These are described in "6.5 Basic Sequence", "6.6 Accommodation Specification", and "Part 7 ECHONET Communication Device Specification, Chapter 6 IrDA Control Router".

6.2 Mechanical/Physical Specifications

6.2.1 Characteristics

The following basic physical characteristics of IrDA Control are specified. These characteristics can be easily realized using a dedicated communication controller and a light receiving/transmitting element.

- Peak wavelength: 850 to 900 nm
- 16 PSM modulation system comprised of a 1.5 MHz sub-carrier
- Communication distance: 8 m as the standard
- Transmission rate: 75 kbps
- Response time: 138 ms as the standard

For details, see the IrDA Control Specification
(Reference can be made to these specifications by referring to http://www.irda.org/standards/specification.asp.)

6.2.2 Topology

The network shape (topology) of the subnet comprised of IrDA Control is shown below. The host functions as a router. Up to 8 Ir terminals that operate as peripherals can simultaneously communicate with the router.

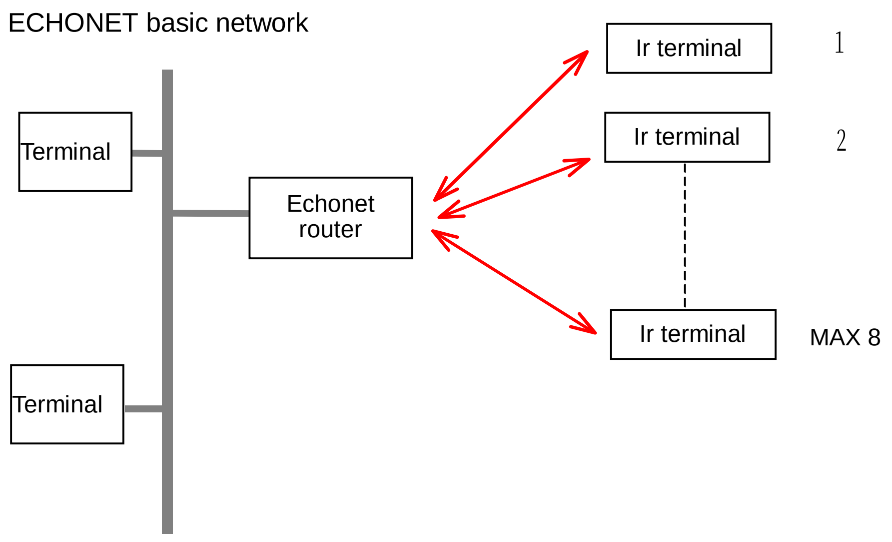


Fig. 6.3 Subnet Topology Using IrDA Control

6.3 Electrical Specifications

6.3.1 Coding system

The IrDA Control system uses the 16PSM system for data coding. Accordingly, there are 16 waveforms to be defined as 16PSM data symbols. There is a 4-bit set associated with each of the 16 symbol values. This is specified as a data bit set (DBS). The following table shows DBSs that are associated with the 16 symbols.

Table 6.1 16PSM Data Symbol Table

Data value (Hex)	Data bit set (DBS)	16PSM data symbol
0x0	0 0 0 0	1 0 1 0 0 0 0 0
0x1	0 0 0 1	0 1 0 1 0 0 0 0
0x2	0 0 1 0	0 0 1 0 1 0 0 0
0x3	0 0 1 1	0 0 0 1 0 1 0 0
0x4	0 1 0 0	0 0 0 0 1 0 1 0
0x5	0 1 0 1	0 0 0 0 0 1 0 1
0x6	0 1 1 0	1 0 0 0 0 0 1 0
0x7	0 1 1 1	0 1 0 0 0 0 0 1
0x8	1 0 0 0	1 1 1 1 0 0 0 0
0x9	1 0 0 1	0 1 1 1 1 0 0 0
0xA	1 0 1 0	0 0 1 1 1 1 0 0
0xB	1 0 1 1	0 0 0 1 1 1 1 0
0xC	1 1 0 0	0 0 0 0 1 1 1 1
0xD	1 1 0 1	1 0 0 0 0 1 1 1
0xE	1 1 1 0	1 0 1 0 0 1 0 1
0xF	1 1 1 1	1 1 1 0 0 0 0 1

A coding example is shown in Fig. 6.4.

Example

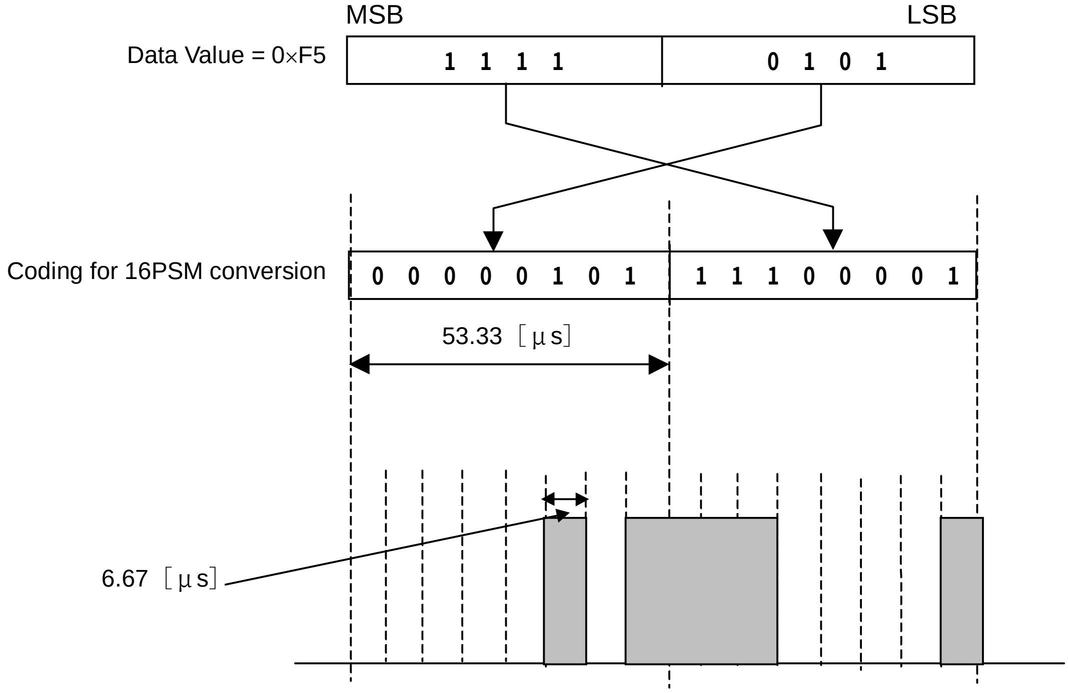


Fig. 6.4 Coding Example

For details, refer to the IrDA Control Specification.

6.4 Logical Specifications

6.4.1 Overall Data Structure Image

The relationship between the IrDA Control data structure and the ECHONET data is described below. The ECHONET data is stored as an LLC frame payload of IrDA Control, the header of the MAC layer is added, and the date id then transmitted as a PHY layer packet. Details of each layer are described in the following Sections.

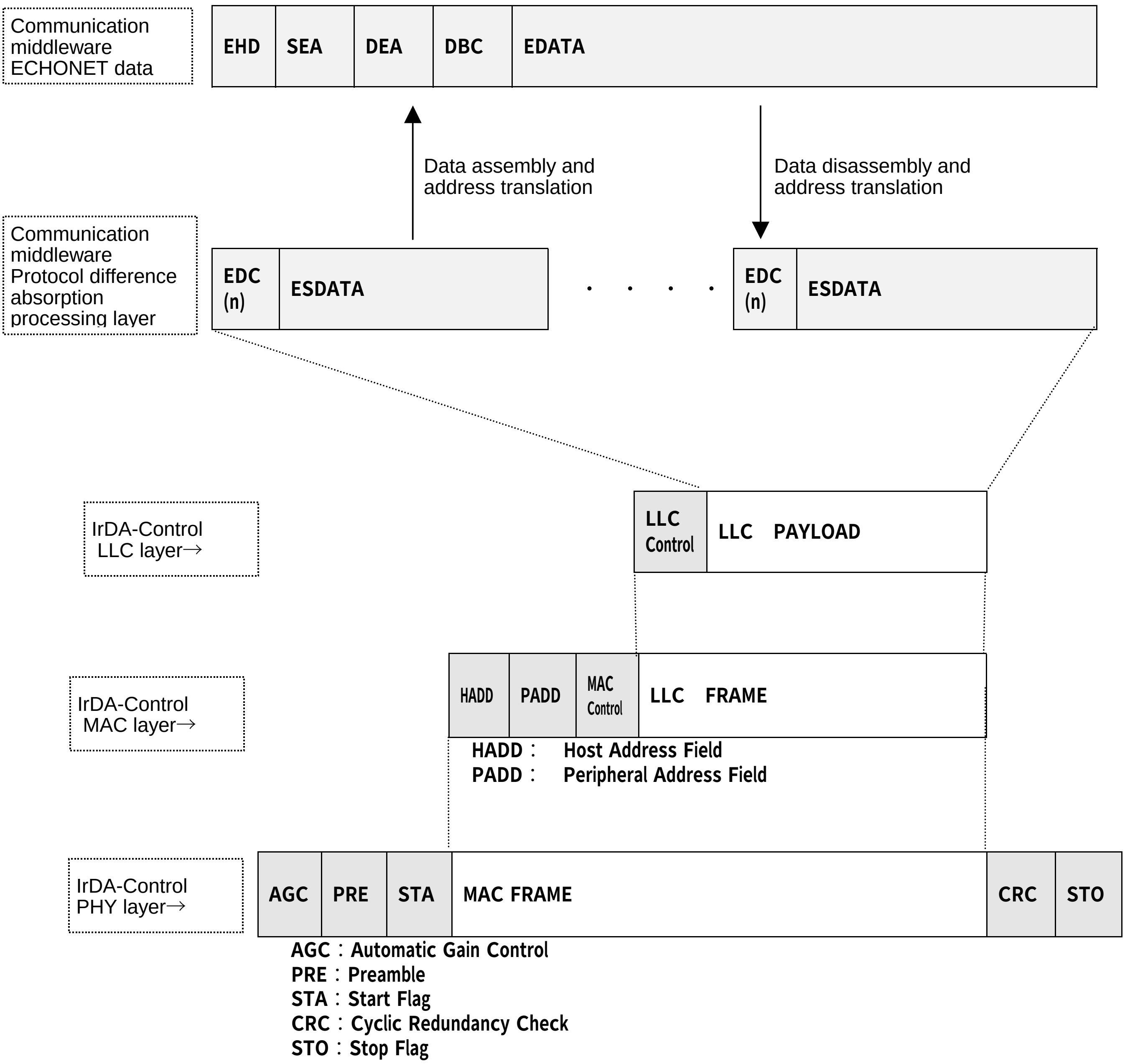


Fig. 6.5 Relationship Between Layers

6.4.2 Layer 1 (PHY layer)

IrDA Control is classified into two types of packet structure based on the difference in MAC frame size.

