# Part III Transmission Media and Lower-Layer Communication Software Specification

Revision record

- Version 1.0 March 18th 2000 released Open to consortium members
  July 2000 Open to the public
- Version 1.01 May 23rd 2001 Open to consortium members
  Version 1.0 addendum & corrigendum
- Version 2.00 August 7th 2001 Open to consortium members
  Since the power line A and power line B methods were integrated into a single power line method (based on the power line A method), the associated descriptions were corrected accordingly.
  The following table-of-contents entries were revised:

| | Revised entry | Revision/addition |
|---|---|---|
| 1 | 1.2, 1.3 | Descriptions were deleted or corrected because the power line A and power line B methods were integrated into a single method. |
| 2 | Chapter 2 | The power line communication protocol specification was renamed because the power line A and power line B methods were integrated into a single method. |
| 3 | Chapters 3 to 6 | Chapter, figure, and table numbers were changed accordingly because the power line A and power line B methods were integrated into a single method. |

- Version 2.01 November 9th 2001 Descriptions were corrected as needed for typographical correction, terminological standardization, and other purposes.
- Version 2.01 December 19th 2001 Open to consortium members.
- Version 2.10 Preview December 28th 2001 Open to consortium members.
- Version 2.10 Draft February 15th 2002 Open to consortium members.
  Part 3 revisions related to the state transition related descriptions in Sections 2.5, 3.5, 5.5, and 6.5.
- Version 2.10 March 7th 2002 Open to consortium members.
- Version 2.11 April 26th 2002 Open to consortium members
  The following table-of-contents entries were revised:

| | Revised entry | Revision/addition |
|---|---|---|
| 1 | 2.5, 3, 5, 4.7, 5.5, 6.5 | - The typographical error “LowReset” for “LowStart” in relation to status change was corrected, and the status acquisition service return value for each was corrected. |
| 2 | 2.5, 6.5 | - The typographical error for “lower layer communication software type acquisition service (LowGetDevID)” was corrected. |
| 3 | Chapters 2 through 6 | - Correction of other typos. |

Contents

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

## 1.1 Positioning on Communication Layers

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

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

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

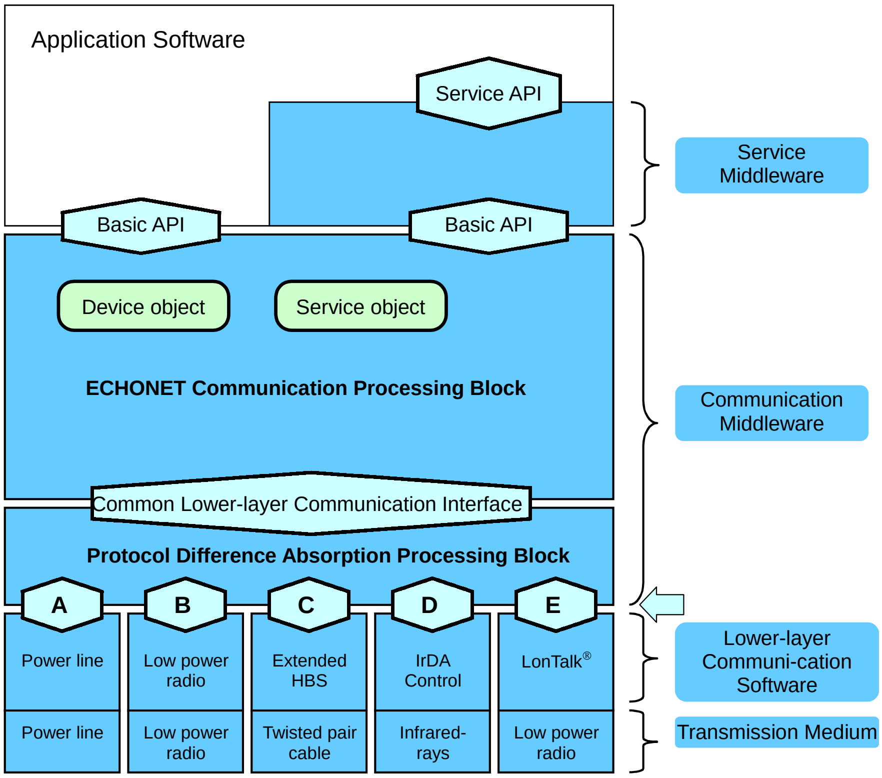



**Figure ECHONET Architecture**

## 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

Direct spectrum spread type lower-layer communication software that uses existing indoor power lines as a medium in compliance with the Radio Law Enforcement Regulations.

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-T67 and STD-30.

③ Extended HBS lower-layer communication software

Lower-layer communication software that uses twisted-pair cables as a medium by means of expansion for compliance with the ET-2101 (HBS) standard of JEITA (equivalent of EIAJ; JEIDA and EIAJ were merged to form JEITA). Changes brought about by the ET-2101 standard include an increase in the maximum transmission distance to 1 km, the permission of one-pair medium use, and the detection of duplicate addresses.

④ IrDA communication software

Lower-layer Communication Software for which the transmission medium is infrared light. 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.

⑤ 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 include other media will be discussed.

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 | – | ○ | – | – |
| Extended HBS lower | – | – | – | ○ |
| IrDA | – | – | ○ | – |
| LonTalk® | – | ○ | – | – |

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 rules are applied.
  - MAC address
  - Maximum data length
  - Lower-layer communication software identification ID
  - Transmission medium identification ID
  - Broadcast function identification ID
  - Transmission rate
- Function to store self-status and to notify communication middleware.
  The following five states shall be mandatory:
  - Stop
  - Initialization
  - Normal operation
  - Error stop
  - Suspension

For individual medium sequences, see the basic sequence descriptions in the associated chapters.

## 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

Already installed indoor power lines are used as the transmission medium. Because existing lines are used to transmit signals, special new cables are not needed. The reduced installation burden is a key advantage.

ECHONET now proposes the direct spread spectrum method.

The object and use of power line-based data transmission are considered to be as follows:

- Object: Residential 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 enables use in devices installed in locations without an AC power supply, and in portable devices.
The characteristics of low-power radio transmission are as 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 frequencies are restricted by law.

(4) Law does not require a radio license for device users.

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

③ Infrared

- No wiring is required.
- Efficient for use with portable devices.
- No leakage of signals outside of building (highly secure).

④ Twisted pair cable

- Highly reliable.
- Highly secure.

## 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, and Rules Related to Technical Standard Conformance Authorization
- Notification of the Ministry of Posts and Telecommunications

  on the basis of related 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/).

③ Infrared

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

④ LonTalk

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

ARIB RCR STD-T67 for specific low-power radio is applied as a transmission medium.

# Chapter 2 Power Line Communication Protocol Specification

## 2.1 System Overview

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

### 2.1.1 Scope of the Standard

This Standard consists of mechanical/physical specifications, electrical specifications, and logical specifications for layer 1 and logical specifications for 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.

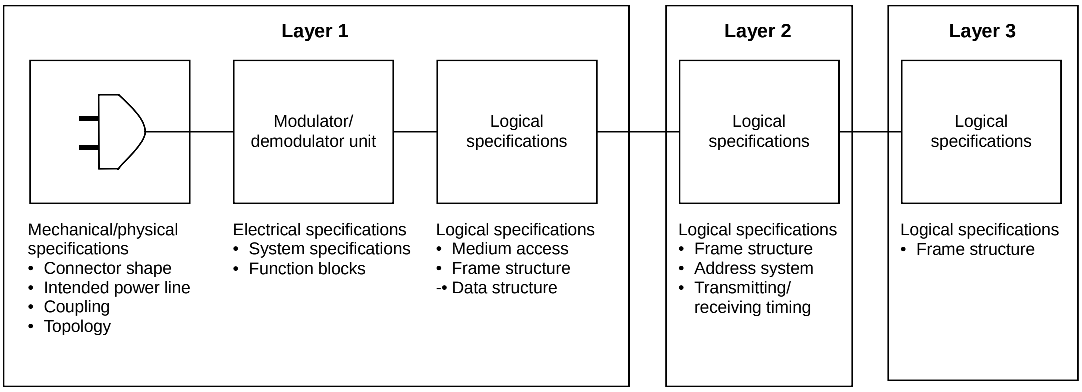



**Fig. 2.1 Scope of the Standard**

## 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, 3-wire lines must provide a means for transmitting signals between phases.

* Measures for 3-phase 3-wire 200 V power cable shall be discussed in the future as necessary.

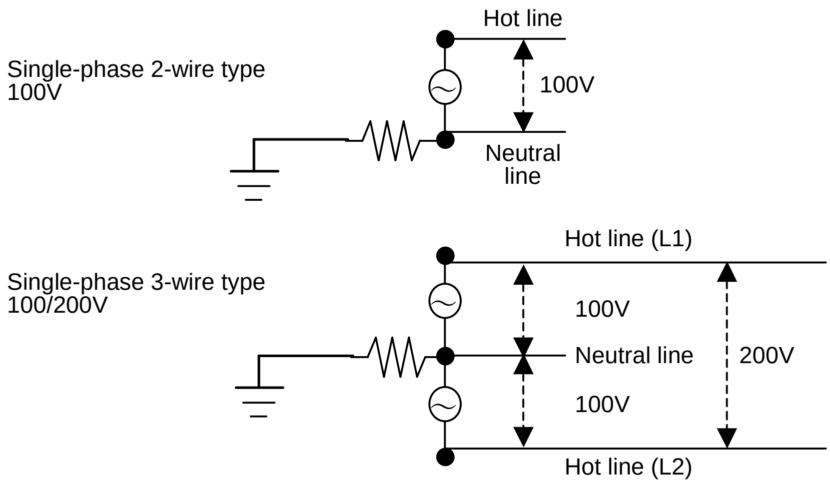



**Fig. 2.2 Electric System**

### 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.

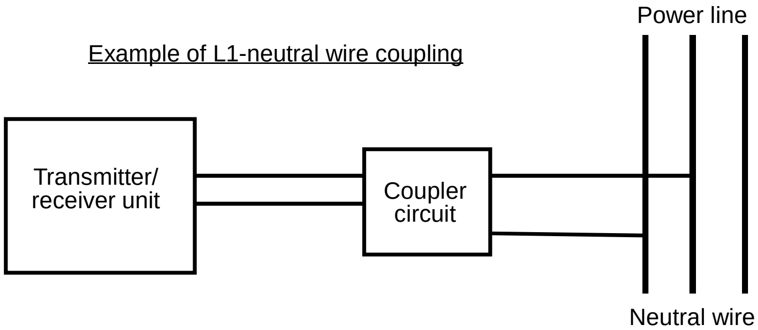



**Fig. 2.3 Coupling System**

### 2.2.4 Topology

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

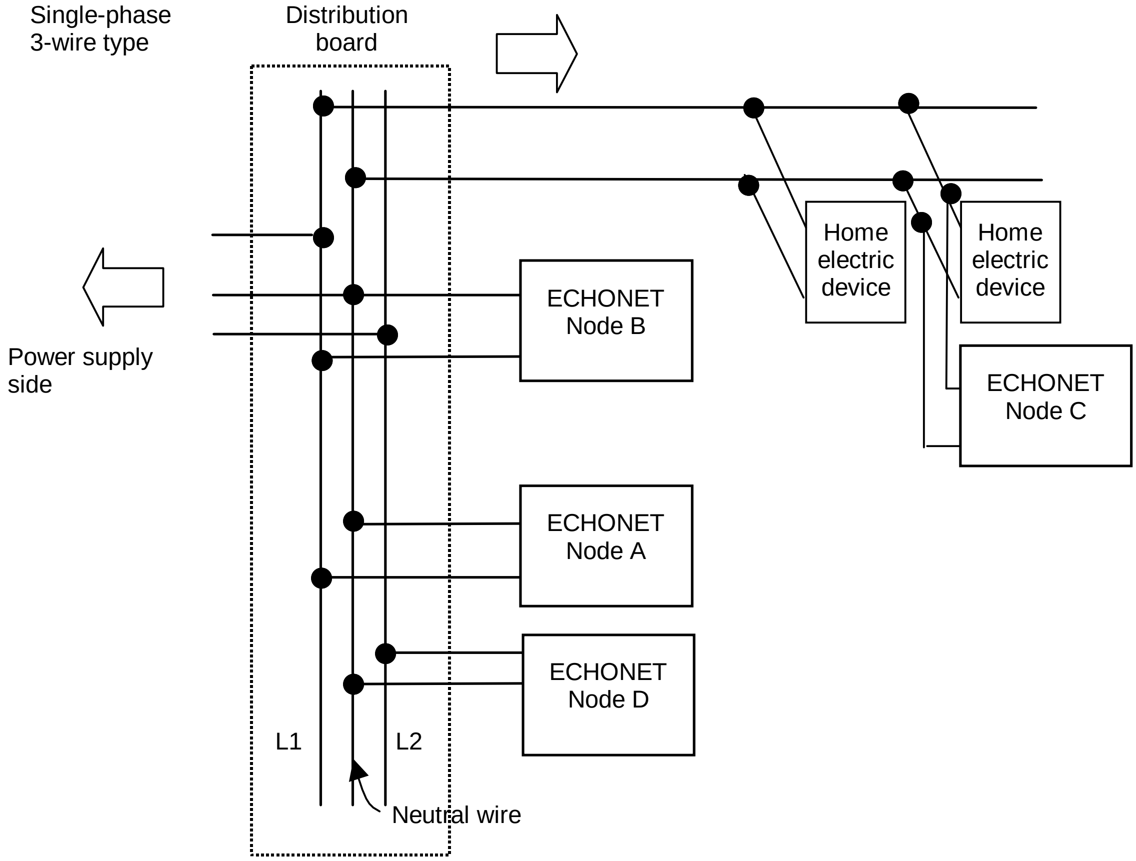



**Fig. 2.4 Power Line Topology**

* Communication quality deteriorates with transmission distance and the number of home electric devices and other appliances between ECHONET nodes. For example, the characteristics of the transmission path between nodes A and C are more likely to deteriorate than those between nodes A and B because of the influence of home electric devices between the nodes.

Further, it is difficult to establish communication between terminals A and D, which are connected to different lines. Here, communication can be established by connecting an HPF or the like between the L1 and L2 or by connecting an ECHONET router between the terminals connected to the L1 and L2 while regarding such terminals as different subnets.

Furthermore, the 200 V air conditioner power line (between L1 and L2 in Fig. 2.4) and 100 V power line, for example, do not carry communication high-frequency signals. Therefore, they are regarded as different subnets. To establish communication between such power lines, it is necessary to furnish a repeater device such as an ECHONET router. Some power lines may require the installation of a blocking filter.

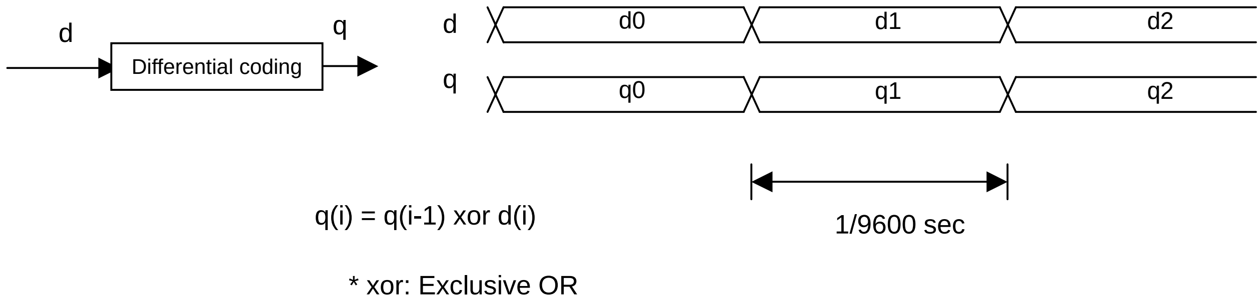
## 2.3 Electrical Specifications

The power line carrier system of this Standard shall conform to the Radio Law Enforcement Regulations, Article 46-2-6 "Conditions for Special Carrier Digital Data Transmitters Using the Spectrum Spread Method for Carrier Wave Modulation" (as of December 2000; the article number was changed by Posts and Telecommunications Ministry Ordinance 60 on July 12, 1999).

### 2.3.1 System Specifications

(1) Spread spectrum system
Direct spread spectrum
Spread code: The data 1 bit and spread code shall agree in length.
The spread code group or chip length is not stipulated.

(2) Primary modulation system
Differential coding




(3) Transmission rate
9600 bps ±50 ppm

(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
(A spread shall take place within a frequency range of at least 200 to 300 kHz.)