1) Short packet

AGC	PRE	STA = STS	MAC FRAME 11 bytes max.	CRC = CRC-8	STO

2) Long packet

AGC	PRE	STA = STL	MAC FRAME 99 bytes max.	CRC = CRC-16	STO

Fig. 6.6 Layer 1 Packet Structure

An outline of the structure is described below. For details, see the IrDA Control Specification.

(1) AGC (Automatic Gain Control)
Signal for infrared receiver sensitivity adjustment.
The symbol is 1111.

(2) PRE: (Preamble)
Used for clock synchronization.
The symbol is 0101010101.

(3) STA (Start Flag)
Performs synchronization with the symbol.
For long packets: STL (0100101101) is used.
For short packets: STS (0100101100) is used.

(4) MAC FRAME
There are two types of frames: short and long.
Data is encoded by 16 PSM.

(5) CRC (Cyclic Redundancy Check)
Used for error detection.
For short packets: CRC-8 is used.
For long packets: CRC-16 is used.

(6) STO (Stop Flag)
Indicates the end of a packet.
The symbol is 01001011.

6.4.3 Layer 2 (MAC layer)

The contents of the MAC frame are as follows.

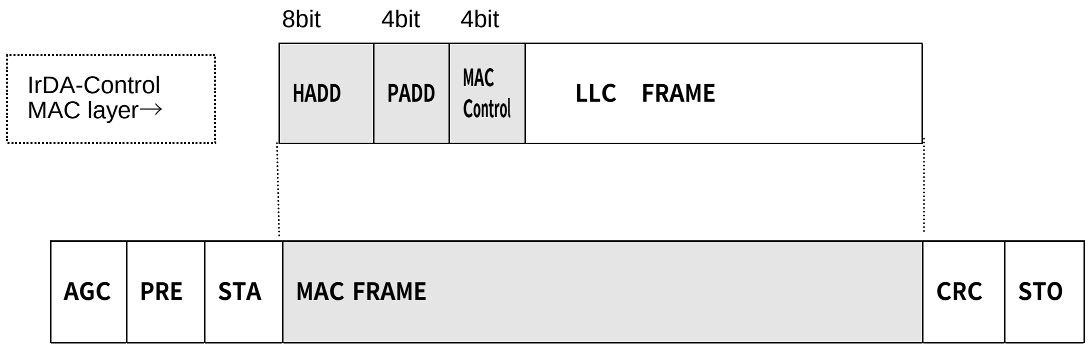


Fig. 6.7 MAC Frame Structure

(1) HADD (Host Address field)
MAC address of the IrDA Control host.
This address consists of 8 bits and is fixed at 0x01. The MAC address is associated with the ECHONET Node ID at 1:1.

(2) PADD (Peripheral Address field)
MAC address of the IrDA Control peripheral.
This address consists of 4 bits. The peripheral address is given by the host at each bind execution (as described later).

(3) MAC Control (MAC Control field)
Four bits are given.
Communication control is defined as described below.

Table 6.2 Details of MAC Control

		Meaning	1	0
Frame from host	D7	Packet direction	1	
	D6	Bind timer	Reset	
	D5	Long packet	Possible	Add
	D4	Haling	○	×
Frame from peripheral	D7	Packet direction	0	
	D6	Polling request	Yes	No
	D5	Reserved	—	—
	D4	Reserved	—	—

6.4.4 Layer 2 (LLC layer)

The contents of the LLC layer are as follows:

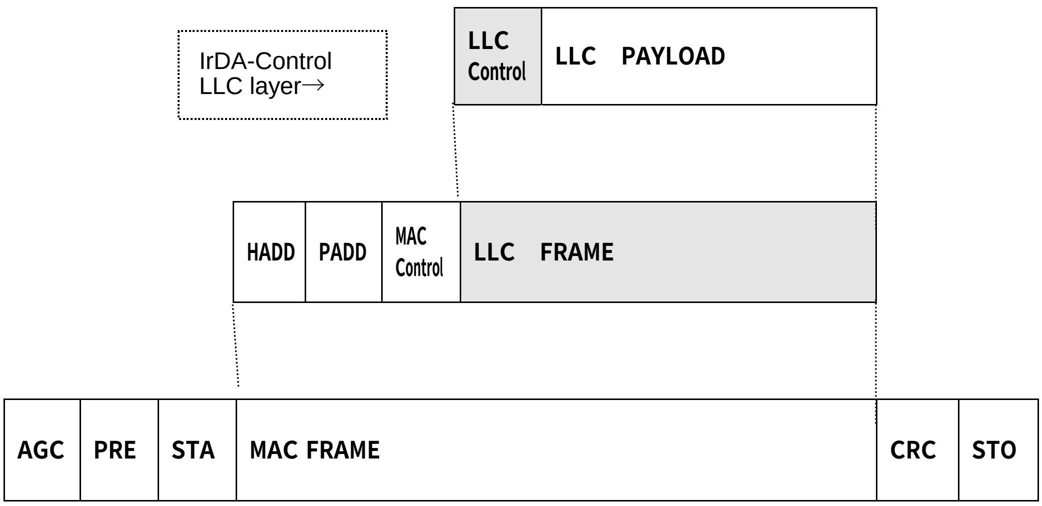


Fig. 6.8 LLC Frame Structure

Table 6.3 Details of LLC Control

LLC Control							
D7	D6	D5	D4	D3	D2	D1	D0
Reserve	Endpoint		Reserve	Packet Type Code			

(1) Packet Type Code

Implements the types (request to receive, data, ACK, NAK, etc.) of the LLC frame and frame sequence numbers.

For details, refer to the IrDA Control Specification.

(2) Endpoint

Represents the type of Pipe serving as a logical communication channel.

Table 6.4 shows Pipe types and Table 6.5 shows the relationship between Endpoint values and Pipe types.

Table 6.4 Pipe Types

Pipe type	Usage
Control Pipe	For transmission of host commands and device requests
IN Pipe	Used for data from devices to the host
OUT Pipe	Used for data from the host to devices

Table 6.5 Relationship between Endpoints and Pipe Types

Endpoint	Pipe type
00	Control Pipe
01	IN Pipe
10	OUT Pipe
11	IN Pipe or OUT Pipe

An “Out Packet” is a packet from the host toward a peripheral. An “In Packet” is a packet from a peripheral toward the host.

6.4.5 Packet accommodation

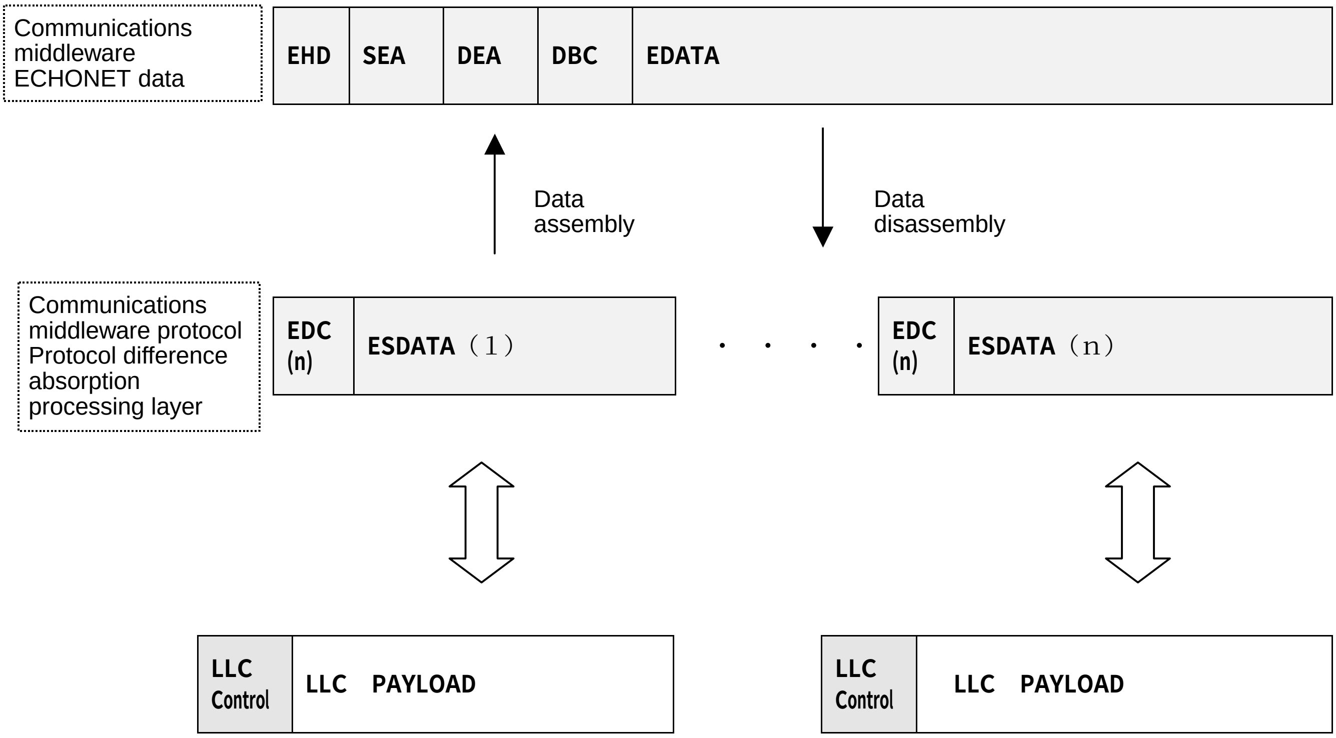


Fig. 6.9 Relationship Between LLC Payload and ECHONET Data

- The total length of ESDATA (1) to ESDATA (n) is 262 bytes.
- EDC is 1 byte.
- LLC PAYLOAD can accommodate up to 96 bytes.

6.5 Basic Sequence

6.5.1 Basic concept

In this Section, the lower-layer communications software status for IrDA Control protocol is classified as follows and an outline of sequence in each status is described.

① Stop status
The status in which the lower-layer software function is stopped.

② Initialize processing status
The status in which all parameters are reset and initial settings are performed.
The host and peripherals perform the procedure called enumeration and exchange information (host address, host ID, peripheral ID). According to the information obtained from this procedure, the host updates the address control table (device ID, virtual MAC address, peripheral address (PADD) associating control table), and determines a “virtual MAC address” for the peripheral (as detailed later).