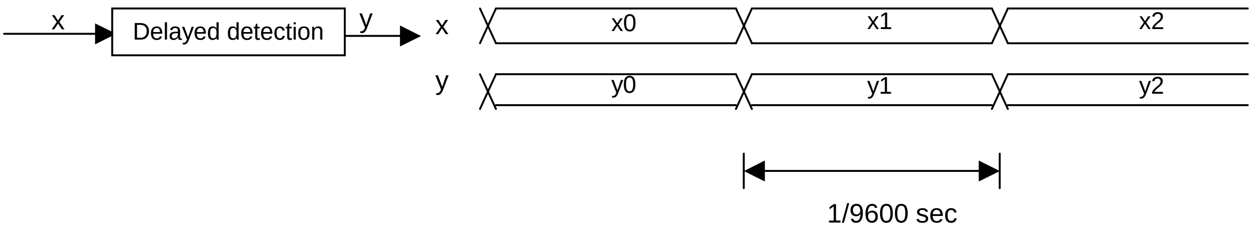
(7) Spurious signal intensity at output terminal
450 kHz-5 MHz (inclusive): 56 dBμV or less
5 MHz-30 MHz (inclusive): 60 dBμV or less

(8) Electric field leakage (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

(10) Demodulator detection method

Delayed detection




* The symbol "x" represents a received spread signal or part of it. Spread code inverse spread and differential decoding take place simultaneously.

(A) When input x is a binary signal

y(i) = x(i) xor x(i - 1)

(B) When input x is multivalue digital signal or analog signal

$$y(i) = \begin{cases} 0 & x(i) \text{ is in phase with } x(i-1). \\ 1 & x(i) \text{ is in opposite phase with } x(i-1). \end{cases}$$

* Multivalue digital signal: Either a digital signal having a larger number of voltage levels than a binary one or a 2k-value digital signal (k = 2 or greater integer) transmitted by a bus comprising two or more binary signal lines.

## 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 caused by home electric devices.

The characteristics of the power line as a transmission line differ significantly 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 Modulator Unit Configuration Example

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.

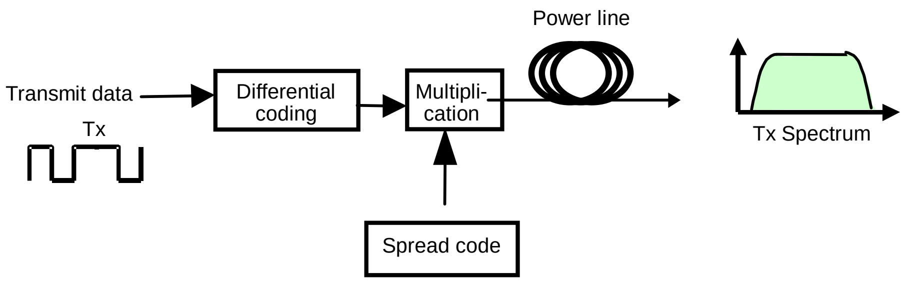
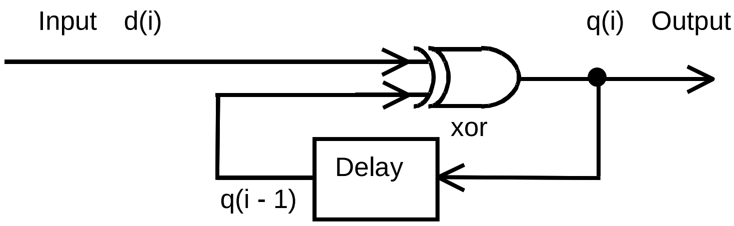



**Fig. 2.5 Modulator Unit (Direct Spread Spectrum) Configuration Example**

## Supplement 1.2 Example of Differential Coding Block Input/Output Data

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Input data | | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |
| Output data | (0) | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |

* When the input data is "0", the immediately preceding output data is output as-is.
When the input data is "1", the immediately preceding data is inverted and then output.
A differential coding block configuration example is shown below:




## Supplement 1.3 Demodulator Unit Configuration Example

Fig. 2.6 shows a sub-band delay detection system as an example of a demodulator.
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.

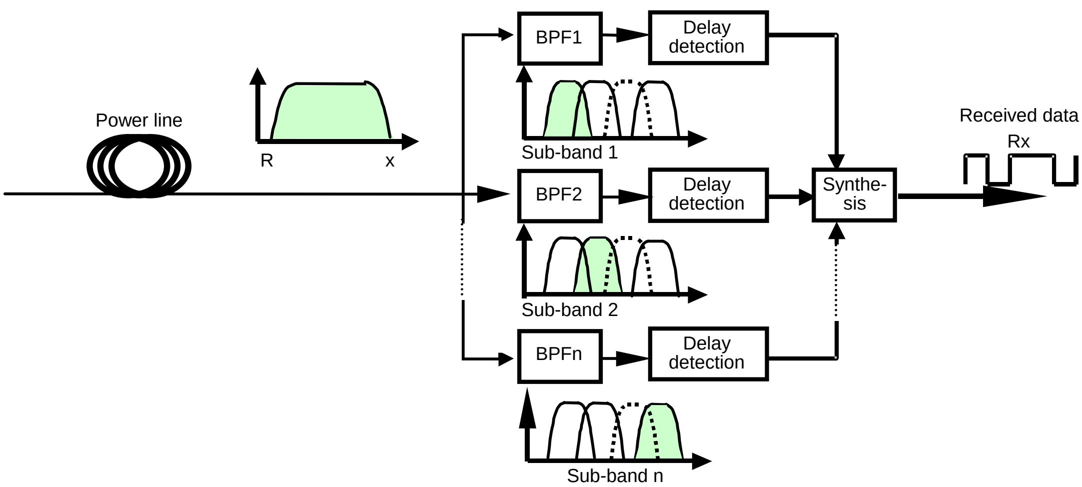



**Fig. 2.6 Demodulator (Sub-band Delay Detection System) Configuration Example**

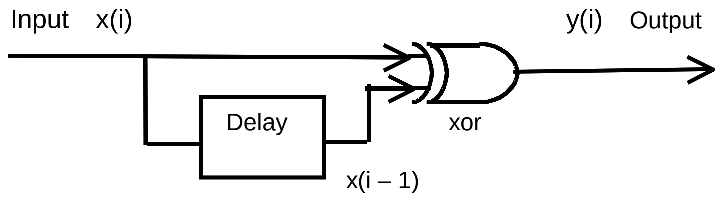
### Supplement 1.4 Delay Detection Block Input/Output Data (Example 1)

(When the input is a binary signal and the spread code is 101)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Input signal | 010 | 101 | 010 | 010 | 101 | 101 | 010 | 101 | 101 | 101 | 010 | 010 |
| Delay signal | | 010 | 101 | 010 | 010 | 101 | 101 | 010 | 101 | 101 | 101 | 010 |
| Output data | | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |

* The input signal and the immediately preceding input signal (delay signal) are XORred (exclusive-ORed) and then used as the output signal.

A delay detection block configuration example is shown below:




### Supplement 1.5 Delay Detection Block Input/Output Data (Example 2)

(When the input is a multivalue digital signal*)

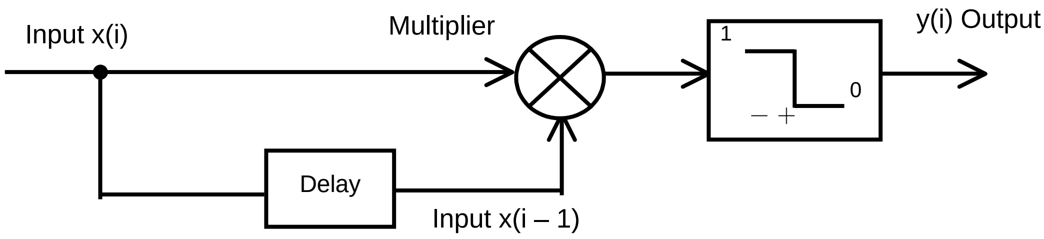
* Multivalue digital signal: Either a digital signal having a larger number of voltage levels than a binary one or a $2^k$-value digital signal (k = 2 or greater integer) transmitted by a bus comprising two or more binary signal lines.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Input signal | -1, 2, -1 | 1, -2, 1 | -1, 2, -1 | -1, 2, -1 | 1, -2, 1 | 1, -2, 1 | -1, 2, -1 |
| Delay signal | | -1, 2, -1 | 1, -2, 1 | -1, 2, -1 | -1, 2, -1 | 1, -2, 1 | 1, -2, 1 |
| Multiplication result | | - | - | + | - | + | - |
| Output signal | | 1 | 1 | 0 | 1 | 0 | 1 |

* The input signal is multiplied by the immediately preceding input signal (delay signal). The obtained multiplication result is converted to a binary equivalent and then output.

- 1 when a minus sign is used (when the input signal is in opposite phase with the delay signal)
- 0 when a plus sign is used (when the input signal is in phase with the delay signal)

A delay detection block configuration example is shown below (implementation is also achievable for an analog input by using an analog circuit in the same configuration):


Input x(i)
Multiplier
1
0
− +
y(i) Output
Delay
Input x(i – 1)

## 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 for normal frames (excluding response signaling and automatic retransmission): 40 ms or longer

(4) Layer 1 frame structure

| Preamble | Synchronization code | Frame type | House code | Layer 1 payload |
|---|---|---|---|---|

(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.

Preamble: 010101….. 0101 (8-byte)

(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.

Synchronization code: 1111010110010000

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

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

SHORT FRAME (frame type: 00000000)

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

MIDDLE FRAME (frame type: 00101110)

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

LONG FRAME (frame type: 01001101)

| | | | | |
|---|---|---|---|---|
| Preamble<br>8 bytes | Synchronization code<br>2 bytes | Frame type<br>1 byte | House code<br>8 bytes | Layer 1 payload<br>96 bytes |

DOUBLE LONG FRAME (frame type: 01100011)

| | | | | |
|---|---|---|---|---|
| Preamble<br>8 bytes | Synchronization code<br>2 bytes | Frame type<br>1 byte | House code<br>8 bytes | Layer 1 payload<br>176 bytes |

ANSWER FRAME (frame type: 10001011)

| | | | | |
|---|---|---|---|---|
| Preamble<br>8 bytes | Synchronization code<br>2 bytes | Frame type<br>1 byte | House code<br>8 bytes | Layer 1 payload<br>16 bytes |

(D) House code: ID for house identification

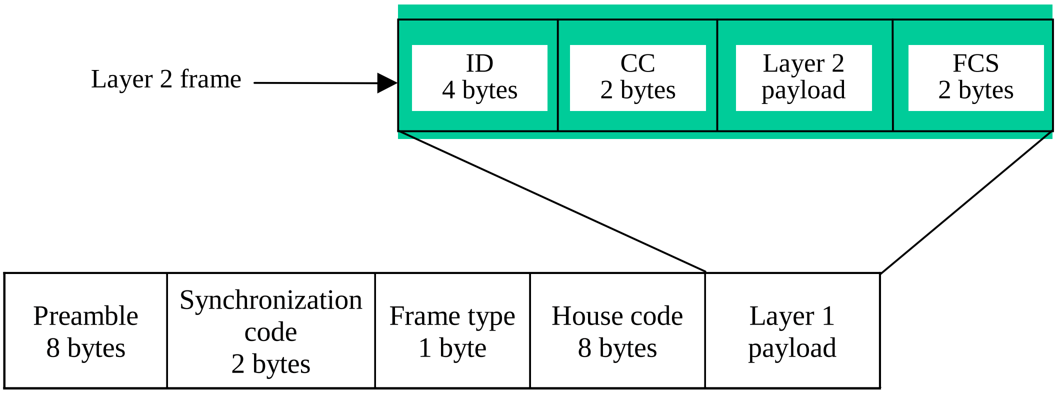
| 1 | 2 | 3 | 4 | 5 | 6 | | 8 |
|---|---|---|---|---|---|---|---|
| Manufacturer code | | | identification code | | | | |

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.
3. P&P setup reservation code
   – For house code P&P setup purposes, the following house code shall be reserved as a common code for all nodes.
     The use of the announce address 0 for purposes other than transmission/reception shall be prohibited during P&P setup.
   – Reservation code: 0x0000000000000000

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

## 2.4.2 Layer 2

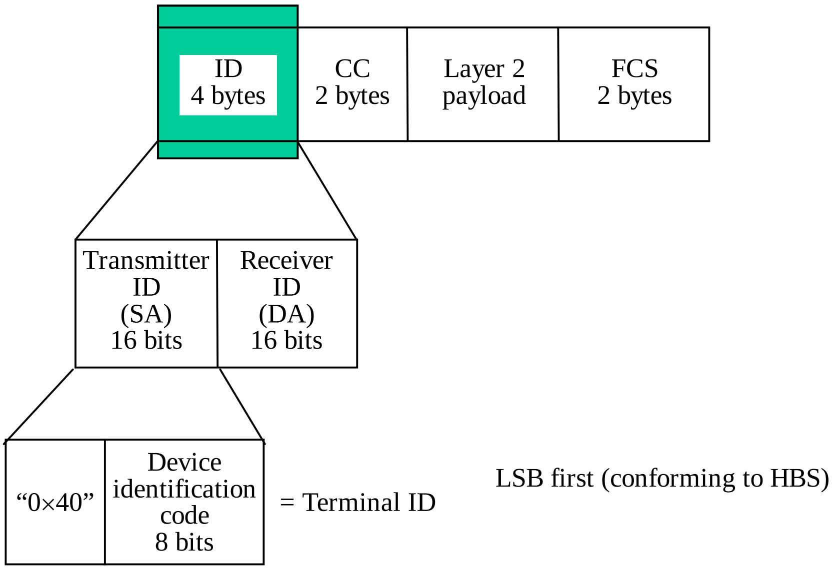
(1) Layer 2 frame structure



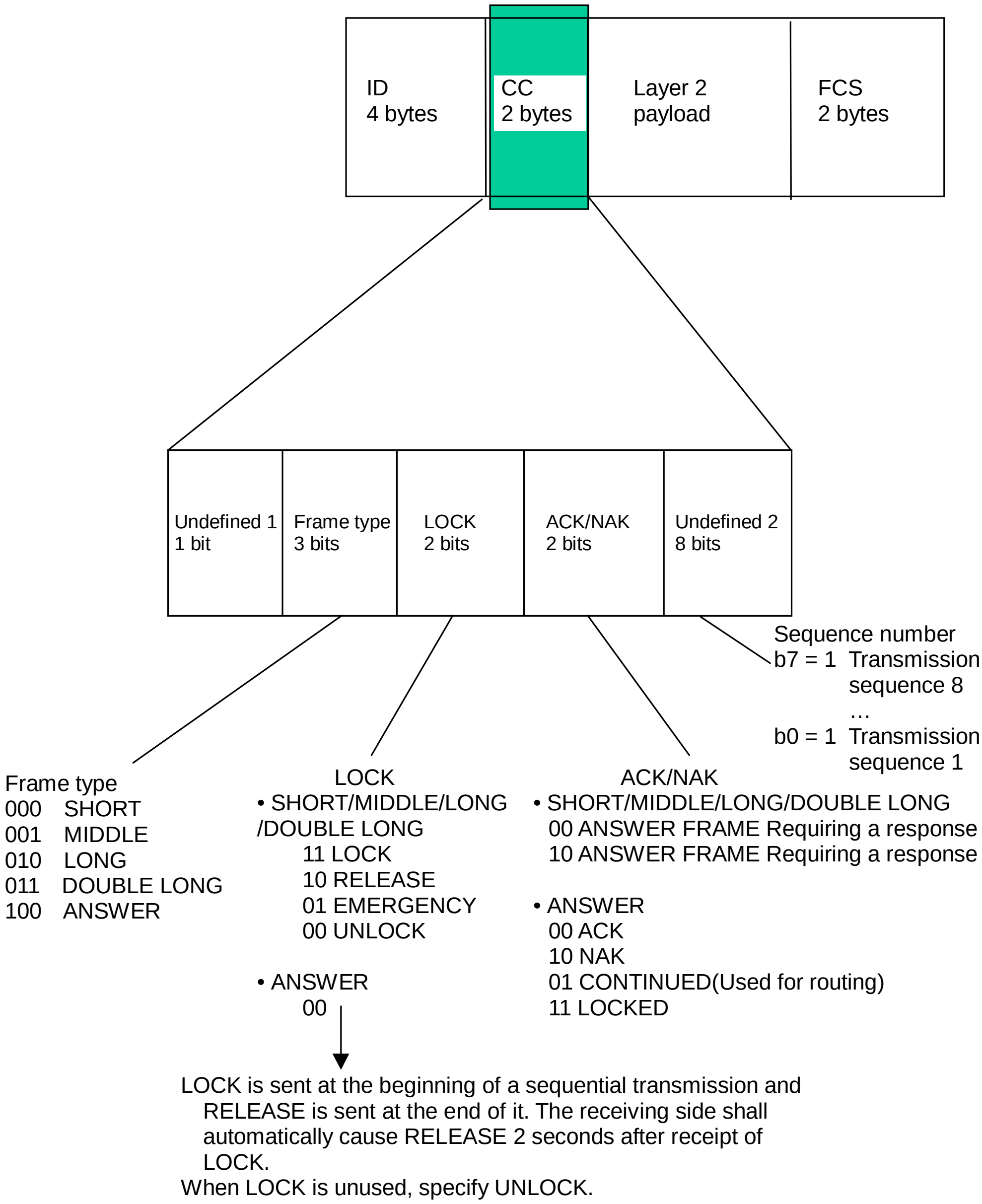

The layer 2 frame structure is as follows:

(A) ID:

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



(B) CC: Control code

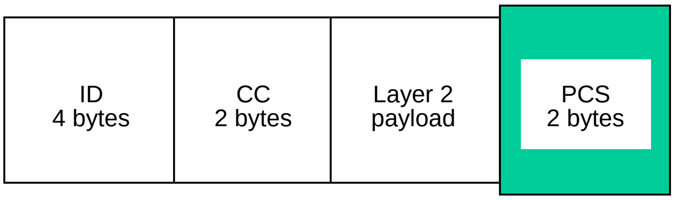


(C) Layer 2 payload:

For data contents, see Section 2.4.3 (1) Layer 3 frame structure.