③ Initialization completion stop
A standby status in which communication is enabled if a communication request is made after completion of the initial settings and enumeration.

④ Normal operation
A status in which communication is in process. To start communication, it is necessary to first perform a bind procedure and a procedure for adding to a polling loop so that the host recognizes a peripheral dynamically.

⑤ Error stop
A communication disable status caused by an error.

⑥ Suspension status
A status in which software operation is suspended by the STOP command.

The following figure shows a state transition of items ① to ⑥ above of the lower-layer communications software for IrDA Control.

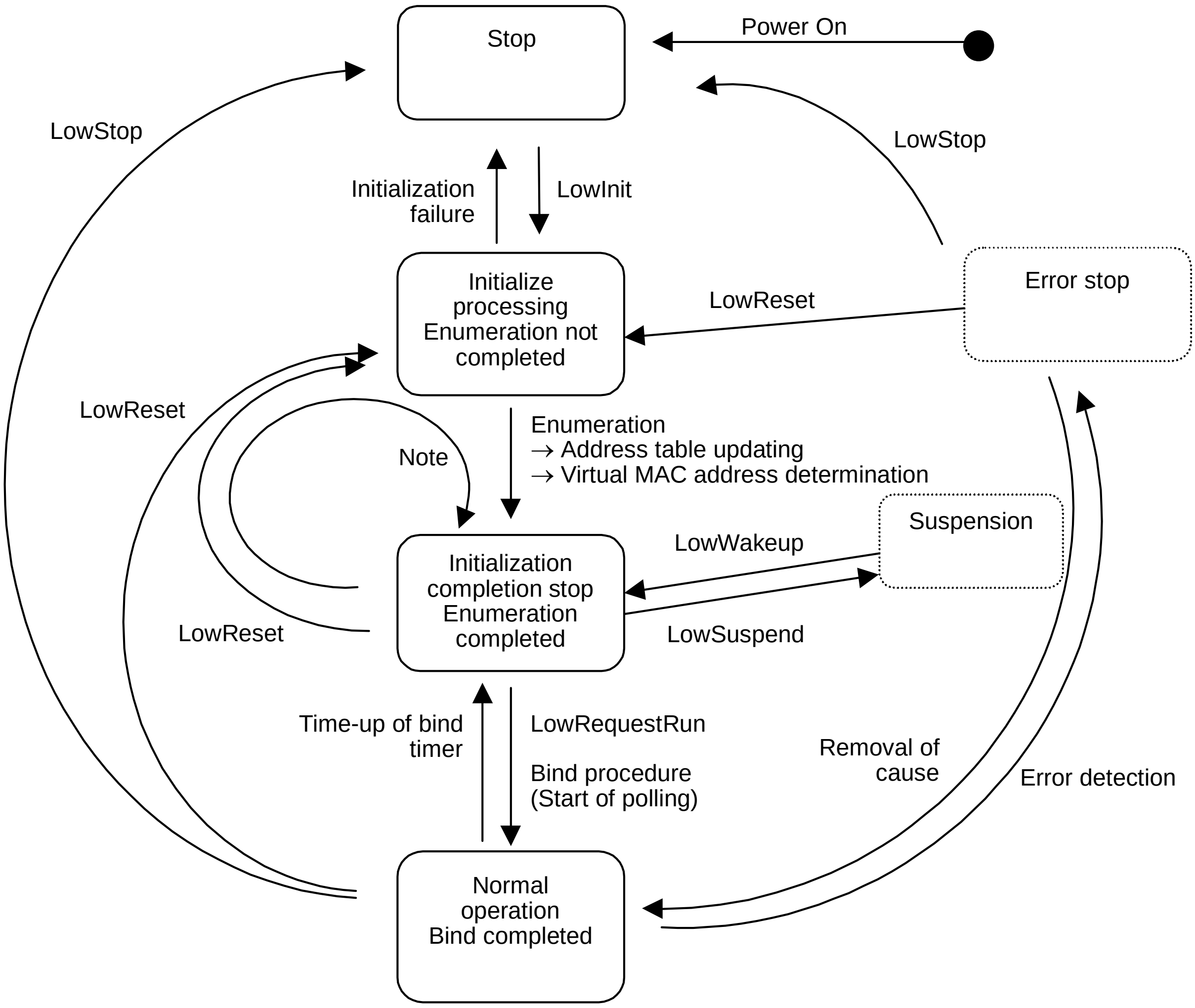


Fig. 6.10 Sequence Transition Diagram

Since the host and peripherals are in a Master-Slave relationship, the following holds:

① Stop: Individual stop for individual peripheral.
Whole subnet stop for the host

② Reset: Individual stop for individual peripheral. EA does not change because of host control. Whole subnet reset for the host.

Note indicates the sequence in the status in which multiple peripherals exist.

6.5.2 Stop Status

Stop status signifies a status in which no lower-layer communications software operations are performed. This status is provided immediately after Power On. An outline of processing immediately after state transition and an outline of Individual Lower-layer Communication Interface services that the stop status receives and its processing are described below.

(1) Trigger and action
Waits for a Individual Lower-layer Communication Interface service.

(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_STOP as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)
Sends back the stop status as status.

The following is a trigger to perform state transition.
Transition trigger to initialize processing status
Transition is caused by an initialization service (LowInit).

6.5.3 Initialize processing status

Initialize processing status signifies that the lower-layer communications software is initialized.

An outline of processing immediately after state transition and an outline of Individual Lower-layer Communication Interface services that the initialize processing status receives and its processing are described below.

(1) Trigger and action

① Software initialization

All parameters are initialized.

② MAC address acquisition

The host MAC address shall be fixed at 0x01. On the other hand, regarding the peripheral MAC address, an information exchange procedure called enumeration (*) is performed between the host and a peripheral. After that, the host assigns a virtual MAC address (address associated with Node ID at 1:1.).

*: Details are provided later.

(2) Status acquisition service (LowStatus)

Return LOW_STS_INIT as status.

(3) Lower-layer communications module operation status acquisition service (LowStatus)

Return operating status as status.

The following is a trigger to perform state transition.

Transition trigger to initialize processing status

Transition is caused by completion of enumeration.

An outline of enumeration is shown below.

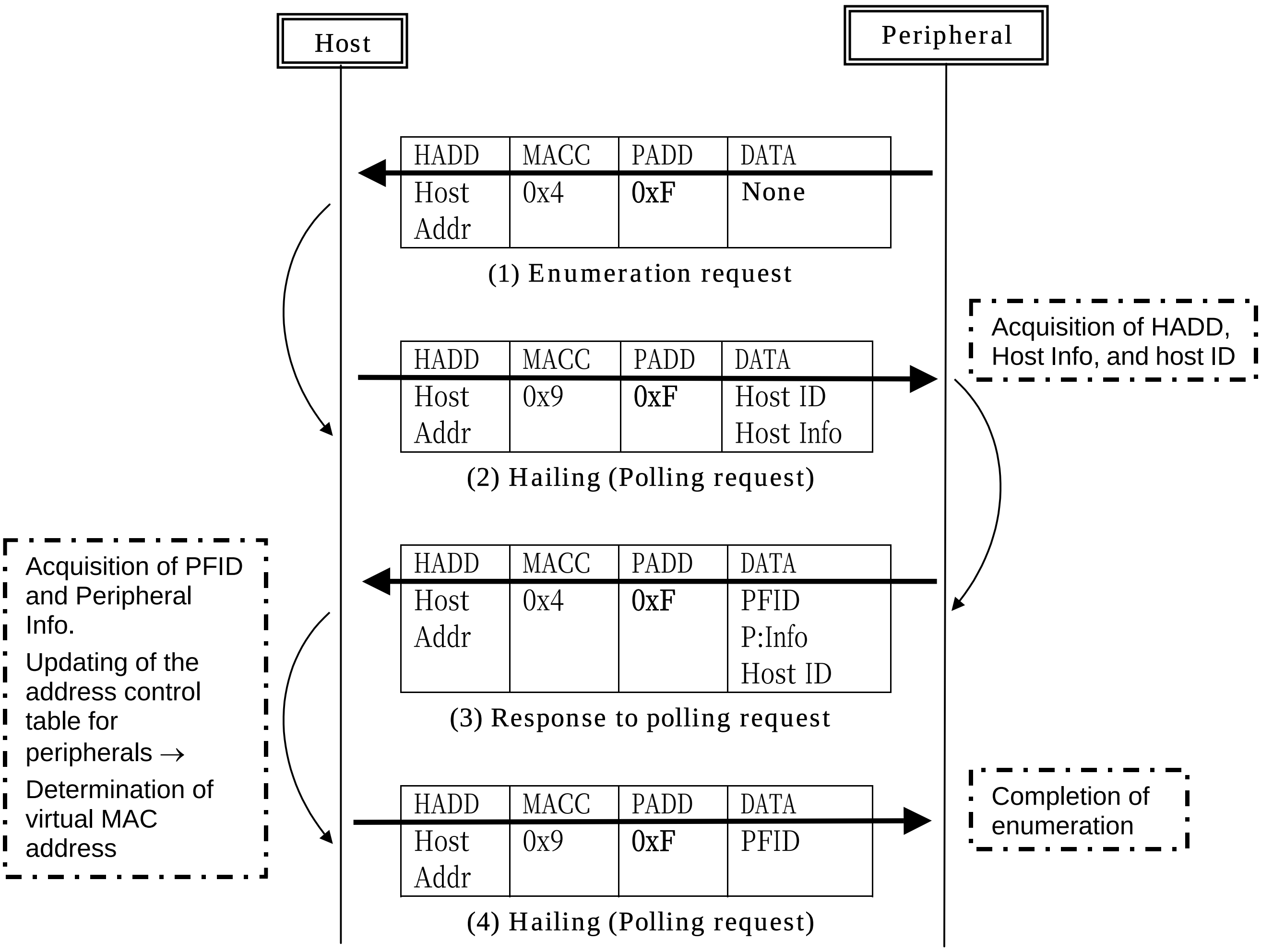


Fig. 6.11 Enumeration Procedure

(1) A peripheral makes an enumeration request.
MACC = 0x4 is a polling request command. In this case, it is used as an enumeration request.

(2) The host transmits a polling request.
At this time, both Host ID and Host information are sent as data. PADD = 0xF is a special address for enumeration. MACC = 0x9 is a command for hailing (polling request).
* With this operation, the peripheral obtains both Host ID and Host information.

(3) The peripheral transmits a response of a polling request.

At this time, the peripheral ID, peripheral information, and host ID are transmitted to the host.

To the peripheral to which enumeration was performed, the host gives an 8-bit virtual MAC address and updates the "peripheral ID", "virtual MAC address", and the address control table that controlled the three parties of "PADD" to be determined by the binding operation.