(D) FCS: Frame inspection sequence

Items between frame type and layer 2 payload shall be computed.




FCS determination formula

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

(2) Layer 2 address system

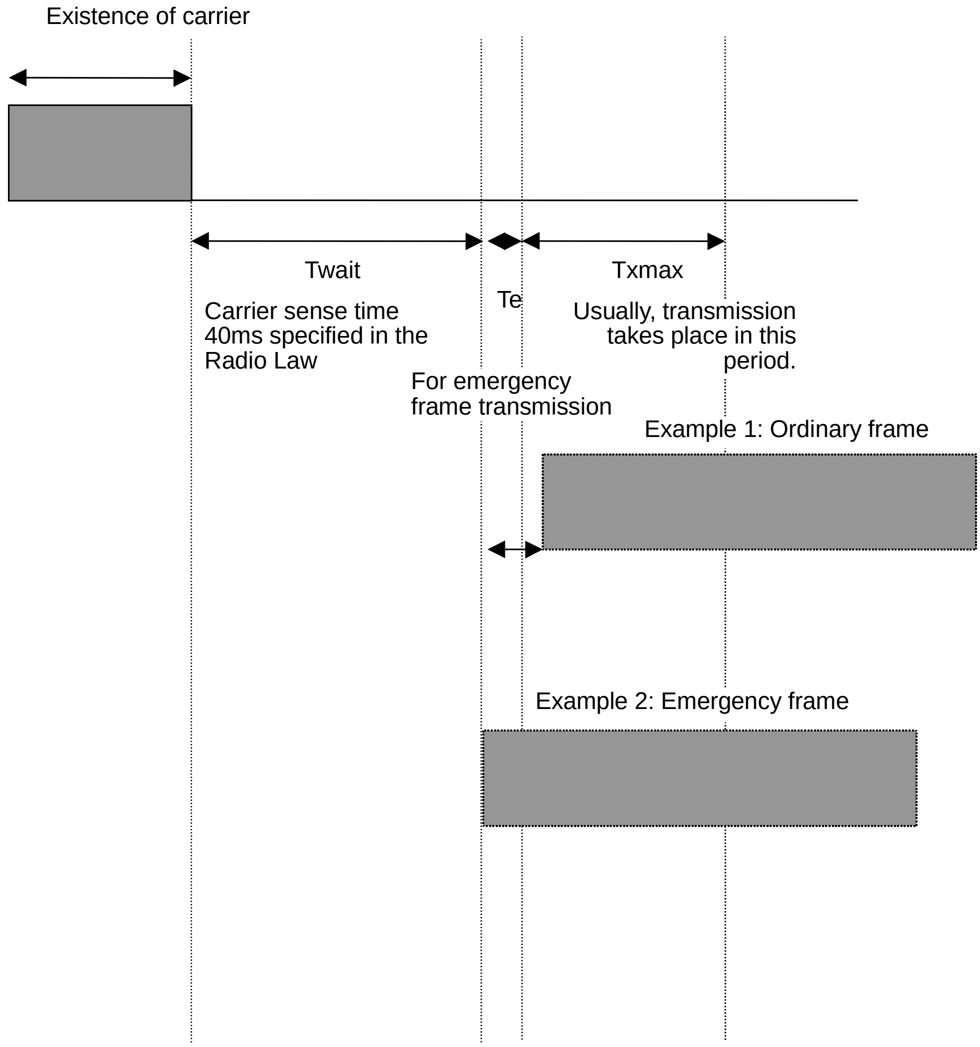
| No. | Object | MAC address (HEX) | |
|---|---|---|---|
| 1 | Plug and play manager address | 40 | 00 |
| 2 | Discrete address | 40 | 01 to EF |
| 3 | Broadcast address | 40 | F0 |
| 4 | Reserved for future use | 40 | F1 to FE |
| 5 | Reserved for P&P | 40 | FF |

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

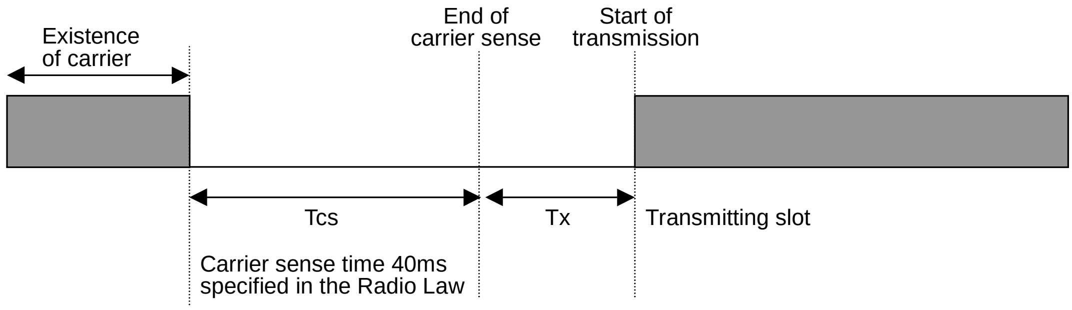
This Standard does not permit the use of a "Reserved for future use" address. However, the reception of a message destined to an "SA = Reserved for future use" address shall be permitted in consideration of future use.

(3) Transmission timing

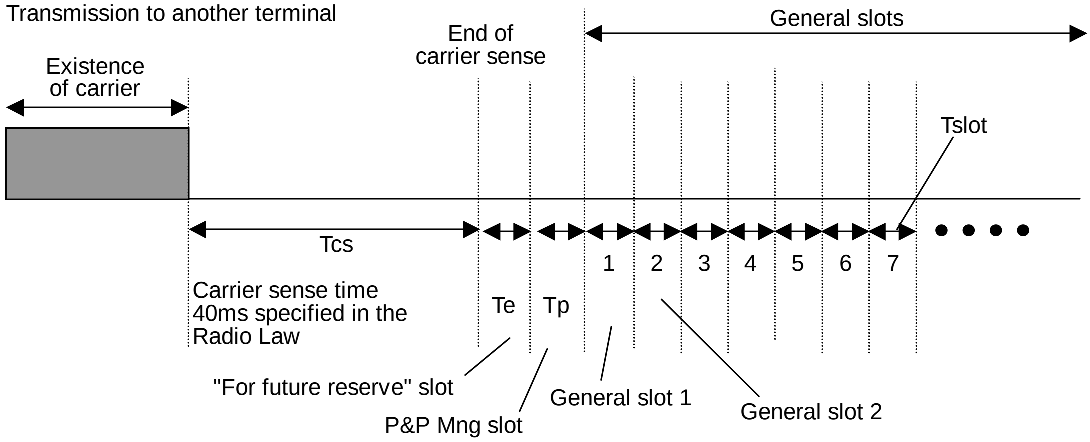
Transmitting timing



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, a) one "Reserved for future use" slot (the use of this slot is prohibited by this Standard), b) one P&PMng slot, and c) 100 general terminal slots are available. The following timing is specified for these slots.




Te = Tp = Tslot = 4msec

In the above situation, the P&PMng shall use the P&PMng slot for P&P processing.
However, it shall use general terminal slots for the other normal communications.

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

Fig. 2.7 shows the transmission timing that prevails on the power line.

When the transmitting side transmits a SHORT, MIDDLE, LONG, or DOUBLE LONG frame, the receiving side shall receive it. When the received frame meets the layer 1 and layer 2 requirements and the receiver ID (DA) agrees with the receiving side MAC address, the receiver side shall start transmitting an ANSWER FRAME along the power line within the timeout time Tout1.

The Tout1 value shall be 35 ms.

If the above requirements are not met at the receiving side as shown in Fig. 2.8, the receiving side shall not send an ANSWER FRAME. The transmitting side starts a retransmission if it does not receive an ANSWER FRAME within timeout time Tout2 after completion of frame transmission. If retransmissions are to take place because messages transmitted from different terminals are lost due, for instance, to collision, each of such retransmissions shall be performed with random timing, using general terminal slots, to avoid collision.

Up to two retransmissions are to be performed. If no response is obtained after two retransmissions, the transmission process aborts. The Tout2 value shall be 100 ms.

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

## Transmission timing

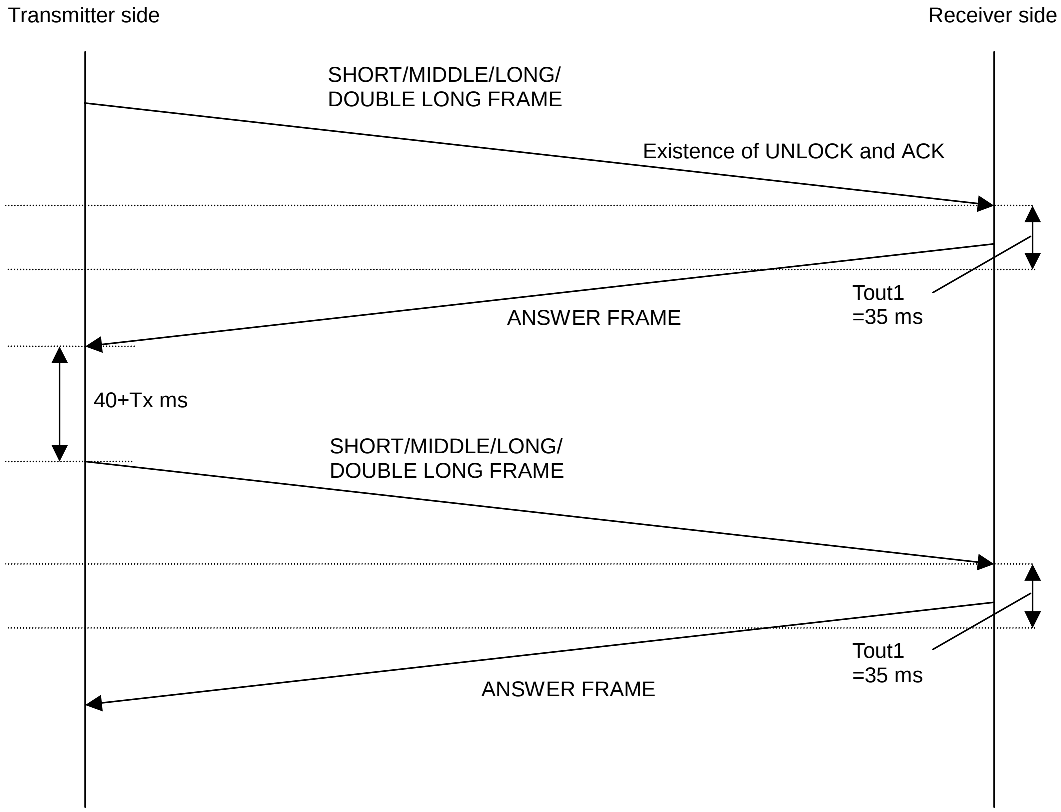
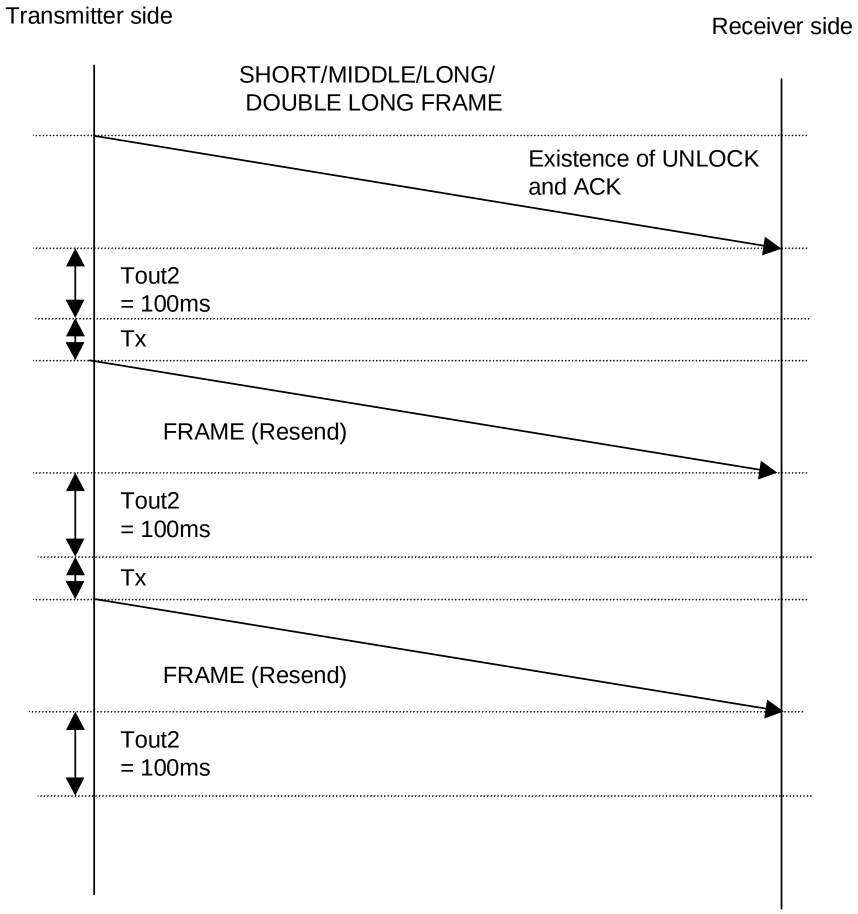



**Fig. 2.7 Transmission Timing**

## Transmission timing (Resend)




Retransmission shall take place if an ANSWER FRAME has not been received when timeout time Tout2 elapses after completion of frame output completion.

Individual retransmissions shall be performed with random timing (Tx) through the use of general terminal slots.

If no response is received despite two successive retransmissions, the application's judgment shall take precedence.

**Fig. 2.8 Transmission Timing (Resend)**

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

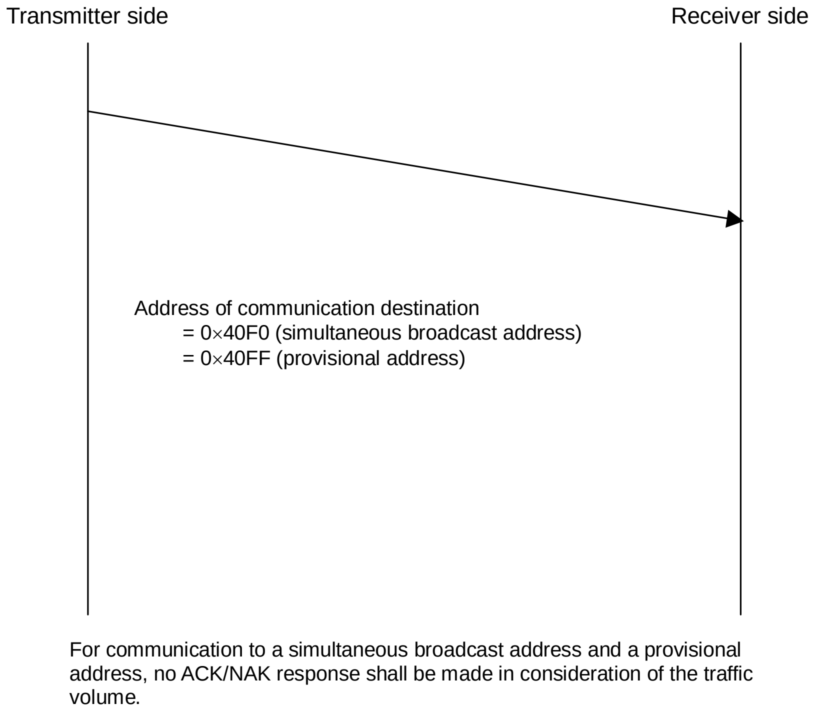
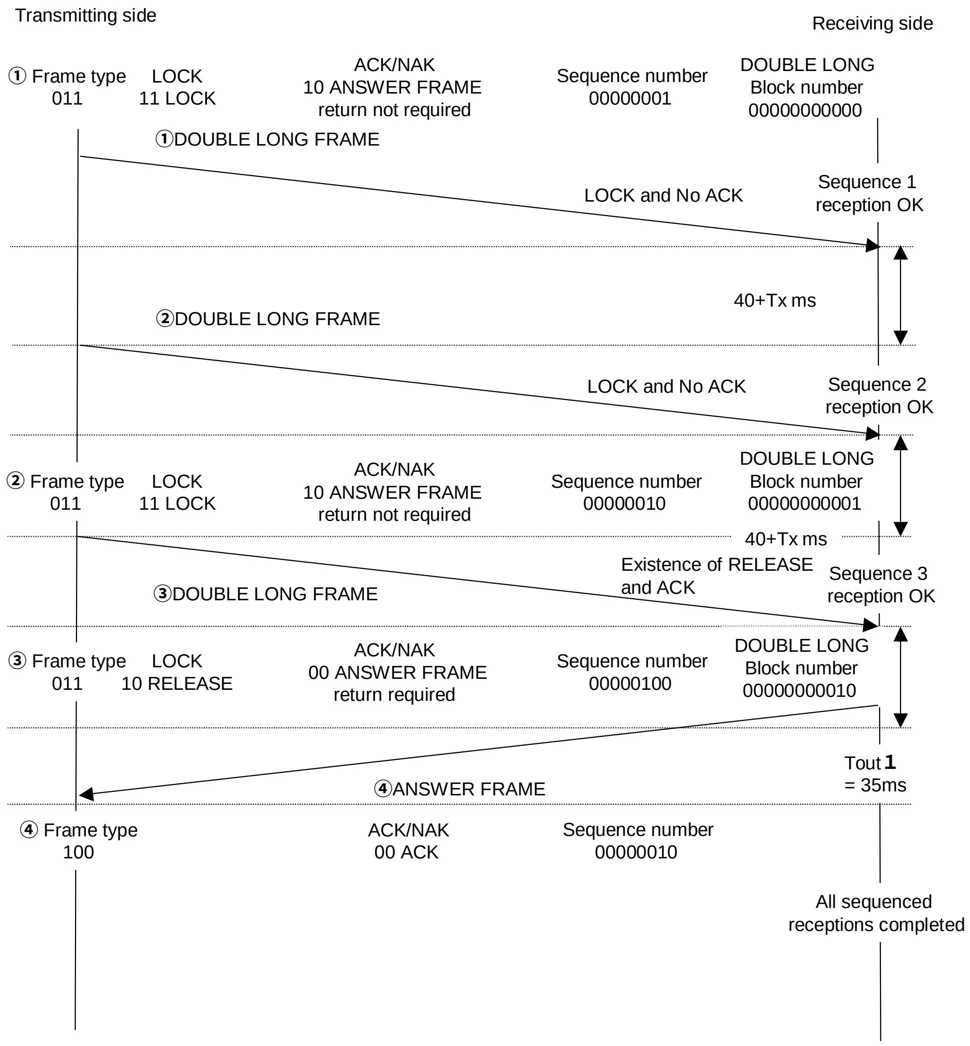