(4) The host completes initialization by informing the peripheral of the "virtual MAC address" specified in (3).

Table 6.6 Address Control Table for Peripherals

	Peripheral ID (32bit) At delivery from the factory	Virtual MAC address (8bit) (= NodeID)	PADD (4bit) To be issued for bind execution
	A	B	C
Peripheral ①	xxxxxx-xxxx-xxxxxxxxxx	0x01	For example, (0x2)
Peripheral ②	xxxxxx-xxxx-xxxxxxxxxx	0x02	For example, (0x6)
Peripheral ③	xxxxxx-xxxx-xxxxxxxxxx	0x03	For example, (0x4)
. . . .	. . . .	. . . .	. . . .
Peripheral ⑧	xxxxxx-xxxx-xxxxxxxxxx	0x08	For example, (0xA)
(Peripheral ⑨) . . .	xxxxxx-xxxx-xxxxxxxxxx	0x08	For example, (0xB)

A → B: Determine "virtual MAC address" by enumeration:

This virtual MAC address is associated with ECHONET Node ID at 1:1. The relationship between A and B is held. A certain relationship is held except for reset processing.

Determine PADD by bind execution:

B → C: PADD is cleared by unbind execution. Accordingly, PADD is given for each bind execution, so it does not always take the same value.

The host can simultaneously bind up to 8 units.

6.5.4 Initialization completion stop status

Initialization completion stop status signifies a status in which the lower-layer communications software has been completed and a request for operation start is awaited from the communications middleware. An outline of processing immediately after state transition and an outline of the Individual Lower-layer Communication Interface services that the initialization completion stop status receives and its processing are described below.

(1) Trigger and action
Waits for individual lower-layer communications interface service.

(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_INIT as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)
Returns operating status as status.

(4) Physical address acquisition service (LowGetMacAddress)
Returns HADD (= MAC address) for the host.
Returns "Virtual MAC address" for a peripheral.

(5) Profile data acquisition service (LowGetProData)
Returns profile data.

The following is a trigger to perform state transition.

(1) Transition trigger to the operation status
Transition is caused by operation start instruction service (LowRequestRun). At this time, if status between host and a peripheral is unbind, a bind procedure (*) is activated.

The bind procedure is shown below.

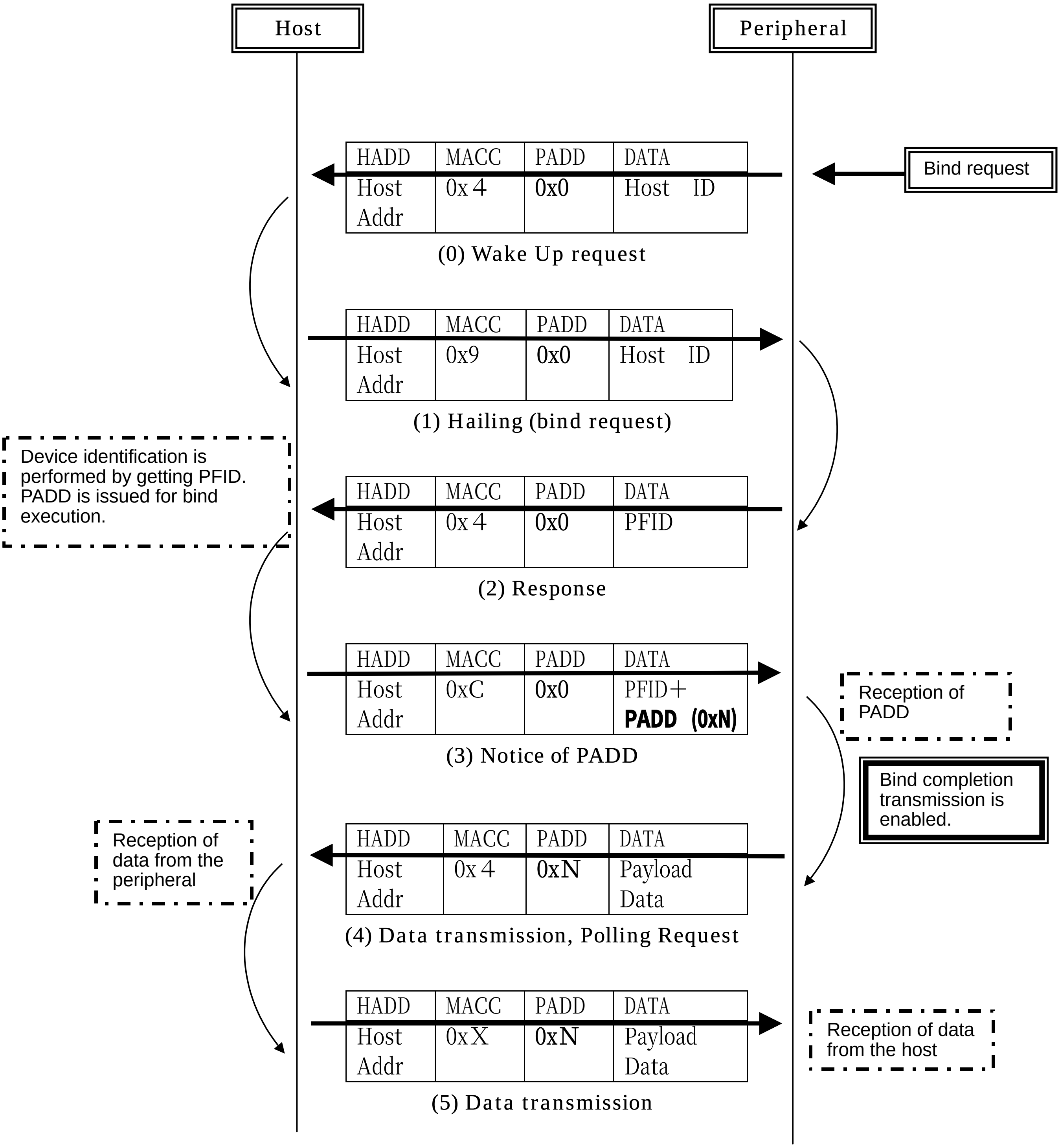


Fig. 6.1.2 Bind Procedure

However, procedure (0) is required only when the host is in a sleep status.

(0) The peripheral transmits a Polling Request to the host.
In this case, HADD is the host address and PADD is 0x0. With this operation, the host in the sleep status starts the following operation (1).

(1) Host transmits Hailing.
At this time, it sends Host ID as data. PADD = 0x0 is a special address for bind execution. MACC = 0x9 is Hailing.

(2) Peripheral receives hailing command from host and transmits Polling Request in response.
At this time, Peripheral ID is transmitted to the host.

(3) The host gives a 4-bit HADD to the peripheral that received Peripheral ID.
This value is changed at each bind execution. The host generates the control table for peripheral ID and ECHONET NODE ID at enumeration. The PADD to be given by bind execution is added to the corresponding control table so that the peripheral can be identified uniquely.

(4) The host transmits the PADD set in (2) above to the peripheral and resets the bind timer.
With this, bind execution is completed.

6.5.5 Operation status

The operation status signifies a status where data is transmitted to or received from a transmission medium as the primary function of the lower-layer communications software. An outline of processing immediately after state transition and an outline of the individual lower-layer communications interface services that the operation status receives and its processing are described below.

(1) Outline of processing immediately after state transition
Waits for the individual lower-layer communications software service.

(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_RUN as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)
Returns operating status as status.

(4) Physical address acquisition service (LowGetMacAddress)
Returns HADD (= MAC address) for the host.
Returns "Virtual MAC address" for a peripheral.

(5) Profile data acquisition service (LowGetProData)
Returns profile data.

(6) Data transmission service (LowSendData)
Translates the received protocol difference absorption processing block data into lower-layer communications software data and outputs it to the transmission medium.

(7) Data reception service (LowRecvData)
Translates the lower-layer communications software data received from the transmission medium into protocol difference processing block data and outputs it to the protocol difference absorption processing block.

The following are triggers to perform state transition.

(1) Transition trigger to the stop status
Transition is caused by end service (LowStop).
<Outline of end processing>
- Clears the bind status, abandons all parameters, and proceeds to stop status.

(2) Transition trigger to suspension status
Transition is caused by lower-layer communication unit stop service (LowSuspend).

(3) Transition trigger to initialize processing status
Transition is caused by reset instruction service (LowReset).

(4) Transition trigger to error stop status
Transition is caused by the occurrence of an error.

6.5.6 Error stop status

Error stop status signifies a status in which the operation is stopped by the occurrence of an error. An outline of processing immediately after state transition and an outline of the individual lower-layer communications interface services that the initialization completion stop status receives and its processing are described below.

(1) Trigger and action
Performs error processing.

(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_SUSPEND as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)
Returns stop status as status.

The following are triggers to perform state transition.

(1) Transition trigger to stop status
Transition is caused by end service (LowStop).

(2) Transition trigger to initialize processing status
Transition is caused by reset instruction service (LowReset).

(3) Transition trigger to normal operation status
Transition is caused by removing the cause of the error.

6.5.7 Suspension status

Suspension status signifies a status in which the operation is paused by an instruction of the communications middleware. An outline of processing immediately after state transition and an outline of the individual lower-layer communications interface services and its processing are described below.

(1) Trigger and action
Stops the operation of the lower-layer communications software.

(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_SUSPEND as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)
Returns stop status as status.

The following are triggers to perform state transition.

(1) Transition trigger to normal operation status
Transition is caused by operation restart service (LowWakeUp).

6.6 Accommodation Specification

6.6.1 Relationship between host and peripherals

The only opposite party with which peripherals can communicate directly is the host. When one peripheral communicates with another peripheral or another subnet device, communication must be performed through the host. The communication rules for inter-peripheral communications and communications with other subnet nodes are specified in detail in Part 7 of the ECHONET Communication Specification, Chapter 6 IrDA Control Router.

6.6.2 Mandatory conditions for host and peripherals

In IrDA Control, it is impossible to start a communication from the host to a peripheral that is in initialization completion stop status (unbind status caused by Unbind or Bind timer over). Accordingly, ECHONET specifies that the following functions should be provided for both host and peripherals.

- The peripheral must be provided with a function to transmit a Wake Up request to the host at a certain interval. However, it should be possible to set this interval optionally (including No transmission) via an application. Details are provided in Part 7 ECHONET Communication Specification, Chapter 6 IrDA Control Router.
    - For cases in which the host is in a communication disable status with any peripheral upon receipt of request data for a peripheral from the controller, the host must be provided with a function to hold the request from the controller in the receiving buffer on the host side for a certain period. Details are provided in Part 7 ECHONET Communication Specification, Chapter 6 IrDA Control Router.