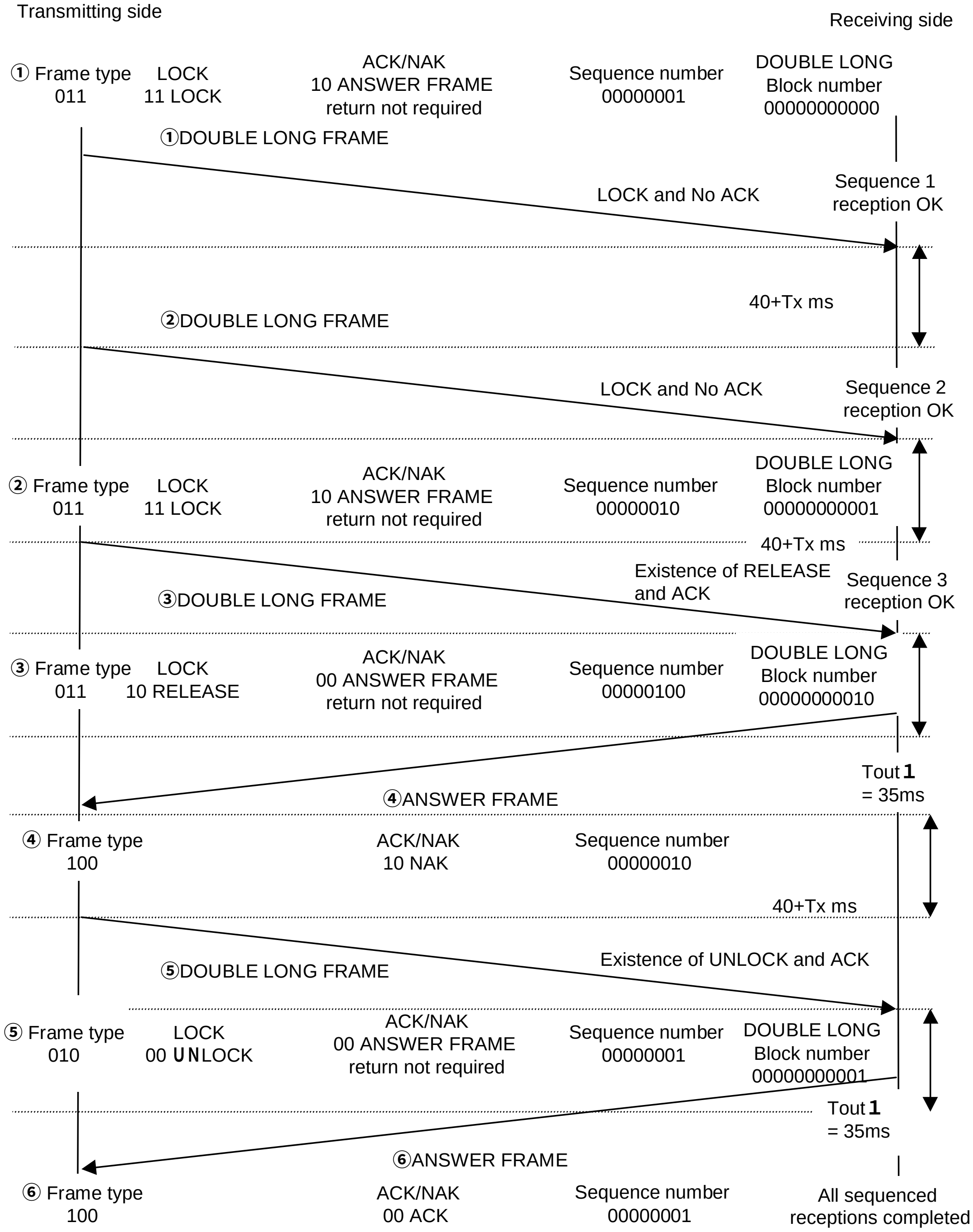

**Fig. 2.9 Transmission Timing (Communication to simultaneous broadcast and provisional address terminals)**

(4) Communication sequence

The figure below shows the communication sequence for frame-divided transmission (3-frame divided transmission) based on DOUBLE LONG FRAME. For frame segments, "LOCK" and "No ACK" shall be specified with CC.




**Communication sequence (frame-divided transmission)**




When a reception NG results, the receiving side shall return NAK with the affected sequence number attached.

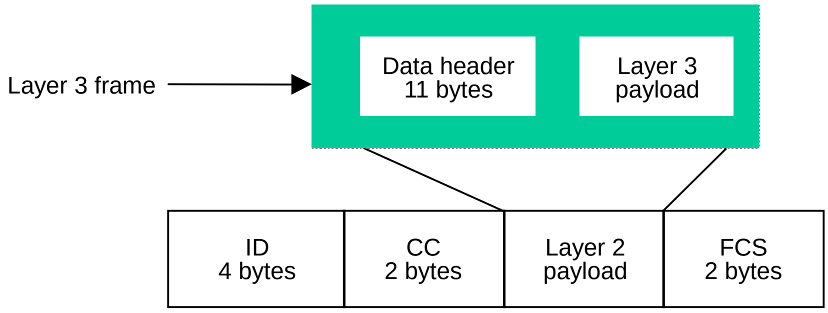
**Communication sequences (frame-divided transmission with retransmission)**

### 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:

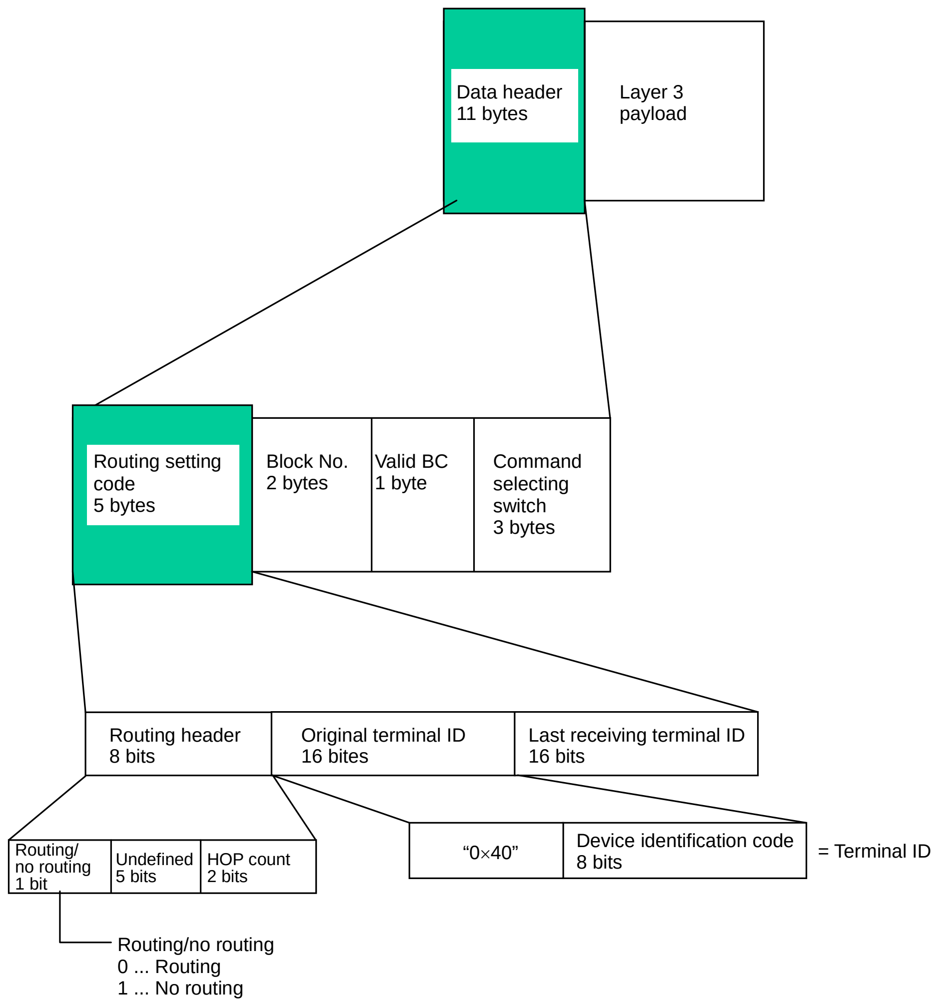



ANSWER FRAME consists only of a data header.

(A) Data header:

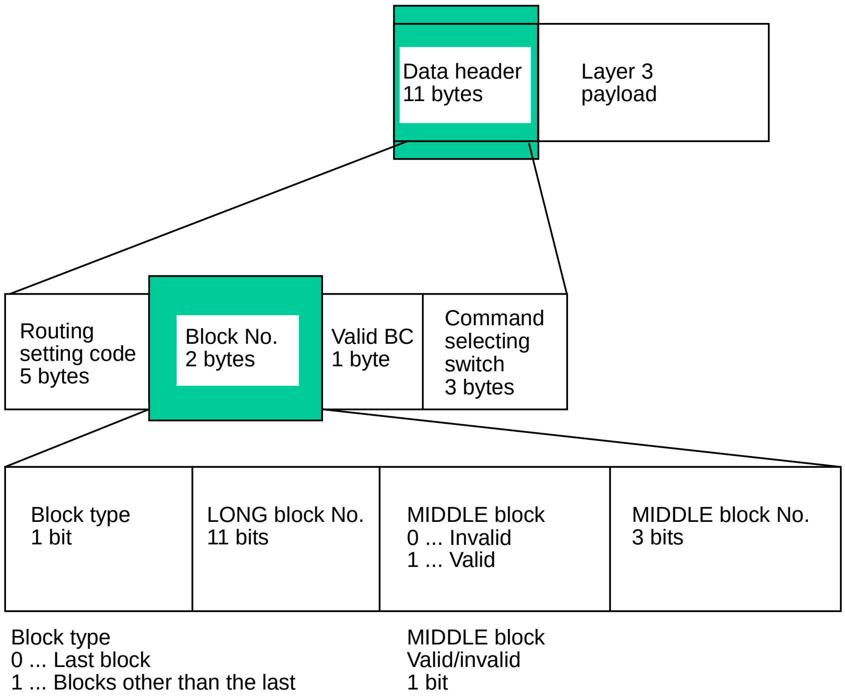
The data header consists of a routing setting code, block No., valid byte counter (BC), and command selection switch.

- Routing setting code



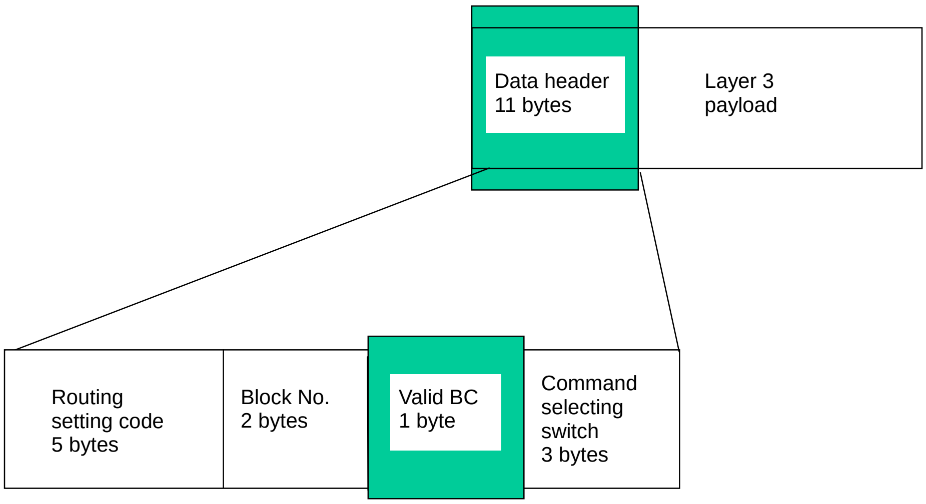
- Block No.

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




- Valid byte counter

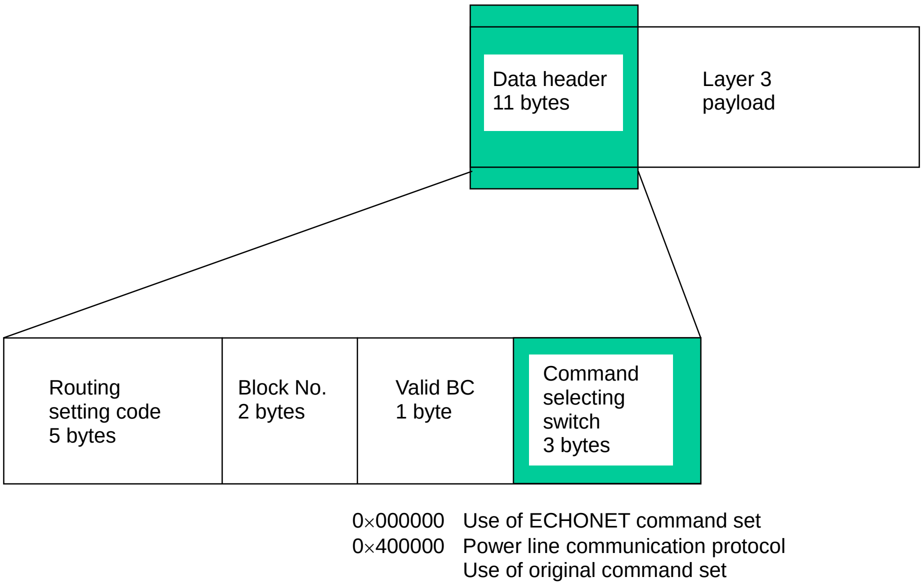
  This counter indicates the number of valid bytes of layer 3 payload.



- Command selection switch

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

  (See Supplement 2.1, "Command Set Unique to Power Line Communication Protocol".)