Chapter 7 LonTalk Communication Protocol Specification

7.1 System Overview

The LonTalk protocol conforms to the reference model of Open System Interconnection (OSI) by the International Organization for Standardization (ISO) and supports layer 1 to layer 7. The LonTalk itself can implement a perfect network protocol.

Fig. 7.1 shows a typical LON node configuration. Protocol processing does not depend on transmission media, so it can work with diversified types of transmission media:

- Twisted pair cable
- Radio frequency (radio wave)
- Infrared
- Coaxial cable
- Power line
- Optical cable

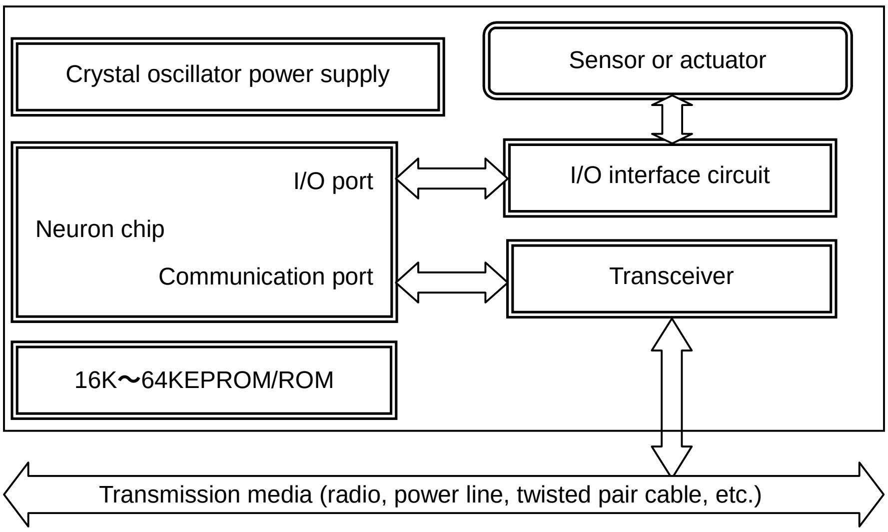


Fig. 7.1 Typical LON Node Configuration

Basically, using LON permits free design of a transceiver individually in consideration of only the I/F with the MAC (Media Access Control) layer of the LonTalk protocol. In other words, network processing in the transmission media controller subsequent to the transceiver need not be considered. Some transmission media may require special protocol processing because of legal regulations; the designer only needs to consider this point.

In ECHONET, the portion subsequent to the transceiver is regarded as layer 1, which supervises transmit/receive and modulate/demodulate processing for the LonTalk PPDU (Physical Protocol Data Unit). Layer 1 performs the processing equivalent to OSI reference model layer 1 and layer 2 individually using the specific protocol for each transmission medium. The LonTalk protocol is positioned as lower-layer communications software to support the layers subsequent to Individual lower-layer communications interface and also as the equivalent to layer 2 and layer 3, which perform basic communication processing. The ECHONET data (addresses, data) sent from the high-order layer is treated as LonTalk protocol data in a lump. For communications, explicit messages are used. Ver 1.0 does not specify the use of network variables.

7.1.1 Organization of Chapter 7

Sections 7.1 to 7.5 summarize the specifications related to LonTalk in ECHONET.

7.1 System Overview

7.2 Mechanical/Physical Characteristics

7.3 Electrical Characteristics

7.4 Logical Specifications

7.5 Basic Sequence

In and after Section 7.6, the transceiver specifications are summarized in each section. Regarding the described contents, the item numbers in each section correspond to the section numbers in Section 7.1 to 7.5. (X >= 6)

7.X.1 System overview

7.X.2 Mechanical/physical characteristics

7.X.3 Electrical characteristics

7.X.4 Logical specifications

7.X.5 Basic sequence

When there are items to be specified further for each transceiver, they are described in Sections 7.X.6 or later.

7.2 Mechanical/Physical Specifications

For a node configuration, it shall be essential to use devices that can implement the LonTalk protocol, and it will be based on a Neuron® chip. When there are legal regulations or other standards related to the mechanical/physical characteristics and specifications of cabinet, connector shape, cable, antenna, etc., they shall be adhered to. The following specifications shall be provided as the ECHONET Standard for each transmission medium as required. Details are provided in 7.X.2 after Section 7.6.

- Connector shape
- Transmission media
- Topology

7.3 Electrical Characteristics

Regarding the electrical characteristics of peripheral devices, including the protocol circuit, the interface with devices implementing the LonTalk protocol, including the Neuron® chip, shall be taken into consideration. When there are legal regulations or other standards related to electrical characteristics and specifications, they shall be adhered to. The following specifications shall be provided as the ECHONET Standard for each transmission medium as required. Details are provided in 7.X.3 after Section 7.6.

- Electrical characteristics of transmission media
- Transmission rate
- Modulation system
- Transmitting/receiving sensitivity (level)

7.4 Logical Specifications

Layer 1 processing is performed by the transceiver, and layer 2 and 3 processing is performed by the LON. The LON shall obtain the following transceiver operation status data as required.

- READY: Transceiver is operating normally.
- BUSY: Transceiver performs transmit/receive processing or initialize processing.
- ERROR: Transceiver causes some errors.
- NO_ID: Node-ID setting (updating) is required.

7.4.1 Layer 1

In the transceiver, the PPDU (Physical Protocol Data Unit) of LonTalk is treated as a data portion in the communication format specified for each transmission medium. Basically, frame conversion is performed into a data format such as that shown in Fig. 7.2 for the sake of communication. The header or footer is a general term for the preamble, address data, control code, etc. native to the transmission medium and specified for each transmission medium. Details are provided in 7.X.4 after Section 7.6. Processing native to the transmission media is described in and after 7.X.5.

Upon request to send from the LON or at the start of transmission, carrier sense and transmission timing adjustment serving as protocol processing in transmission media are performed, and the transmission media modulate the transmission media communication basic data to perform communications. The receiving side deletes the header and footer (format substitution) from the transmission media communication basic data demodulated in the transmission media and transmits PPDU to the LON. When the transceiver must stop new data transmission from the LON during header/footer processing, it informs the LON of BUSY during this processing, and when the transmission of new data is permitted, it clears BUSY and notifies READY.

Header	Data (LonTalkPPDU)	Footer

Fig. 7.2 Transmission Media Communication Basic Data Format

7.4.2 Layer 2

The NODE_ID information received from the protocol difference absorption processing layer is reflected in AddEmt and Address. The following PDU is put into the Eccl.PDU area according to PDUFmt. Data content and format are performed automatically by LonTalk. Accordingly, it is not necessary to consider the contents of the data structure, but they are described for reference. For details, see the LonTalk Protocol Specification.

<table>
<tr><td colspan="9">PPDU</td></tr>
<tr><td rowspan="2">PPDU Header</td><td colspan="7">NPDU</td><td rowspan="2">CRC</td></tr>
<tr><td>Ver</td><td>PDUFmt</td><td>AddFmt</td><td>Len</td><td>Address</td><td>Domain</td><td>Encl.PDU</td></tr>
</table>

Fig. 7.3 Layer 2 Data Format

- PPDU (Physical Protocol Data Unit)
  PPDU-Header: 9bit+ α (Bit synchronization signal + Byte synchronization one-bit length)
  CRC:16bit
- NPDU (Network Protocol Data Unit)

Ver:	2bit	Protocol Version
PDUFmt:	2bit	Encl.PDU is specified. 00: Encl.PDU = TPDU 01: Encl.PDU = SPDU 10: Encl.PDU = AuthPDU (Not specified in Ver 1.0) 11: Encl.PDU = APDU
AddFmt:	2bit	Specifies the format of address data.
Len:		Specifies the length of address data.
Address:		LON address data 24 bits min. or 72 bits max.
Domain:	0bit	LON domain: 0 (Not specified in Ver 1.0)

Addressing method (in LON)

- Broadcast
  All nodes in the domain: 24 bits are used for the address.
  All nodes in the SUBNET: 24 bits are used for the address.
- Multicast
  All nodes in the group: 24 bits are used for the address. (48 bits are used for ACK)
- Unicast
  Specific logical node: 32 bits are used for the address
  Specific physical node: 72 bits are used for the address (NeuronID)

Address length (in LON)

- Domain: 0
- SUBNET: 8bit
- Node: 8bit (1 to 127: The effective set value as node is 1 to 126.)
- Group: 8bit

7.4.3 Layer 3

This layer processes the NODE-ID and ECHONET data received from the protocol difference absorption processing layer. The address information is reflected in AddFmt and Address of layer 2. The whole ECHONET data is put into the DATA area of the APDU. When the protocol difference absorption processing layer divides the data, EDC(n) + (ESDATA)(n) is put into the DATA area. In this case, data processing takes place n times. However, this is independent of the data content and format.

The data size to be handled by layer 3 differs depending on the software mounting condition. The maximum buffer size is notified to the high-order layer beforehand. However, the minimum value shall be 34 bytes. This is because the maximum value of ECHONET data is 256 + 6 bytes and the maximum number of data divisions is 8.

APDU					
APDU-Header	Data				
Destin&Type	EHD	SEA	DEA	EBC	EDATA

Fig. 7.4 Layer 3 Data Format (1)

APDU		
APDU-Header	Data	
Destin&Type	EDC(n)	ESDATA(n)

Fig. 7.5 Layer 3 Data Format (2)

7.5 Basic Sequence

The following items are described.