## 2.5 Basic Sequence

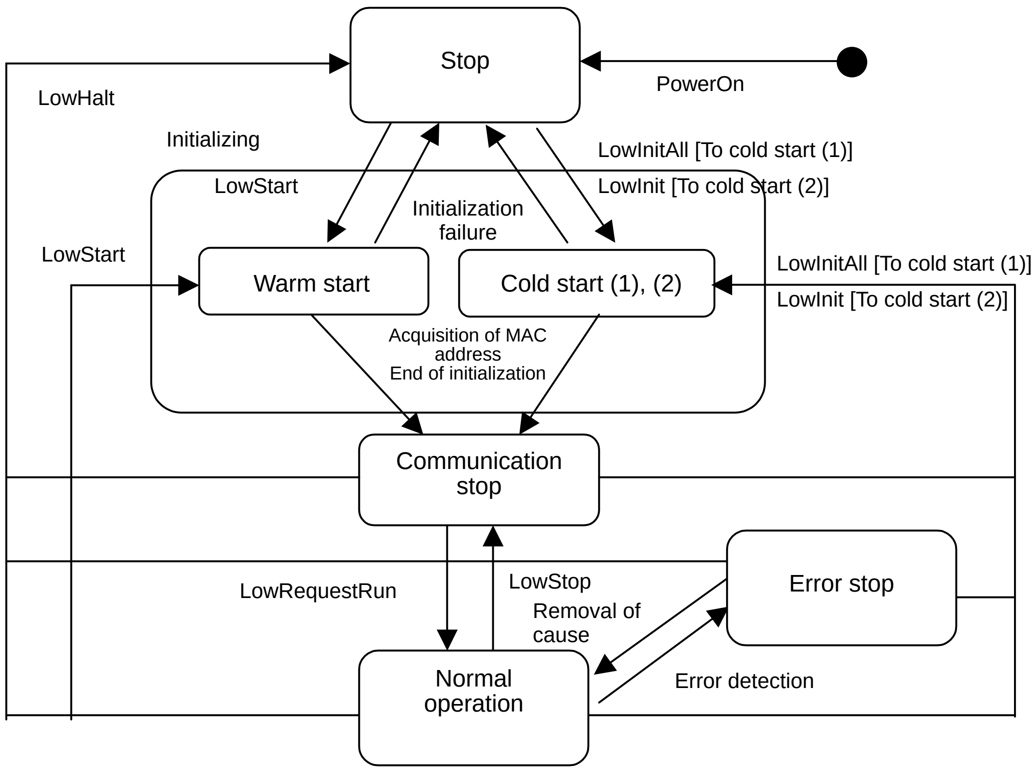
This section deals with the following:
- State transition diagram
- Sequence descriptions of various states indicated in the state transition diagram

### 2.5.1 Basic concept

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

① Stop status
② Initialize processing status
③ Communication stop status
④ Normal operation status
⑤ 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 in which no lower-layer communication software operations are performed except for the P&P settings of the lower-layer communication software's independent functions that change due to the installer's power ON operation, etc. 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 stop status receives, and related processing, are described below.

(1) Trigger and action
Waits for an 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 communication software type acquisition service (LowGetDevID)
Returns the lower layer communication software type.

The triggers for state transition are as follows:

(1) Transition trigger to initialize processing status
The transition is caused by the initialization service (LowStart, LowInit, LowInitAll).

### 2.5.3 Initialize processing status

In initialize processing state, the Lower-layer Communications Software is initialized. This state can be roughly divided into warm start, cold start (1), and cold start (2).
An outline of processing immediately after state transition and an outline of Individual Lower-layer Communication Interface services that initialize processing status receives, and related processing, are described below.

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

(2) LowStart (warm start)
Terminates an initialization process and switches to communication stop status if the MAC address and house code are retained. If the MAC address and house code are not retained, however, the initialization process fails and the status changes to communication stop status.

(3) LowInitAll (cold start (1))

If the house code and MAC address have been retained, both are discarded. Further, the following operations are performed to acquire a new house code and MAC address. When the house code and MAC address are acquired, the initialization process ends and the status changes to communication stop status. If the house code and MAC address cannot be acquired, the initialization process fails and the status changes to communication stop status.

① Acquiring a house code

A unique house code for power line communication protocol domain identification is acquired. The installer selects an acquisition method manually with a DIP switch, etc. An alternative is to exercise the Lower-layer Communications Software's "Register_ID" functions described in Section 2.6, "P&P Setup of House Code and MAC Address", from the only one plug-and-play manager (hereinafter abbreviated to the P&PMng) within the power line domain.

② Acquiring a MAC address unique within a subnet

A MAC address unique within the power line domain is to be acquired. As explained earlier under "1) Acquiring a house code", the installer selects an acquisition manually with a DIP switch. An alternative is to exercise the Lower-layer Communications Software's "Register_ID" functions described in Section 2.6, "P&P Setup of House Code and MAC Address", from the only plug-and-play manager (hereinafter abbreviated as P&PMng) within the power line domain.

(4) LowInit (cold start (2))

When the house code and MAC address are retained, a new MAC address is to be acquired while the retained one is discarded The MAC address acquisition method is the same as explained earlier under "(3) LowInitAll (cold start (1))", "2) Acquiring a MAC address unique within a subnet". When the MAC address is acquired, the initialization process terminates and the status changes to communication stop status. If the MAC address cannot be acquired, the initialization process fails and the status changes to stop status. When the house code and MAC address are not retained, the initialization process fails and the status changes to stop status.

(5) Status acquisition service (LowGetStatus)

In a warm start, returns LOW_STS_RST as the status. In a cold start ((1) or (2)), returns LOW_STS_INIT as the status.

(6) Lower layer communication software type acquisition service (LowGetDevID)

Returns the lower layer communication software type.

Triggers for state transitions are shown below:

(1) Transition trigger to communication stop status

This transition takes place upon completion of initialization.

(2) Transition trigger to stop status

This transition takes place upon an initialization failure, power ON, or any abnormal occurrence.

### 2.5.4 Communication stop status

In communication stop status, an operation start request from the communication middleware is awaited after completion of lower-layer communication software initialization. This section outlines the process to be performed upon a state transition, describes the individual lower-layer communication interface services acceptable during communication stop status, and gives an overview of the associated process.

(1) Trigger and action
Waits for an individual lower-layer interface service.
(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_INIT as the status.

The triggers for state transition are as follows:

(1) Transition trigger to normal operation state
The transition is caused by the operation start instruction service (LowRequestRun).
(2) Transition trigger to initialize processing state
The transition is caused by the initialization service (LowStart, LowInit, LowInitAll).
(3) Transition trigger to stop status
This transition is caused by the stop service (LowHalt).
(4) Lower layer communication software type acquisition service (LowGetDevID)
Returns the lower layer communication software type.

### 2.5.5 Normal operation status

The 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 communication software. An outline of processing immediately after state transition and an outline of the Individual Lower-layer Communication Interface services that normal operation status receives, and related 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) Data transmission service (LowSendData)
Received Protocol Difference Absorption Processor data are divided according to the data size, and each divided data is translated into lower-layer communication software data and then output to the transmission medium.
(4) Data reception service (LowRecvData)

Lower-layer communication software data received from a transmission medium is translated into Protocol Difference Absorption Processor data and then output to the Protocol Difference Absorption Processor.

(5) Lower layer communication software type acquisition service (LowGetDevID)
Returns the lower layer communication software type.

The triggers for state transition are as follows:

(1) Transition trigger to initialize processing status
This transition is caused by the initialization service (LowStart, LowInit, LowInitAll).
(2) Transition trigger to error stop status
This transition is caused by the error.
(3) Transition trigger to communication stop status
This transition is caused by the end service (LowStop).
(4) Transition trigger to stop status
This transition is caused by the stop service (LowHalt).

### 2.5.6 Error stop status

The error stop status signifies a status in which 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 error stop status receives, and related processing, are described below.

(1) Trigger and action
This transition occurs upon error detection. Error processing will be performed.
(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_ESTOP as status.
(3) Lower layer communication software type acquisition service (LowGetDevID)
Returns the lower layer communication software type.

Triggers for state transitions are shown below:

(1) Transition trigger to initialize processing status
This transition is caused by the initialization service (LowStart, LowInit, LowInitAll).
(2) Transition trigger to normal operation status
This 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.
(3) Transition trigger to stop status
This transition is caused by the stop service (LowHalt).

## 2.6 P&P Setup of House Code and MAC Address

This section furnishes the information on P&P setup, which is performed from the plug-and-play manager (P&PMng) to assign a house code and MAC address to an ECHONET node newly connected to a power line domain, using the Lower-layer Communications Software's Register_ID functions.

Note that this Standard does not stipulate a manual setup procedure. However, the processing functions provided for ordinary nodes (nodes without the P&PMng function or nodes whose P&PMng function is disabled) by Register_ID shall be implemented. Even when house code/MAC address setup is completed by a manual setup procedure, it shall be possible for P&PMng to perform resetup. In a power line domain having the same house code, however, ECHONET nodes whose house code/MAC address setup is completed by P&P setup shall not be allowed to coexist with ECHONET nodes whose house code/MAC address setup is completed manually.

(A) Man-machine interface requirements

- User operation requirements

  A means of switching to a setup mode shall be provided.

- User operation supplement

  Typical examples for switching to a setup mode are given below:

  P&PMng: Holding down a setup mode switch for several seconds, etc.

  Ordinary nodes: Turning the power ON or pressing a reset switch, etc. when MAC address setup is not completed

- Indicator requirements

  A node type indicator and operation mode indicator shall be provided.

  The node type indicator, however, shall be mandatory only for nodes having the P&PMng function.

  If an LED indicator is used, its color is not stipulated. However, due provision shall be made so that the user can identify the node type indicator, operation mode indicator, and LED indicators stipulated in Part 7, "ECHONET Communications Equipment Specification", Chapter 3, "ECHONET Device Adapter", Section 3.3.2, "Display Block" (in terms of color, panel, etc.).

  The table below provides definitions of LED indicators:

| | On | Off | Blinking |
|---|---|---|---|
| Node type | P&PMng | Ordinary node | |
| Operation mode | Setup mode | Normal operation | Setup error |

If indicators other than LEDs are to be used, they must make it possible for the user to identify the indications as stipulated in the above table.

(B) House code and MAC address in setup mode

- House code (HC) requirements

(C) See under "Individual terminal operations".

- MAC address requirements

  P&PMng: 0x4000 shall be used.

  However, ordinary nodes shall accept announce address 0 for addresses other than 0x4000.

  In situations where the P&PMng is installed in the local domain, the correct house code is manually set by the installer or factory set prior to shipment.

  Further, the P&PMng shall be furnished beforehand so as to cover the maximum number of nodes to which MAC addresses can be assigned.

  Ordinary nodes: Address 0x40FF, which is reserved for P&P, shall be used as a tentative address when MAC address setup is not completed.

(D) Individual terminal operations

(1) P&PMng operation

- When the user performs a procedure to place the P&PMng in setup mode, it shall transmit announce address 0 at T0 intervals. 0x0000000000000000 shall be used as the house code for announce address 0.
- As a rule, to prevent the traffic from being preoccupied for the announce address 0 frame, the value T0 should be 700 msec. The operation mode indicator shall indicate that the setup process is in progress.
- The P&PMng shall operate for 5 minutes in setup mode. When a predetermined period of time elapses, the P&PMng shall exit setup mode, with the operation mode indicator indicating that a normal operation is being performed.
- An unused MAC address shall be chosen from the locally managed MAC address table (individual addresses: 0x4001 to 0x40EF) and assigned to a received Request_ID frame by means of an ID notification.

  The ID notification shall be transmitted to a tentative address (0x40FF) with a unique terminal identification code attached for identifying a terminal contained in the received Request_ID frame. If the distant party's address (DA) is a tentative address, the terminal identification code shall be used to determine whether or not to accept the received frame.

(2) Ordinary node operation

- When an ordinary node enters setup mode, it shall wait for the reception of announce address 0. The operation mode indicator shall indicate that the node is in setup mode.

- When a predetermined timeout time elapses, setup mode shall be superseded by normal operation mode. Here, the operation mode indicator shall indicate a setup failure. Although the timeout time is not stipulated, it should be no longer than 3 minutes in order to prevent a neighboring P&PMng from performing improper setup.
- Announce address 0 is received for a period of longer than $10T_0$ (this is called "overhear"). As a result, if announce address 0 is received 10 consecutive times from the P&PMng having the same house code, the house code contained in the announce address 0 frame shall be acquired as the formal house code. The formal house code shall be used to transmit Request_ID, which contains a terminal identification code, to request that the P&PMng assign a MAC address.
- Upon receipt of the ID notification, the formal MAC address shall be acquired. The acquired formal house code and formal MAC address shall be finalized as the local codes with the mode change applied to enter the normal mode. The operation mode indicator shall indicate that a normal operation is being performed. After the P&P setup communication sequence for house code and MAC address is completed, the formal house code and formal MAC address shall be retained in nonvolatile memory.
- If the MAC address indicated by the ID notification is outside the range from 0x4001 to 0x40EF, it shall be rejected.
- If the ID notification is not received after Request_ID transmission, Request_ID shall be transmitted again.
- If announce address 0 is received from more than one P&PMng prior to the receipt of the ID notification, the previously acquired house code shall be discarded with the operation mode indicator indicating a setup failure.

(E) Terminal identification code

As the terminal identification code, the terminal attribute data (e.g., node manufacturer name, terminal type, and magic number "Nmagic" explained in Section 2.4.2, "Layer 2", "(3) Transmission timing") shall be used.

Although the terminal attribute type is not stipulated, an 8-byte value should be used to ensure that the individual terminals are unique.

(F) Communication sequence

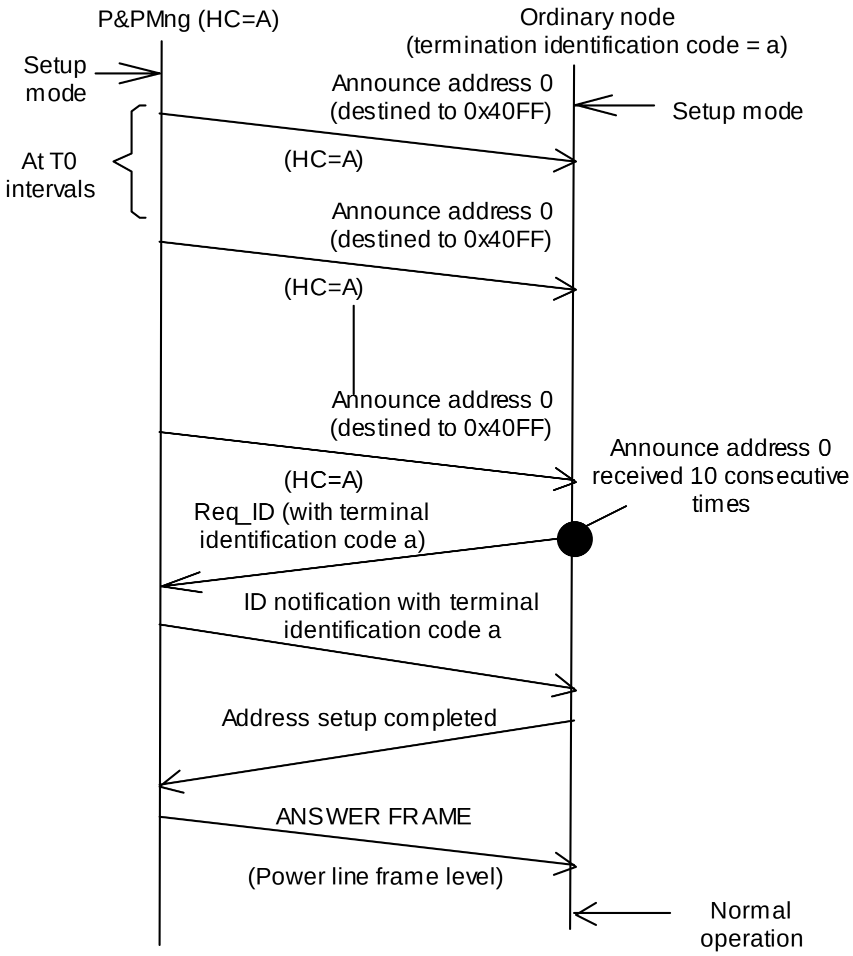



**Fig. 2.10 Register_ID Basic Communication Sequence (1)**

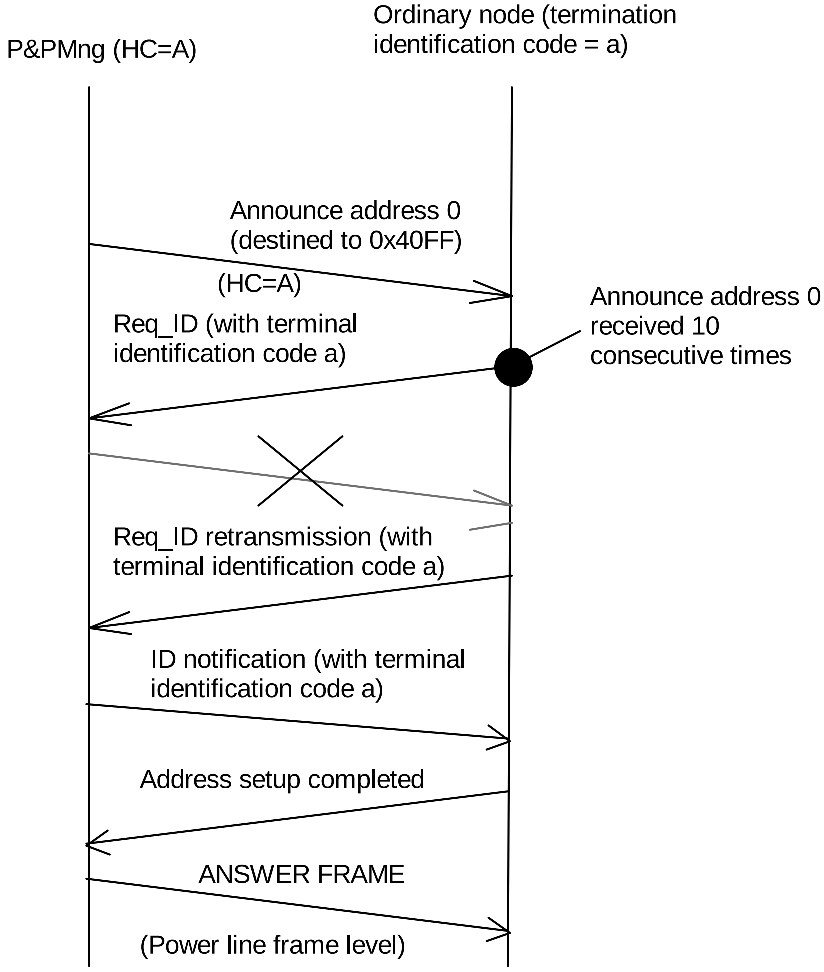



**Fig. 2.11 Sequence of Req_ID, ID Notification, and Other Retransmissions**

When P&PMng performs the aforementioned announce address 0 operation, "overhear" occurs. As a result, ECHONET node A shall send a formal address request Req_ID with a terminal identification code to the P&PMng, using the formal house code received by means of announce address 0. The P&PMng assigns formal address 0x4001 to ECHONET node A as indicated by the terminal identification code. At this stage, however, a tentative MAC address is used for ECHONET node A so that there is no alternative but to use a tentative address as the destination for formal address assignment command. Therefore, the terminal identification code shall be attached to such a tentative address to prevent other ECHONET nodes with a tentative address from receiving the wrong data.

Here, the ECHONET node having a tentative MAC address shall transmit a formal address request, receive a formal address assignment command only when the attached terminal identification code agrees with its own terminal identification code, and use the assigned formal address as its MAC address.

After the MAC address is replaced with the formal one, the ECHONET node shall use the formal house code and formal address to send an address setup completion notification to the P&PMng. After receiving an ANSWER FRAME that the P&PMng transmits in response to the address setup completion notification, the ECHONET node shall store the formal house code and formal address in nonvolatile memory and terminal normally.

Similarly, the P&PMng shall continue distributing formal addresses to the remaining ECHONET nodes by referencing the formal addresses and individual ECHONET node information provided by the terminal attribute data representing terminal identification codes.

Although the terminal attribute type is not stipulated, an 8-byte value containing the node manufacturer name, terminal type, magic number, and other attribute information should be used to ensure that the individual terminals are unique.

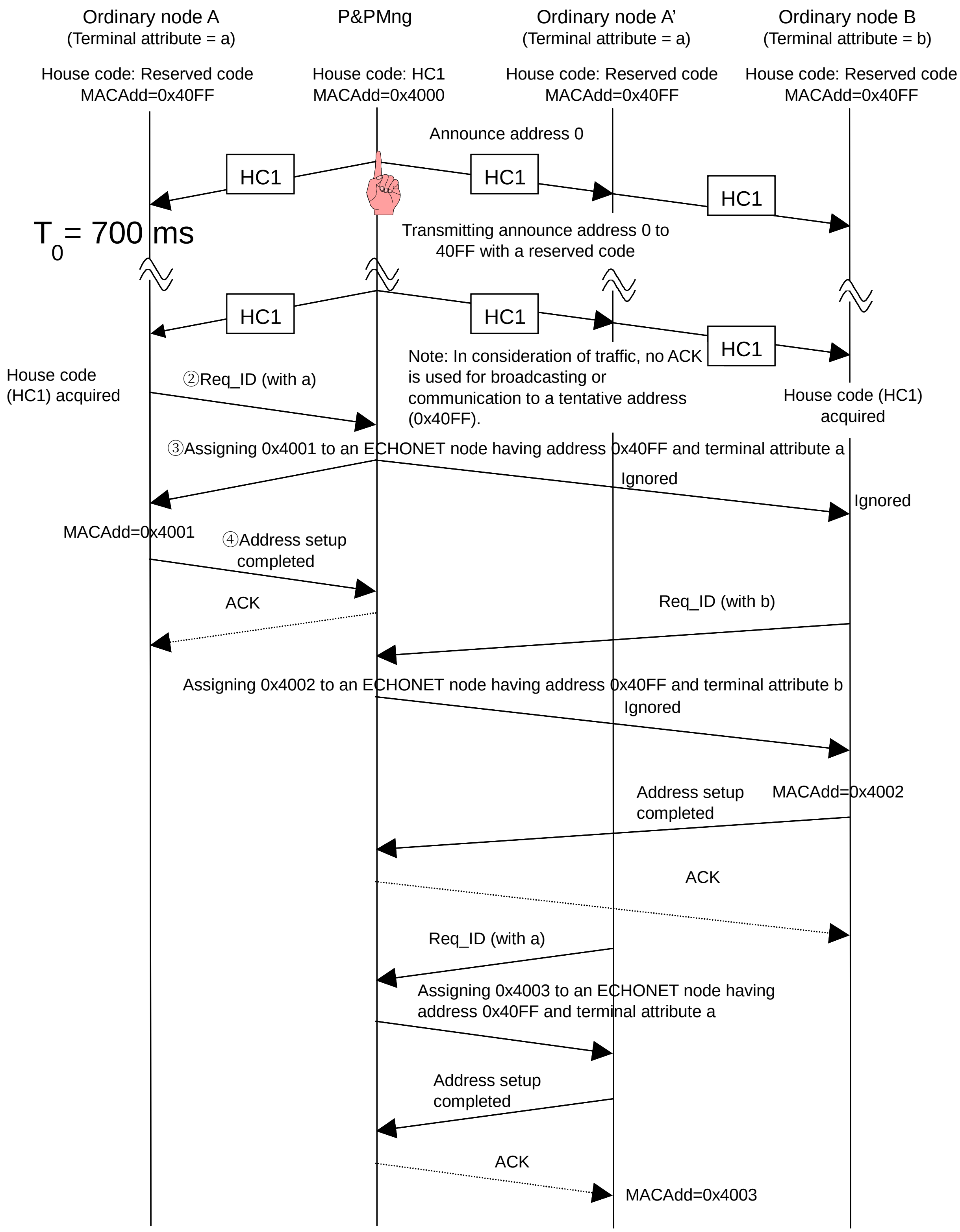



**Fig. 2.12 Register_ID Basic Communication Sequence (2)**

(F) P&P setup command unique to power line communication protocol

The P&PMng's house code/MAC address assignment process (Register_ID) is executed by the following unique command set. Note that Register_ID is executed by a local command unique to the power line communication protocol, which is differentiated from ECHONET commands by means of a command selector switch (see Supplement 2.1, "Command Set Unique to Power Line Communication Protocol").

For the processing sequence, see the Register_ID processing sequence in Fig. 2.10.

When an ordinary node properly receives 3) ID notification and 4) address setup completion notification, it shall return ACK to the P&PMng with an ANSWER FRAME.

Note that parenthesized numbers in the "STATE/DATA" column below indicate the number of bytes.

Also, note that the P&PMng uses a top-priority slot to transmit commands 1) and 3) below.

The commands shown below are used when an 8-byte magic number is used as a terminal identification code for terminal attribute indication. Although the terminal attribute type is not stipulated by this Standard, an 8-byte value should be used so as to ensure terminal uniqueness.

As shown in Fig. 2.12, the P&PMng uses a top-priority slot (see under "2. Transmission slots" in Section 2.4.2-(3), "Transmission timing"). Therefore, when ECHONET node A sends Request_ID to the P&PMng, the P&PMng can transmit an ID notification frame prior to ECHONET node A's Request_ID. Consequently, no confusion results because the same formal address will not be assigned to two or more terminals having the same terminal attribute (e.g., magic number).

1) Announce address 0

| ATTRIBUTE | | METHOD | | | STATE/DATA |
|---|---|---|---|---|---|
| TS | Property_name | methodtype | action | subtype | DATA |
| P&P | Housecode | INDICATE | do | normal | Housecode (8) |
| 0x20 | 0x81 | 0x04 | 0x00 | 0x00 | 0x0123456789ABCDEF |

2) Request ID

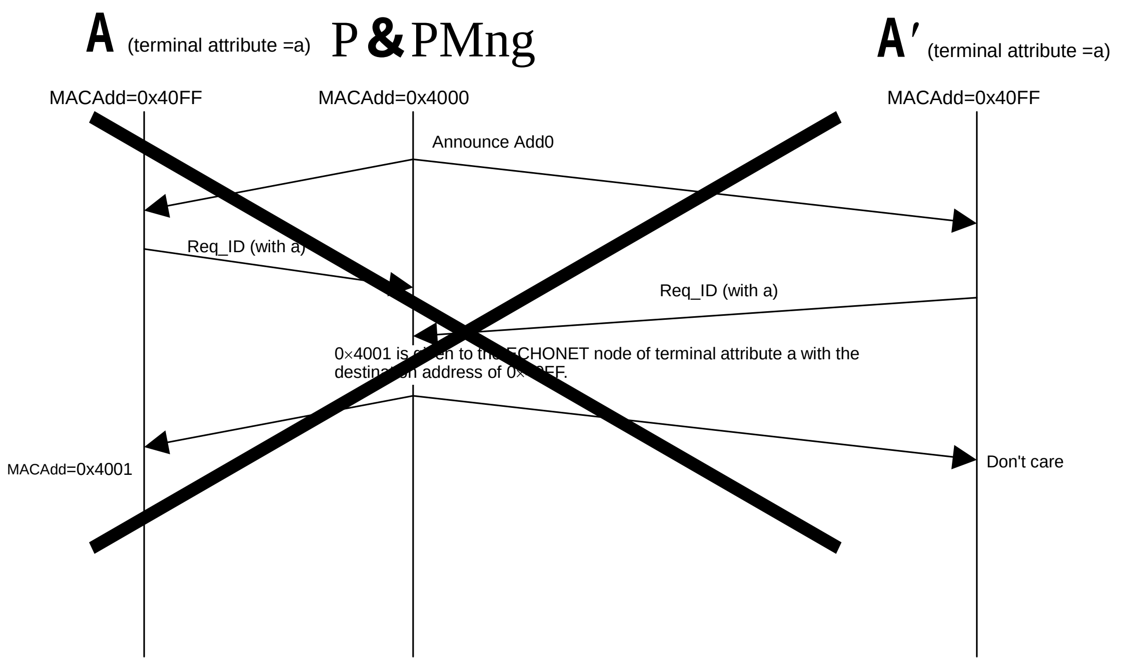
| ATTRIBUTE | | METHOD | | | STATE/DATA |
|---|---|---|---|---|---|
| TS | Property_name | methodtype | action | subtype | DATA |
| P&P | MacAddress | INQUIRE | do with housecode | normal | magic_number (8) |
| 0x20 | 0x01 | 0x02 | 0x01 | 0x00 | 0x0123 |

3) ID notification

| ATTRIBUTE | | METHOD | | | STATE/DATA |
|---|---|---|---|---|---|
| TS | property_name | methodtype | action | subtype | DATA |
| P&P | MacAddress | WRITE | do with housecode | normal | magic_number (8)<br>MacAddress (2) |
| 0x20 | 0x01 | 0x01 | 0x01 | 0x00 | ‘0x0123, 0x4010 |

4) Address setup completion

| ATTRIBUTE | | METHOD | | | STATE/DATA |
|---|---|---|---|---|---|
| TS | property_name | methodtype | action | subtype | DATA |
| P&P | MacAddress | RESPONSE | done | normal | MacAddress (2) |
| 0x20 | 0x01 | 0x05 | 0x10 | 0x00 | 0x4010 |




Transmissions do not take place in the above-indicated order because of slot priority for the P&PMng. Therefore, the same address will not be assigned to nodes having the same attribute. In addition, extended announce address 0 is used for terminal checkout.

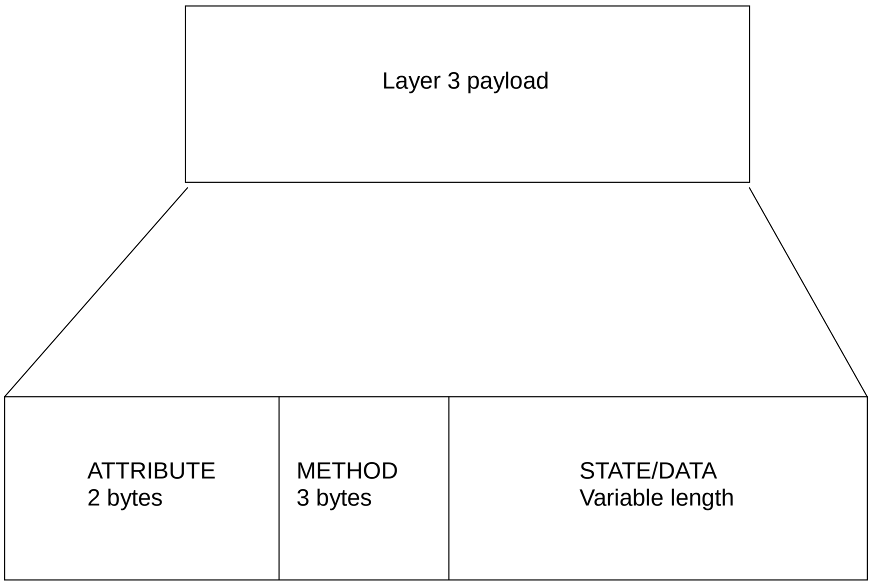
**Fig. 2.13 Register_ID Basic Communication Sequence (Nonexistent in Reality)**

## Supplement 2.1 Command Set Unique to Power Line Communication Protocol

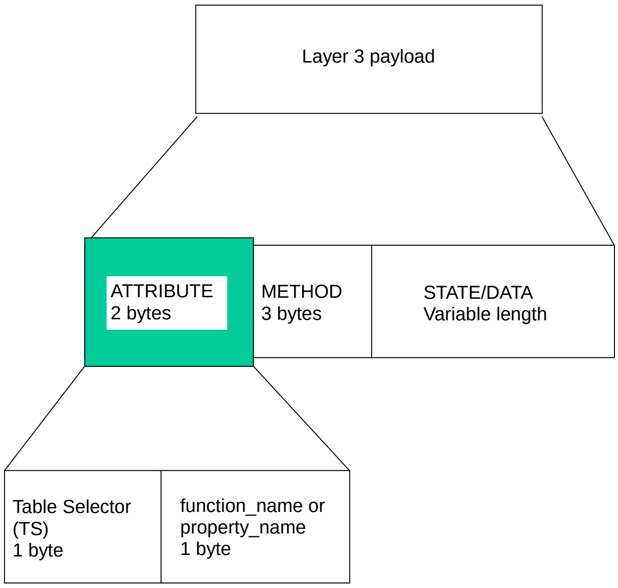
The command set unique to the power line communication protocol is described below for reference. It comprises local commands contained in the layer 3 payload, except for ECHONET commands.

This command set consists of ATTRIBUTE (2-byte), METHOD (3-byte), and STATE/DATA (variable-length). ATTRIBUTE specifies the control target. METHOD specifies the process for the ATTRIBUTE-specified target.

Note that the command set executes the plug-and-play manager's MAC address assignment process "Register_ID", which is described under "2.5.3 Initialize processing status" in Section 2.5, "Basic Sequence".



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

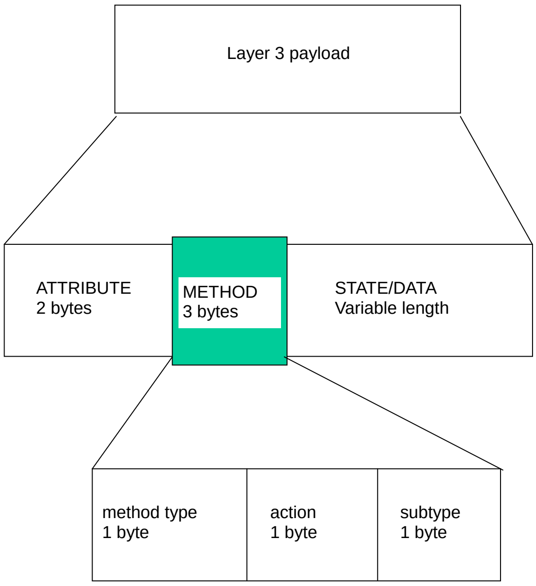



A Table Selector list and property_name for Table Selector = P&P are shown below for reference:

| Type | Table Selector | Table Selector value |
|---|---|---|
| Plug-and-play | P&P | 0×20 |

| property_name | value |
|---|---|
| serial_number | 0×00 |
| MacAddress | 0×01 |
| Magic_number | 0×02 |
| seed | 0×03 |
| maker | 0×10 |
| model | 0×11 |
| type | 0×12 |
| type_id | 0×13 |
| P&P | 0×20 |

METHOD consists of one byte of method type, one byte of action, and one byte of subtype, 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 |
| RESPONSE | Response | | 0×05 |
| MAKE | Add an item | Optional | 0×06 |
| REMOVE | Delete an item | Optional | 0X07 |
| OPEN | Start connection | Optional | 0×10 |
| CLOSE | End connection | Optional | 0×11 |

| 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 |

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

## Supplement 2.2 Determination of P&PMng (Set_P&PMng)

A neighboring P&PMng can presume to be the local P&PMng as a result of leakage of its declaration. Therefore, the method allowing the last P&PMng declarer to remain the final P&PMng is no longer adopted.