- State transition diagram
- Sequence explanation of each state in the state transition diagram

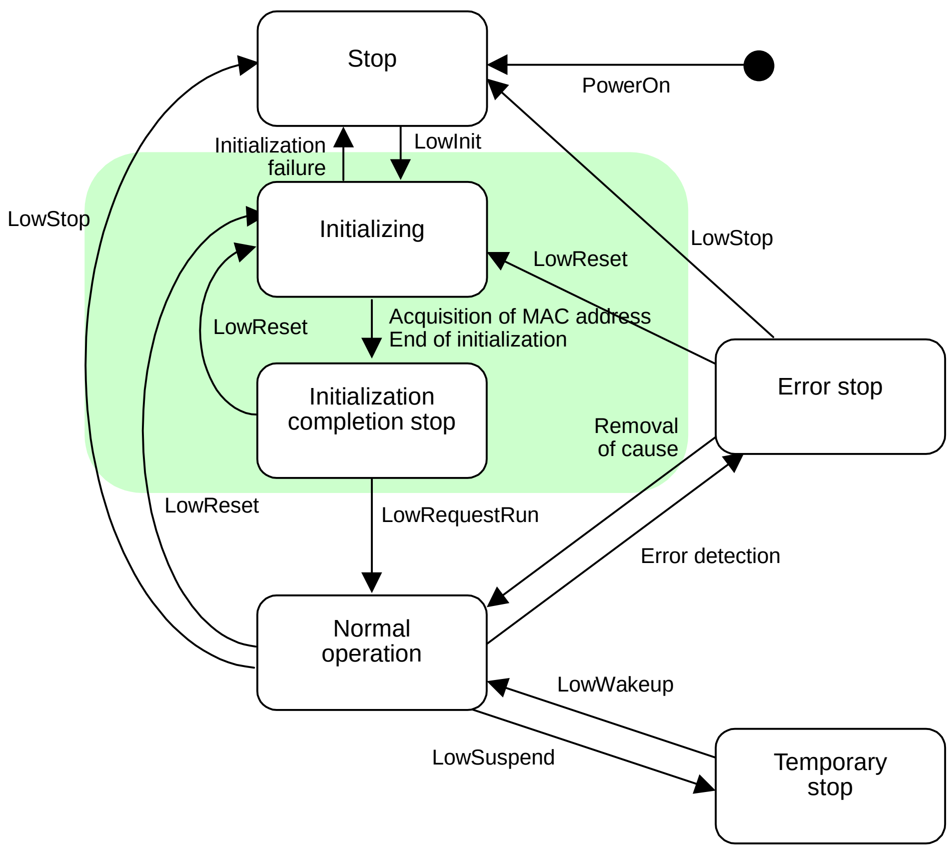
7.5.1 Basic concept

This subsection outlines the sequence in each state by classifying the LonTalk Individual lower-layer communications software status as shown below.

① Stop status
② Initialize processing status
③ Normal operation status
④ Error stop status

The figure below shows the state transition diagram for each status.

The state transition of the transceiver includes a portion that operates in non-synchronization with the LON, and is therefore described for each transceiver in 7.X.5 after Section 7.6.



7.5.2 Stop Status

Stop status signifies a status in which any operation of lower-layer communications software is not performed. This status is provided immediately after Power On. An outline of processing immediately after state transition and an outline of Individual lower-layer communications interface services that the stop status receives and its processing are described below.

(1) Trigger and action
Waits for an Individual lower-layer communications interface service.

(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_STOP as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)
Sends back the stop status as status.

The following is a trigger to perform state transition.

(1) Transition trigger to initialize processing status
Transition is caused by initialization service (LowInit).
Transceiver initialization is performed in non-synchronization with the LON without an initialization service.
The transceiver informs the LON of BUSY at the start of initialization.

7.5.3 Initialize processing status

Initialize processing status signifies that the lower-layer communications software is initialized.
An outline of processing immediately after state transition and an outline of Individual lower-layer communications interface services that the initialize processing status receives and its processing are described below.

(1) Trigger and action
① Initializes the transceiver.
Transceiver initialization is performed in non-synchronization with the LON.
After Power On reset is cleared, BUSY is notified to the LON, and initialization is performed.
At the end of initialization, READY is notified to the LON.

② Obtains a unique MAC address in the SUBNET.
The Node-ID of the LON is converted into 8 bits, and the converted data with an MSB of “0” is notified as the MAC address.
When the Node-ID is undefined, Node-ID define processing is performed.

③ Obtains a house code.
Media that handle house codes are not supported in Ver 1.0.

(2) Status acquisition service
Returns LOW_STS_INIT as status.(LowGetStatus)

(3) Lower-layer communications module operation status acquisition service.(LowGetAliveStatus)
Returns initializing status as status.

The trigger for state transition is shown below.

(1) Transition trigger to initialization completion stop status
Transition is caused by initializing the transceiver, obtaining a MAC address, and obtaining a radio system identification code.

7.5.4 Initialization completion stop status

Initialization completion stop status signifies a status of waiting for a request for operation start from the communications middleware after the lower-layer communications software is initialized. An outline of processing immediately after state transition and an outline of individual lower-layer communications interface services that the initialization completion stop status receives and its processing are described below.

(1) Trigger and action
Waits for individual lower-layer communications interface service.

(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_INIT as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)
Returns operating status as status.

(4) Physical address acquisition service (LowGetMacAddress)
Returns a MAC address.

(5) Profile data acquisition service (LowGetProData)
Returns profile data.

The trigger to perform state transition is shown below.

(1) Transition trigger to normal operation status
Transition is caused by operation start instruction service (LowRequestRun).

7.5.5 Normal operation status

Normal operation status signifies a status in which data is transmitted to or received from a transmission medium as the primary function of the lower-layer communications software. An outline of processing immediately after state transition and an outline of individual lower-layer communications interface services that the normal operation status receives and its processing are described below.

(1) Trigger and action
Waits for individual lower-layer communications interface service.

(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_RUN as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)
Returns operating status as status.

(4) Physical address acquisition service (LowGetMacAddress)
Returns a MAC address.

(5) Profile data acquisition service (LowGetProData)
Returns profile data.

(6) Data transmission service (LowSendData)
Translates the received protocol difference absorption processing block data into lower-layer communications software data and outputs it to the transmission medium.

An outline of transmission sequence is described.

- Checks the transceiver READY status and outputs a signal.
- Advances processing according to LonTalk after that.
  The sequence between MAC layer and transceivers differs with the transmission medium.
- The transceiver checks that the transmission request signal of the LON has been cleared and completes the output.

The BUSY signal is cleared.

(7) Data reception service (LowRecvData)

Translates the lower-layer communications software data received from a transmission medium into protocol difference absorption processing block data and outputs the translated data to the protocol difference absorption processing block.

An outline of the reception sequence is described.

- After starting reception, the transceiver sends a collision detection signal and a BUSY signal to the LON.
- Of the received data, only PPDU is transferred to the LON. After completion of reception on the transceiver side, the collision detection signal and the BUSY signal are cleared. After that, processing is advanced according to LonTalk.
- The received lower-layer communications software data is translated into protocol difference absorption processing block data, and the translated data is output to the protocol difference absorption processing block.

The following are triggers to perform state transition.

(1) Transition trigger to stop status

Transition is caused by end service (LowStop).

(2) Transition trigger to suspension status

Transition is caused by lower-layer communication block stop service (LowSuspend).

(3) Transition trigger to initialize processing status

Transition is caused by reset instruction service (LowReset).

(4) Transition trigger to error stop status

Transition is caused by the occurrence of an error.

7.5.6 Error stop status

Error stop status signifies a status in which the operation is stopped by the occurrence of an error. An outline of processing immediately after state transition and an outline of individual lower-layer communications interface services that the error stop status receives and its processing are described below.

(1) Trigger and action
Transition is caused by the occurrence of an error. Performs error processing.

(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_SUSPEND as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)
Returns stop status as status.

The following are triggers to perform state transition.

(1) Transition trigger to stop status
Transition is caused by end service (LowStop).

(2) Transition trigger to initialize processing status
Transition is caused by reset instruction service (LowReset).

(3) Transition trigger to normal operation status
Transition is caused by removing the cause of the error.

7.5.7 Suspension status

Suspension status signifies a status in which operation is paused by an instruction from the communications middleware. An outline of processing immediately after state transition and an outline of individual lower-layer communications interface services and its processing are described below.

(1) Trigger and action
Transition is caused by lower-layer communication unit stop service (LowSuspend).
Stops operation of lower-layer communications software.

(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_SUSPEND as status.

(3) Lower-layer communications module operation status acquisition service (LowGetAliveStatus)
Returns stop status as status.

The following are triggers to perform state transition.

(1) Transition trigger to normal operation status
Transition is caused by operation restart service (LowWakeUp).

7.5.8 (LON)Node-ID setting sequence

The Node-ID to be used in 7.5.8 indicates the Node-ID in the LON and corresponds to the MAC address specified in ECHONET. This Node-ID is associated with the Node-ID of ECHONET uniquely according to the conversion specifications described in Part 2, Section 7.4.5. In the SUBNET, one node always exists as the Master and controls (LON)Node-ID in the SUBNET. The Master (LON)Node-ID shall be 0x7E. (LON)Node-ID = 0x7F is specified as Node-ID undefined status and the others are assigned to Slaves in the SUBNET without redundancy. In the relationship with portions higher than the protocol difference absorption processing layer, there is no difference in Master/Slave operation. However, in communication processing after the transceiver, the distinction between both is specified as required.

Regarding the (LON)Node-ID setting, the following two types are specified:

1. Setting by the DIP-sw:
   - Set any optional value between 0x01 to 0x7D without redundancy in the SUBNET using I/O ports.

2. Automatic setting by communication port
   - The Slave issues a service message when its own (LON)Node-ID is undefined.
   - Upon receiving the service message, the Master refers to its own domain table and informs the Slave having issued the service pin message of the data of a free address. At this time, the Neuron ID (address type 2) is specified as the Slave address of the destination.
   - When receiving the address data, the Slave rewrites its own domain table and sets its own (LON)Node-ID.
   - A confirmation signal is transmitted to the Master by address type 1.
   - The Master transmits ACK upon receipt of the confirmation signal.
   - When the Slave receives ACK, a series of (LON)Node-ID acquisition sequences is completed.
   - If NO-ID is received from the transceiver in the status in which the ID has already been obtained, it is judged that the node has moved from the SUBNET, the current (LON)Node-ID is invalidated, and a new (LON)Node-ID is obtained.

7.6 RCR STD-16 Transceiver Specifications

The transceiver is specified for the case in which the specific low-power radio (hereafter referred to as RCR STD-16) to which the ARIB Standard RCR STD-16 is applied is used as a transmission medium.

RCR STD-16: Radio equipment for telemetering and telecontrol in a specific low-power radio station.

7.6.1 System Overview

In order to perform transmit/receive processing to satisfy the RCR STD-16, frame conversion is performed for the addition of special header data to the PPDU. In addition, protocol processing that cannot be controlled by LonTalk as carrier sense, automatic communication channel switching, group ID registration, and inter-node communication check is performed in non-synchronization with LonTalk, and the transceiver operation status (Status) is directly notified to layer 3. To perform such processing, the specific low-power radio transceiver consists of a Neuron ® chip, RF module, RF microcomputer as an intermediary between both, TxSW for transmission and RxSW for reception for switching messages with the header to be transmitted or received between PPDU and RF module, auxiliary memory to store necessary control information, and identification codes.

The above RF microcomputer, TxSW, and RxSW may not always be a microcomputer and switches represented by their names but may be the corresponding function blocks. Detailed configurations for these are not specified in ECHONET.