The installer shall have the option of effecting a P&PMng changeover.

## 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 it assigned exits correctly on the power line. This action is also meant to ensure that communication has not been disabled (despite an existing ECHONET node) by proximity or distance, noise, or power line distortion. Sometimes the ECHONET node will have been removed and will 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.

Because 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.

This increases the number of MAC addresses that the P&PMng can assign. The method for deleting a MAC address is not specified in this Standard.

# Chapter 3 Low-Power Radio Communications Protocol Specification

## 3.1 System Overview

We now consider a low-power radio communications system using 400 MHz band radio waves and conforming to laws and the 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
- Distinguish ECHONET Standard radio signals from other radio signals at an early stage using the frame synchronization signal.

### 3.1.1 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

### 3.1.2 ARIB Standard

The ARIB Standards include some standards by use. The low-power radio communication protocol takes into account RCR ARIB STD-T67 (STD-T67) for telemeter/telecontrol and ARIB STD-30 (STD-30) for security.

## 3.2 Mechanical/Physical Characteristics

This Standard adopts STD-T67 and STD-30.

## 3.3 Electrical Characteristics

This Standard adopts STD-T67 and STD-30.

### 3.3.1 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
2400 bps (mandatory) or 4800 bps (optional) ±100 ppm

(6) Modulation degree
2.1 kHz ±0.4 kHz

(7) Code type
NRZ (Non-return-to-zero) coding

### 3.3.2 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 to 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-T67 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 way 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 varies with communication frequency. When communication frequency is low, 3 channels (basic channels) are used. For more frequent communication, 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 shown below. In addition to communication channel groups A to F, a channel is prepared and used for radio system setup.

| Communication channel group | Basic channel | | Additional channel |
|---|---|---|---|
| | (STD-T67 intermittent communications zone) | (STD-T67 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 every 3 minutes (approx.)
- When using 5 channels: Once or less every 40 seconds (approx.)

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 increases.

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

(1) Additional channel (e.g., channels 35 and 44 in group A)

(2) Continuous communication zone (of the basic channels) (e.g., channels 8 and 20 in group A)

(3) Intermittent communications zone (of the basic channels) (e.g., channel 1 of group A)

When 3 channels are used, (1) above shall not be used. Instead, the priority is (2) and (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 varies depending on the frequency of communication. For low communication frequencies, 3 channels (basic channels) are used. For more frequent communication, 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 is prepared and 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 every 70 minutes (approx.)
- When using 5 channels: Once or less every 15 seconds (approx.)

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 increases.

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

(1) Additional channel (e.g., channels 19 and 38 in group A)

(2) Channels (of the basic channels) to be shared with other groups (e.g., channels 17 and 34 in group A)

(3) Channels (of the basic channels) to be used exclusively by the self-group (e.g., channel 1 of group A)

When 3 channels are used, (1) above shall not be used. Instead, the priority is (2) and (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

As 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.

The operating frequency should be set based on how the radio system will be used and the frequency characteristics of the radio transmitter/receiver circuit.

It is desirable that the communication channel groups should be adjusted to take into account nearby radio systems. As the default, communication channel groups may be determined by a different radio system identification code for each radio system. The number of channels should be adjusted in accordance with communication volume.

The use of 3 channels can be selected as the default. However, the setting must be changeable to 5-channel use to provide for a possible future increase in communication volume.

The system setup channel shall be used to set communication channel groups and the number of channels via radio communication. It is also possible to use wire telecommunication or perform individual settings by switch for each device instead.

## 3.4 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 which transmission is performed. Or transmission is performed after completion of another radio wave. However, if STD-30 is complied with, carrier sense execution is not required.

(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

Not only a continuous wait for reception (mandatory), which gives priority to communication efficiency, but also an intermittent wait for reception (optional), which gives priority to low power consumption during standby for reception, can be provided. These are specified as follows in consideration of the transmission time limit:

- 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 3.4.2.).

This Standard provides a communication procedure to boost communication efficiency by switching over to continuous wait for reception only at communication in devices performing an intermittent wait for reception. (See Section 3.4.4.)

### 3.4.1 Data structure

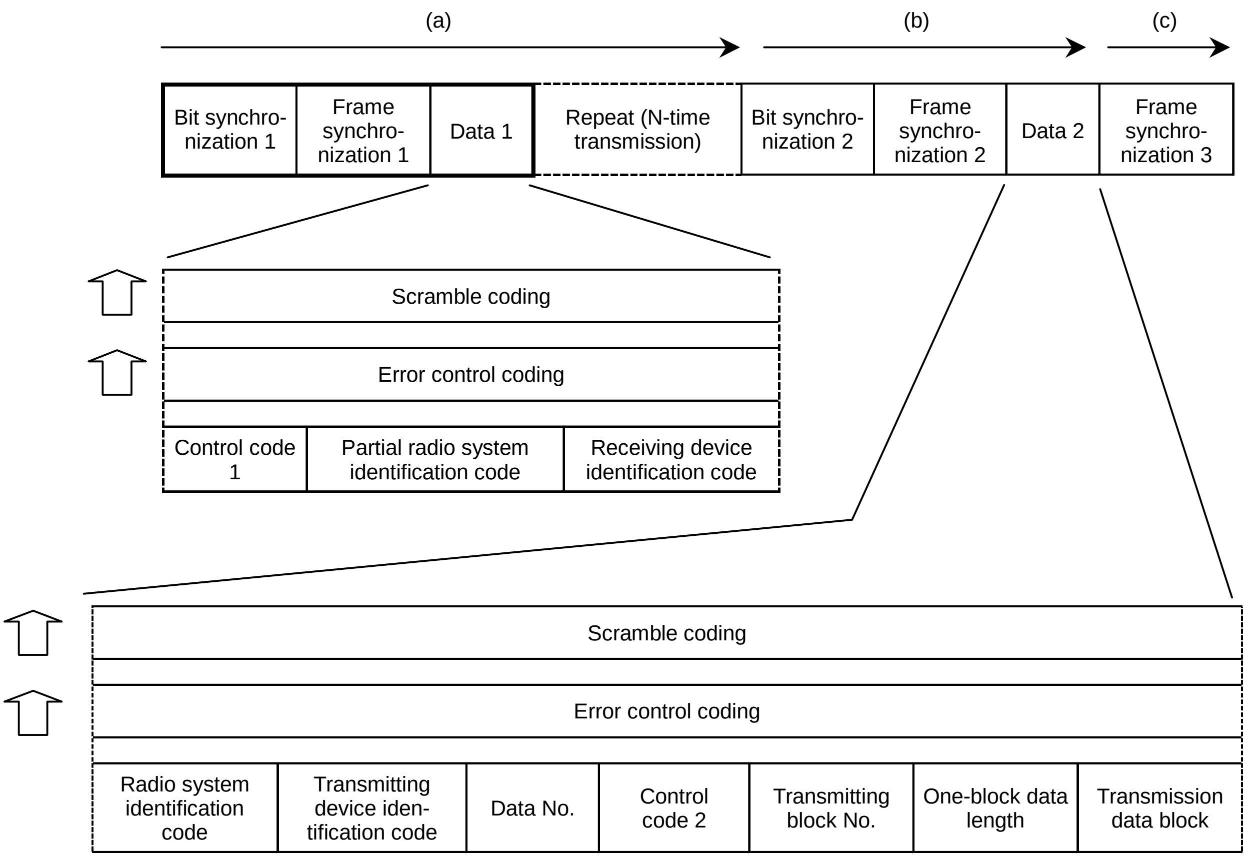
The data format to be used for radio communication is divided into the information transmitting signal (for information transmission) and the ACK signal, a response acknowledging reception. The data format for these shall be as common as possible.

The data format consists of the three elements 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 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.



### 3.4.2 Layer 1

| Bit synchronization 1 | Frame synchronization 1 | Data 1 | Repeat (N-time transmission) | Bit synchronization 2 | Frame synchronization 2 | Data 2 | Frame synchronization 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 “01010101010101010101010101010101010101010”.

(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 3.4.3).
- Error control coding for error detection/correction is performed (details are provided in Section 3.4.3), followed by scramble code conversion for limiting the number of continuous same bits (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”.

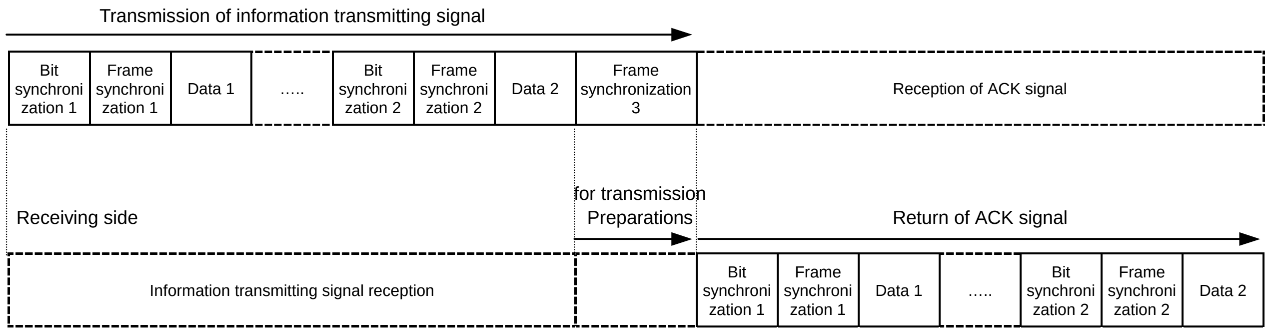
(F) Data 2

- Includes information about the opposite party of communication, data to be transmitted, etc. (details are provided in Section 3.4.3).
- Error control coding for error detection/correction is performed (details are provided in Section 3.4.3), followed by scramble code conversion for limiting the number of continuous same bits (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 3.4.3, 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 3.4.3, 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.

Transmitting side




(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 3.4.3) 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

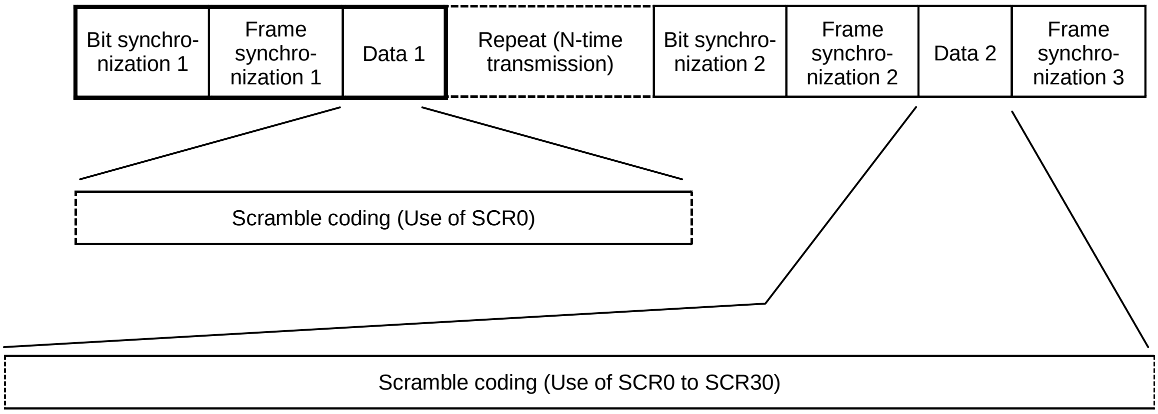
[Received data (d)] → [Data that has undergone scramble processing (f)] → Received contents analyze processing

(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

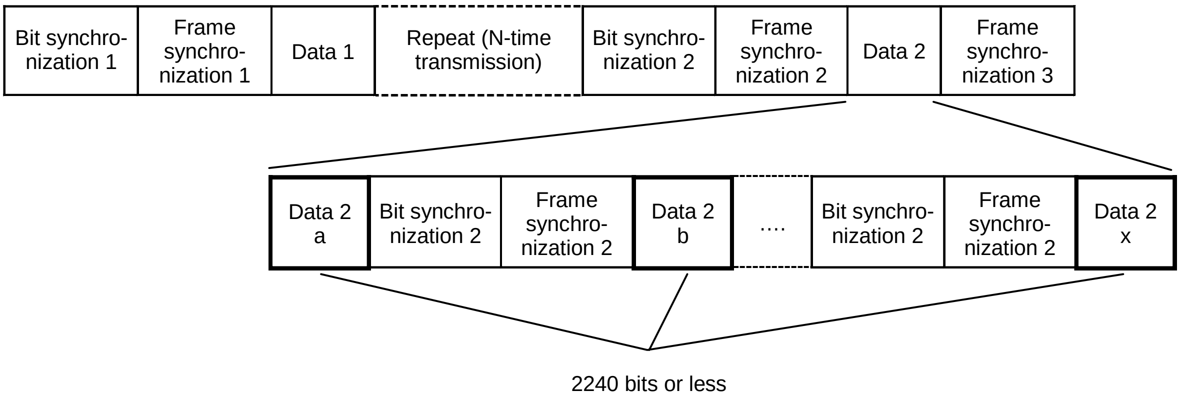
| | High-order　　　　　　　　　　Lower-layer |
|---|---|
| SCR0 | 11011010011000001110010001010110 |
| SCR1 | 11101101001100000111001000101010 |
| SCR2 | 11110110100110000011100100010100 |
| SCR3 | 01111011010011000001110010001010 |
| SCR4 | 101111101101001100000111001000100 |
| SCR5 | 010111110110100110000011100100010 |
| SCR6 | 101011111011010011000001110010000 |
| SCR7 | 010101111101101001100000111001000 |
| SCR8 | 001010111110110100110000011100100 |
| SCR9 | 000101011111011010011000001110010 |
| SCR10 | 100010101111101101001100000111000 |
| SCR11 | 010001010111110110100110000011100 |
| SCR12 | 001000101011111011010011000001110 |
| SCR13 | 100100010101111101101001100000110 |
| SCR14 | 110010001010111110110100110000010 |
| SCR15 | 111001000101011111011010011000000 |
| SCR16 | 011100100010101111101101001100000 |
| SCR17 | 001110010001010111110110100110000 |
| SCR18 | 000111001000101011111011010011000 |
| SCR19 | 000011100100010101111101101001100 |
| SCR20 | 000001110010001010111110110100110 |
| SCR21 | 100000111001000101011111011010010 |
| SCR22 | 110000011100100010101111101101000 |
| SCR23 | 011000001110010001010111110110100 |
| SCR24 | 001100000111001000101011111011010 |
| SCR25 | 100110000011100100010101111101100 |
| SCR26 | 010011000001110010001010111110110 |
| SCR27 | 101001100000111001000101011111010 |
| SCR28 | 110100110000011100100010101111100 |
| SCR29 | 011010011000001110010001010111110 |
| SCR30 | 101101001100000111001000101011110 |

(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 100 ppm, a single synchronization makes it possible to received data of about 5000 bits.

In consideration of a receiver synchronization error, this Standard provides that data 2 shall be divided into multiple blocks when its length exceeds 2240 bits (this number of bits contains an error control code). Bit synchronization 2 and frame synchronization 2 shall be inserted between blocks.



### 3.4.3 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 differs, 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 standardized to the radio system identification code of the master node.

In 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. Before shipping a device having a master node function, manufacturers shall store a radio system identification code in nonvolatile RAM, etc. Devices with the master node function shall also offer the slave node function by switch selection. Some devices may come with only a slave node function.

When a new slave node is to be added to an existing radio communication system, the master node's radio system identification code shall be written into the slave node's nonvolatile RAM, etc. When the radio system identification code has been written, the device identification code is cleared to unset status.

For manual setting, radio communication (via the system setup channel) or wire communication may be used for setting in addition to individual setting using a switch for each device. Items to be stipulated are the radio system identification code, channel count, communication channel group, scramble code (optional), and reception cycle information (optional).

When changing the master node, the radio system identification code written in all the slave nodes within the subnet shall be replaced with the radio system identification code of 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 device identification code of the master node shall be 0×01. The master node shall be capable of assigning device identification codes between 0x02 and 0x3F. The identification code manager shall assign device identification codes between 0x40 and 0x7F independently of the master node. If device identification code setup is not completed, however, provisional device identification codes between 0x80 and 0xFF are stored in the slave nodes. For example, the provisional device identification codes may be randomly assigned at the factory prior to shipment.

When the master node assigns device identification codes to the slave nodes, it uses radio communication to perform setup in the following sequences:

(Setup sequence 1)

The following describes the setup sequence to be followed when the requirements (radio system identification code, etc.) for communication are established, except for the device identification code.

- When a switch, message, or other means is used to issue the "(a) Registration process request" from a higher layer, the slave node's low-power radio unit switches into registration mode.
- The slave node uses a provisional device identification code as the local address to set a radio system setup message flag as indicated under "control code 2" in Section 3.4.3, specifies the master node as the destination, and starts a transmission under the "Transmission data: none" condition ((1) Information transmission). A channel in the ordinary communication channel group is used for transmission.
- Upon receipt of the radioed message above, the master node switches into registration mode, views its domain table, and issues an available device identification code. Further, the master node specifies a provisional device identification code as the destination address, sets a radio system setup message flag, places the issued device identification code in the data section, and transmits it to the slave node ((2) Information transmission). The system setup channel is used for transmission. Reception occurs continuously.