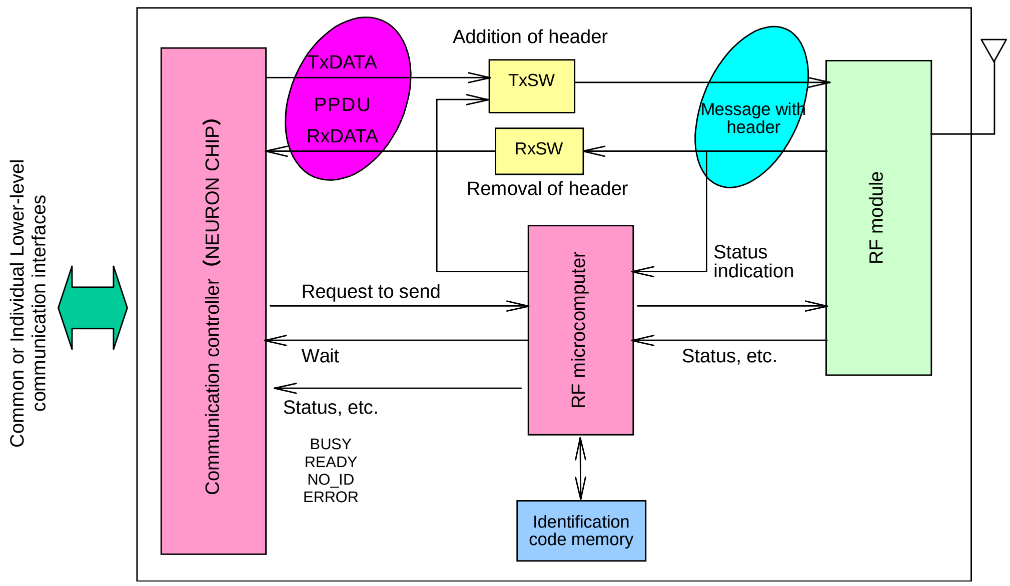


Fig. 7.5 Transceiver Configuration

7.6.2 Mechanical/physical specifications

- Connector shape: Antenna type and shape and connector shape are not specified. However, the requirements of the RCR STD-16 shall be satisfied.
- Transmission media: 400 MHz band continuous communication channels, channels 7 to 46, 429.2500 MHz to 429.7375 MHz.

  Channel groups such as those shown in Table 7.2 are configured. For channel use, the channel switching system described in Section 7.6.6 shall be operated.
- Topology: Free. A group ID shall be owned by each SUBNET.
- Others: Starting means for the group registration mode (mandatory) and the test signal transmission mode shall be provided (this is optional, but test signal receive processing is mandatory).

  A means that permits checking the progressive status of the group registration mode shall be provided.

7.6.3 Electrical characteristics

- Electrical characteristics of media: RCR STD-16 shall be adhered to.
- Transmission rate: Differential Manchester 2400 bps
- Modulation system (transmission system): Binary FSK (F1D) NRZ
- Transmitting/receiving sensitivity (level): RCR STD-16 shall be adhered to.
- Basically, the RF module shall always be waiting for reception, and the specific node (Master) shall perform a transmit operation periodically as shown below. Accordingly, a stable, continuous supply of power is recommended.

Table 7.2 Channel Frequency Bands

Channel pair	ChA	ChB	
0	*8ch*	*28ch*	Pair group 1
1	*10ch*	*30ch*	
2	*12ch*	*32ch*	
3	*14ch*	*34ch*	
4	*16ch*	*36ch*	
5	*18ch*	*38ch*	
6	*20ch*	*40ch*	
7	*22ch*	*42ch*	
8	*24ch*	*44ch*	
0	*9ch*	*29ch*	Pair group 2
1	*11ch*	*31ch*	
2	*13ch*	*33ch*	
3	*15ch*	*35ch*	
4	*17ch*	*37ch*	
5	*19ch*	*39ch*	
6	*21ch*	*41ch*	
7	*23ch*	*43ch*	
8	*25ch*	*45ch*	
0	7ch	26ch	
1	27ch	46ch	

7.6.4 Logical specifications (layer 1)

The layer 1 data structure is as shown below; the footer is not specified. Data transmission is based on “MSB First”.

Header							LON PPDU
1st header			2nd header				
Bit synchronizat-ion	Frame synchronizati-on 1	Identification code	Bit synchronizati-on	Frame synchronizati-on 2	Group ID	Command	

Fig. 7.6 RCR STD-16 Layer 1 Data Structure

- 1st header: Consists of two synchronization signals (preamble: Bit synchronization signal + Frame synchronization 1 signal) and the subsequent 48-bit identification code based on Radio Law regulations.
- 2nd header: Consists of two synchronization signals (preamble: Bit synchronization signal + Frame synchronization 2 signal), group ID, and a command. The 2nd header may be transmitted more then one time. (1 to 16)
- Bit synchronization signal: Repetition of “1” with enough length for the system to perform carrier sense for one channel. (50 bits min., 120 bits max.)
- The frame synchronization signal shall be a 32-bit signal resulting from adding 0/1 to the 31-bit M series code.

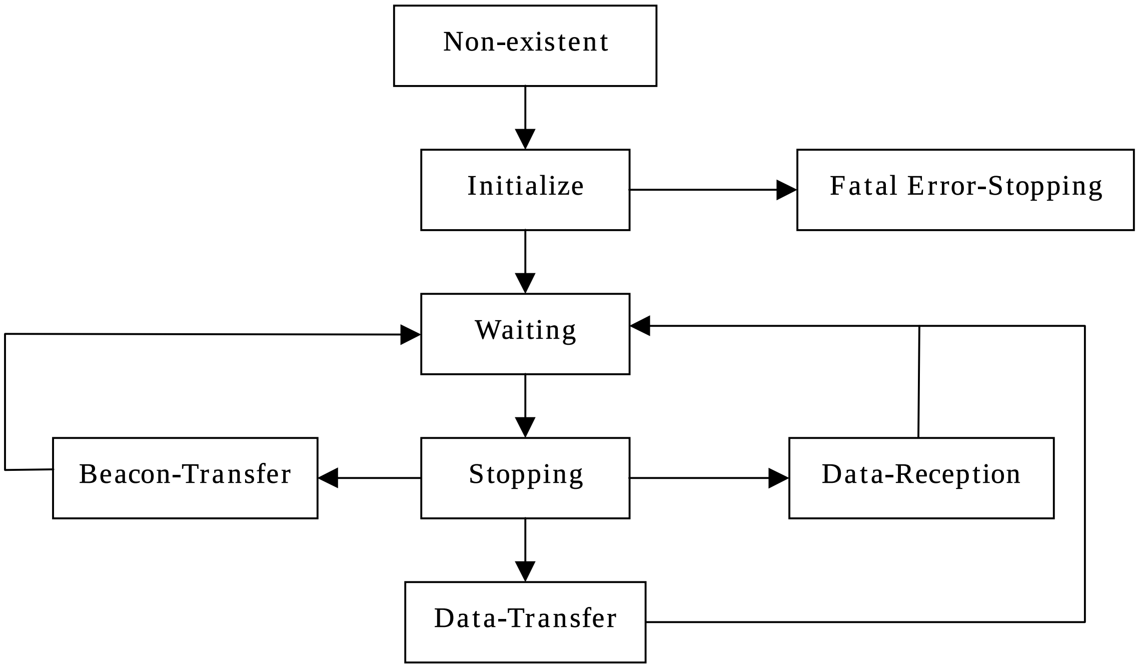
  Frame synchronization 1 signal: “00011011101010000100101100111110”

  Frame synchronization 2 signal: “00011011101010000100101100111111”
- The identification code is the Neuron_ID (48 bits) of the Neuron ® chip of each node.
- Group ID: Uses an identification code having a node that becomes the Master in the SUBNET. It is registered in all the nodes in the SUBNET including the Master (48 bits).
- Command: Discrete command to indicate the contents to be judged by the RF portion (32 bits). The following is specified for the high-order bit, b31, to the low-order bit, b0.
  - b31: Assigned to the Master/Slave flag. “1” at Master.
  - b30 to b24: Command proper
  - b23 to b20: Residual count at 2nd header repetitive transmission (F to 0)
  - b19 to b16: Number of “1s” in b31 to b20.
  - b15 to b1: BCH code for b31 to b16 based on BCH (31, 16)
  - b0: Even parity

Group ID registration (GIDCMD=0x10) :	Indicates that the Master is transmitting the group ID.
Group ID registration (SIDCMD=0x20) :	Indicates that the response operation for group ID registration is in process.
Transmission test (TSTCMD=0x30):	Indicates that an inter-node transmit/receive test is performed.
Reference signal (MCACMD=0x40):	Indicates that the transmit data is a reference signal.
LonTalk (LONCMD=0x50):	Indicates that the LON message follows the command.

All others shall be reserved for future use.

7.6.5 Transceiver operation sequence



Non-existent:	Not operated.
Initialize:	Address setting, initial setting of RF circuit.
Waiting:	Wait for reception. Wait for timer, key input, or request to send.
Stopping:	Setting for a transmission stop request for LON and various requests.
Beacon-Transfer:	Periodic signal transmission to secure or check communication channels, including a communication test.
Data-Reception:	Data reception, including various processing of LONTALK exchange and data.
Data-Transfer:	Data transmission (RD header and LONTALK PPDU).
Fatal Error-Stopping:	Stop at address redundancy detection, stop upon error occurrence, etc.

7.6.6 Automatic channel switching system

- A specific node in the SUBNET is set as the Master. The Master node selects one pair from the pair groups. (Default: Channel pair 0.)
- Carrier sense is performed alternately by the two channels in the selected pair.
- After a lapse of one minute, if one of these channels is free, the reference signal is output. When either of them is free, the reference signal is output by this free channel. When both channels are free, the reference signal is output by chA.

If both are not free, the next channel pair is selected and carrier sense is restarted.

- For nodes other than the Master node, carrier sense is performed alternately by the two channels of a certain channel pair. (Default: Channel pair 0.)
- When the reference signal or a signal from the same SUBNET is not detected within one minute, a channel change is made to the next pair.

7.6.7 Group ID registration

The RCR STD-16 nodes perform group ID registration as the initial setting to participate in the network. The registered group ID shall be non-volatile, i.e., valid unless the network configuration is changed. The communication enable nodes shall be those belonging to the same SUBNET specified in ECHONET and have a unique group ID for each SUBNET. If the respective SUBNET is different, communication is performed through a router. An optional one node (generally a node being a router) in the SUBNET shall be specified as the Master and the Master node identification code is used as a group ID. The other nodes shall be Slaves, and group ID registration is performed according to the following procedure.

- To let a new node participate in the network as a Slave, the Slave starts the ID registration mode by the ID registration channel pair and waits for ID transmission from the Master.
- After transmitting the reference signal in succession, the Master moves to the ID registration channel pair and starts the ID registration mode, and then transmits its own group ID according to the following format:

Bit synchronizat-ion	Frame syn-chronizati-on 1	Identification code	Bit synchronizati-on	Frame synchronizati-on 2	Group ID (Master identification code)	ID registration command (GIDCMD)

- The slave stores the received group ID into its own memory and responds to the Master according to the following format:

Bit synchronizat-ion	Frame synchronizati-on 1	Identification code	Bit synchronizati-on	Frame synchronizati-on 2	Group ID (Master identification code)	ID registration command (SIDCMD)

- If the transmission from the Master cannot be confirmed within 12 seconds, the group registration mode is terminated and the operation is stopped.
- After confirming reception from the Slave, the Master informs the Slave of the completion of registration by SIDCMD (bit 31 = 1) and terminates the group ID registration mode. The node ID that will occur in succession is set by an ordinary channel pair. However, if no response is received from the Slave within 10 seconds or the group ID does not match, GIDCMD is transmitted again. If, the reception still cannot be confirmed despite up to 4 retries (5 retries in total including the first retry), the group ID mode is terminated, returning to normal operation.
- After responding, the Slave checks the SIDCMD and terminates the group ID registration mode. The Slave informs (NO_ID) the LON that group registration has been performed in succession and asks for (LON)Node-ID setting.

7.6.8 (LON)Node-ID setting

The (LON)Node-ID corresponds to the Mac address specified in ECHONET. After group ID registration, (LON)Node-ID setting is performed. See Section 7.5.8.

7.6.9 Transmission system

- For the request to send (transmission enable) and reference signal from the LON, or upon occurrence of a test signal transmission request event, a collision detection signal and BUSY signal are output to the LON.
- After completion of a procedure such as carrier sense, the RF circuit is switched over to the transmission mode and the 1st header and 2nd header are output to the RF by a free channel. In cases other than LONCMD, the RF circuit is switched over to reception mode, and the collision detection signal and BUSY signal are cleared to READY status.
- On the other hand, upon receiving a collision detection signal, the LON completes the PPDU output or suspends it upon completion of preamble transmission (selectable by LON setting; in any case, the message output is not output to the RF before collision detection signal is cleared). After that, the LON attempts re-transmission in the randomized pause time.
- After completion of the RF output, the collision detection signal is cleared after confirming that the LON is not transmitting the PPDU, and then the RF output (modulation input to the RF circuit) is switched over to the LonTalk side.
- After the end of the pause time, the LON transmits the PPDU, and this message is sent to the RF.
- After it is confirmed that the transmission request signal has been cleared, the RF output is terminated.
- The RF circuit is switched over to reception mode, and the collision detection signal and the BUSY signal are cleared to READY status.

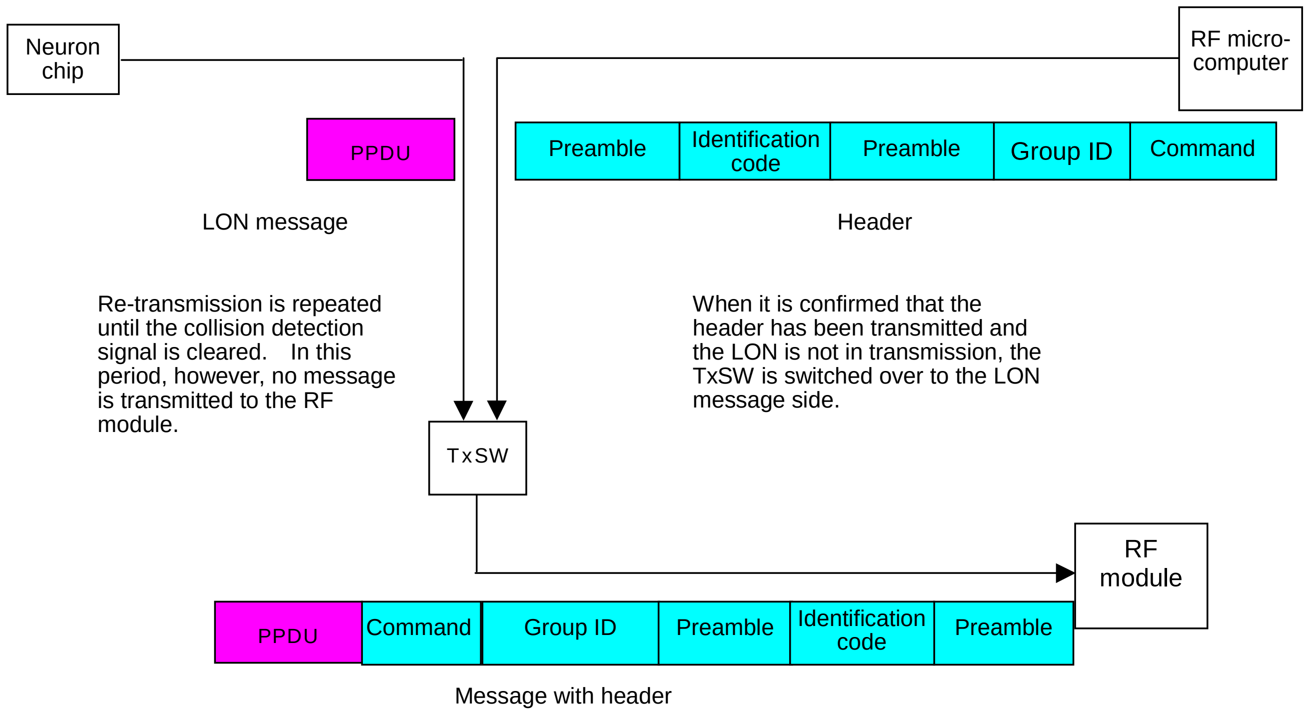


Fig. 7.7 LON RCR STD-16 Transmission Image

7.6.10 Reception system

- After confirming that a receiving carrier exists, the collision detection signal and the BUSY signal are output to the LON, and reception is started.
- The group ID in the 2nd header is read. When it is found to match the self-group ID, the command data subsequent to it is received, and operations are performed according to the contents of the command data. If the group ID does not match (except for group ID registration), receive processing is suspended.
- When the command data is LONCMD, the RxSW is switched to cause the LON to receive the PPDU.
- After confirming that a receiving carrier does not exist, reception is terminated.
- The collision detection signal and the BUSY signal are cleared to READY status.
- ACK/NAK/re-transmission: No ACK/NAK request or response or data re-transmission is performed by layer 1. This depends on the setting or judgement of layer 2 or higher.

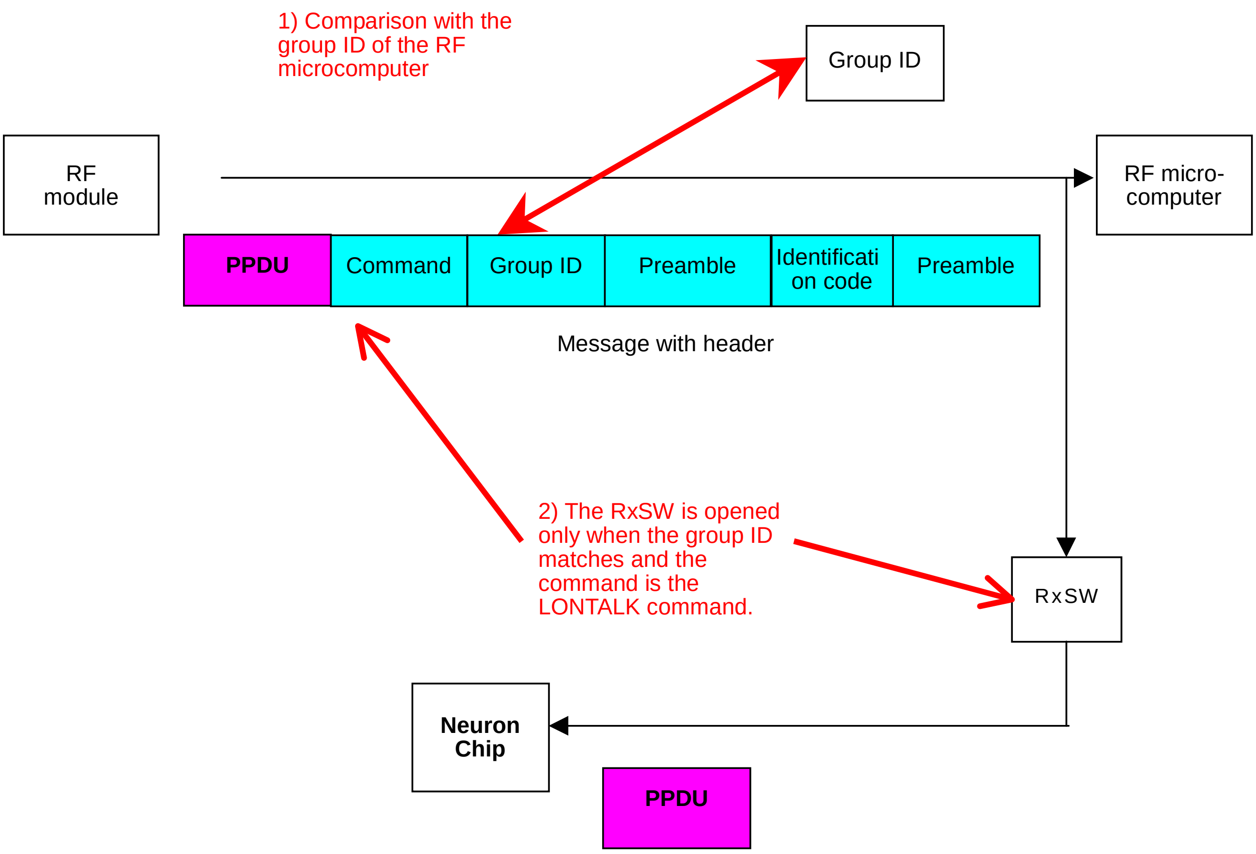


Fig. 7.8 LON RCR STD-16 Reception Image

Appendix Documents Cited

(1) Neuron Chip TMPN3150/3120 Data Book
(2) Neuron Chip Application Guide User's Manual
(3) Distributed Intelligent Control Network LON Works TM Overview
Toshiba Corporation Semiconductor Company, Domestic Sales Control Department
(Toshiba Bldg.) 1-1-1 Shibaura, Minato-ku, Tokyo 105-8001 (03) 3457-3405
(4) Neuron C Programmer's Guide
(5) Neuron C Reference Guide
(6) Technical Reference Materials for Lon Works Custom Node Development
(7) Technical Reference Materials for Neuron 3150® Chip External Memory Interface
(8) Technical Reference Materials for LonTalk® Protocol
(9) Technical Reference Materials for Enhanced Media Access Control with LonTalk Protocol
Echelon Corp. http://www.echelon.com ftp://lonworks.echelon.com
(10) ARIB Standard RCR STD-16 3.0
Association of Radio Industries and Businesses
(Tel: 03-5510-8590 Fax: 03-3592-1103)