(Data section of data 2 for "(2) Information transmission")

- Upon receipt of the radioed message above, the slave node sets a radio system setup message flag using the device identification code issued as the local address, places the local unit's reception cycle in the data section, and transmits it to the master node ((3) Information transmission). The system setup channel is used for transmission. Reception occurs continuously. Further, the slave node sends the "(c) Registration completion notification" to notify the higher layer of registration process completion and stores the issued device identification code in nonvolatile RAM, etc.

(Data section of data 2 for "(3) Information transmission")

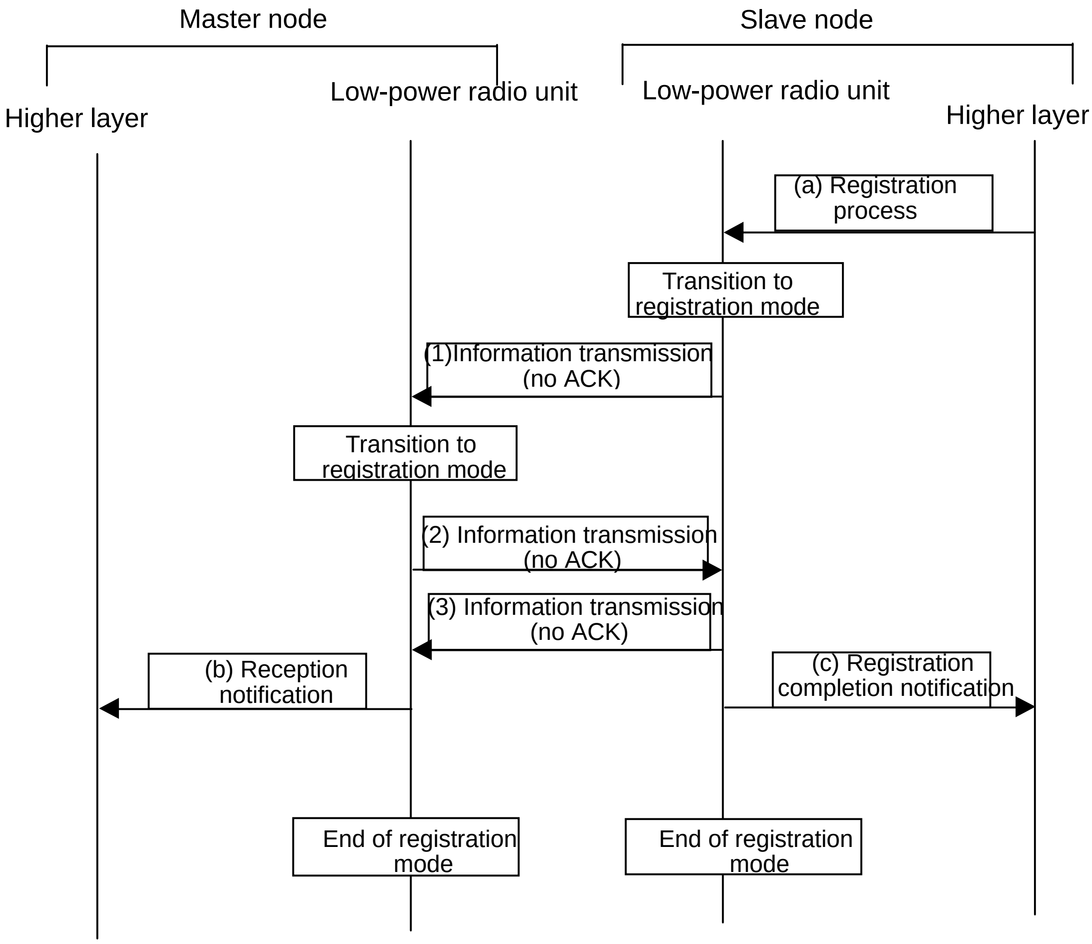
| Local unit's reception cycle (8 bits) |
|---|

- Local unit's reception cycle (3-bit information)

| 429 MHz | 426 MHz | Higher bits Lower bits |
|---|---|---|
| Continuous | Continuous | *****000 |
| 0.5 sec | 0.5 sec | *****001 |
| 3 sec | 1 sec | *****010 |
| 5 sec | 1.5 sec | *****011 |
| 15 sec | 2 sec | *****100 |
| 25 sec | 2 sec | *****101 |
| 35 sec | 2 sec | *****110 |

Upon receipt of the radioed message above, the master node sends the "(b) Reception notification" to notify the higher layer of the slave node's reception cycle.

The sequence diagram is shown below:




(Setup sequence 2)

The following describes the setup sequence to be followed when the requirements (radio system identification code, etc.) for communication are not met (except for the device identification code) or when the slave node does not satisfy the requirements (master node reception cycle and scramble code) for master node communications.
Device identification code setup can be performed via setup sequence 1 after changing settings so that the slave node satisfies the requirements for master node communications.

- Upon receipt of the "(a) Registration process request" from the higher layer, the low-power radio units of the master and slave nodes switch to registration mode.

- The slave node sets a radio system setup message flag using a provisional device identification code as the local address, specifies the master node as the destination, and transmits it under the "Transmission data: none" condition ((1) Information transmission). The system setup channel is used for transmission. Reception occurs continuously. Further, an all-1 radio system identification code is used.
- Upon receipt of the radioed message above, the master node views its domain table and issues an available device identification code. Further, the master node specifies a provisional device identification code as the destination address, sets a radio system setup message flag, places the issued device identification code, radio system identification code, channel count, communication channel group, scramble code, and reception cycle information in the data section, and transmits it to the slave node ((2) Information transmission). The system setup channel is used for transmission. Reception occurs continuously. Further, an all-1 radio system identification code is used.

(Data section of data 2 for "(2) Information transmission")

| Device identification code | Radio system identification code | Channel count/communication channel group | Scramble code/reception cycle |
|---|---|---|---|

- Channel count (1-bit information)

| | Higher bits Lower bits |
|---|---|
| 3ch | ***0**** |
| 5ch | ***1**** |

- Communication channel group (4-bit information)

| | Higher bits Lower bits |
|---|---|
| Group A | ****0001 |
| Group B | ****0010 |
| : | : |
| Group O | ****1111 |

- Scramble code (5-bit information)

| | Higher bits Lower bits |
|---|---|
| SCR0 | 00000*** |
| SCR1 | 00001*** |
| : | : |
| SCR30 | 11110*** |

- Reception cycle (3-bit information)

| 429 MHz | 426 MHz | Higher bits Lower bits |
|---|---|---|
| Continuous | Continuous | *****000 |
| 0.5 sec | 0.5 sec | *****001 |
| 3 sec | 1 sec | *****010 |
| 5 sec | 1.5 sec | *****011 |
| 15 sec | 2 sec | *****100 |
| 25 sec | 2 sec | *****101 |
| 35 sec | 2 sec | *****110 |

- Upon receipt of the radioed message above, the slave node sets a radio system setup message flag using the device identification code issued as the local address, places the local unit's reception cycle in the data section, and transmits it to the master node ((3) Information transmission). The system setup channel is used for transmission. Reception occurs continuously. The radio system identification code received from the master node is used.
- The "(c) Registration completion notification" is transmitted to notify the higher layer that the registration process is completed. At the same time, the device identification code and other information issued by the slave node are stored in nonvolatile RAM, etc.

(Data section of data 2 for "(3) Information transmission")

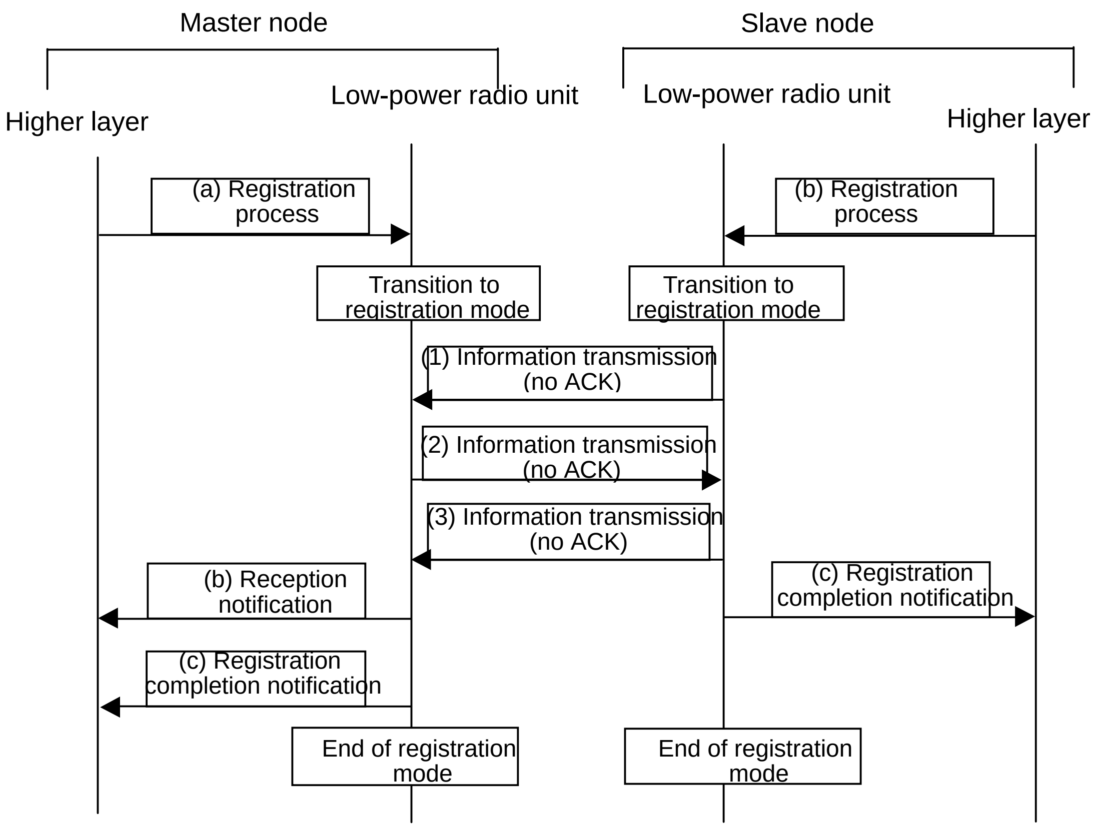
| |
|---|
| Local unit's reception cycle (8 bits) |

- Local unit's reception cycle (3-bit information)

| 429 MHz | 426 MHz | Higher bits Lower bits |
|---|---|---|
| Continuous | Continuous | *****000 |
| 0.5 sec | 0.5 sec | *****001 |
| 3 sec | 1 sec | *****010 |
| 5 sec | 1.5 sec | *****011 |
| 15 sec | 2 sec | *****100 |
| 25 sec | 2 sec | *****101 |
| 35 sec | 2 sec | *****110 |

- Upon receipt of the radioed message above, the master node sends the "(b) Reception notification" to notify the higher layer of the slave node's reception cycle and issues the "(c) Registration completion notification" to notify the higher layer that the registration process has been completed.

The sequence diagram is shown below:




(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. If the codes do not match, 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 |

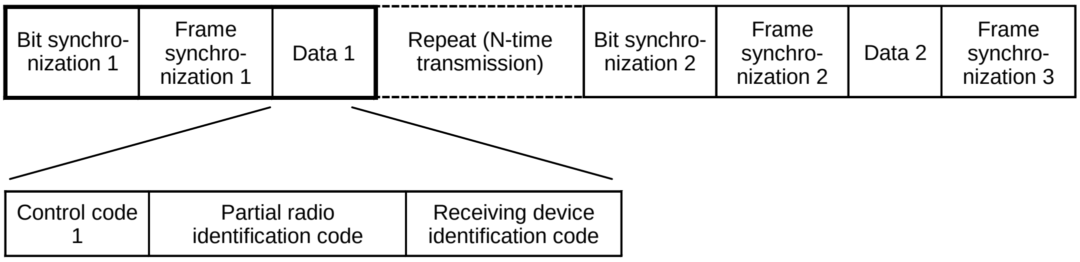
(4) Error detection/correction

- Error control is performed for 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”, reception is suspended.

| Transmit signal<br>16 bits | BCH error control code<br>15 bits | Even parity code<br>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 ：１０＊＊＊＊＊＊
- Individual communication (information transmitting signal) ：００＊＊＊＊＊＊
- Individual communication (ACK signal) ：０１＊＊＊＊＊＊

(2) Flag to indicate 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. If the codes do not match, 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

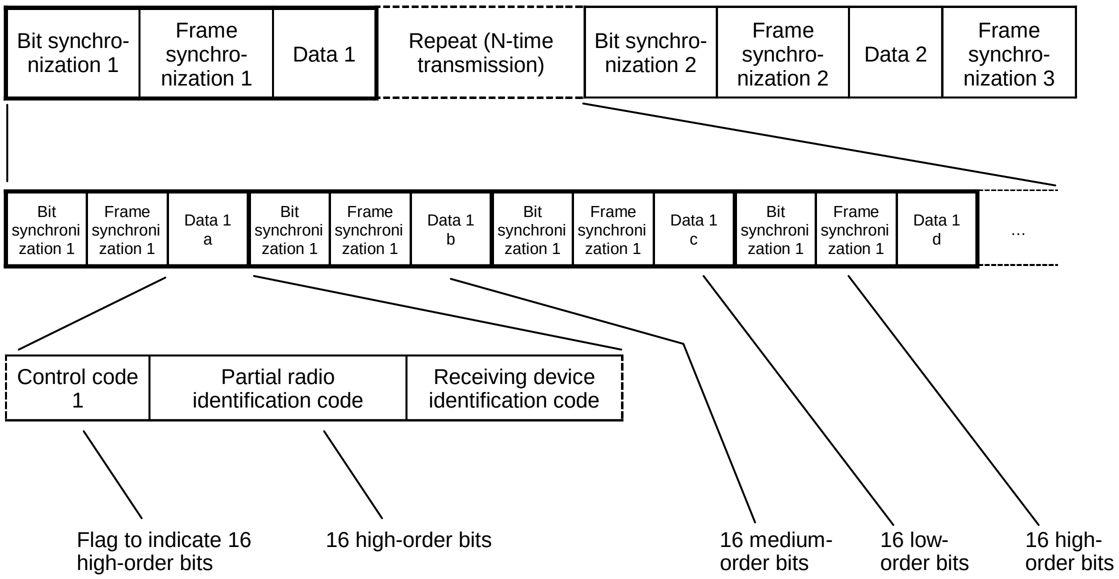
| **Channel No.** | **‘001’** | **‘010’** | **‘011’** | **‘100’** | **‘101’** |
|---|---|---|---|---|---|
| Communication channel group | Basic channel | | | Additional channel | |
| Group A | 1ch | 17ch | 34ch | 19ch | 38ch |
| Group B | 2ch | 19ch | 37ch | 23ch | 41ch |
| Group C | 3ch | 21ch | 40ch | 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 → low-order → high-order → etc., (or low-order → medium-order → high-order → low-order → 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/low-order or not and checks that it matches the corresponding portion of its radio system identification code. If the codes do not match, 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. If the codes do not match, 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 its own device identification code. If the codes do not match, 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

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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 |

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

- 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. For the second block and after, the radio system identification code, transmitting device identification code, data No., and control code 2 are omitted.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 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 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Data 2 a | Bit synchro-nization 2 | Frame synchro-nization 2 | Data 2 b | …. | Bit synchro-nization 2 | Frame synchro-nization 2 | Data 2 x |

Data 2a

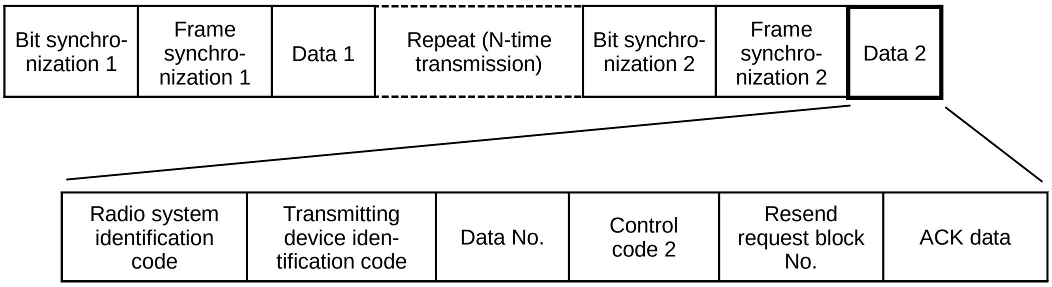
| | | | | | | |
|---|---|---|---|---|---|---|
| Radio system identification code | Transmitting device iden-tification code | Data No. | Control code 2 | Transmitting block No. | One-block data length | Transmission data block |

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.




(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 its radio system identification code. If the codes do not match, 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 (i.e., higher than the lower-layer communication 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 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 for indicating the contents of the information transmission signal

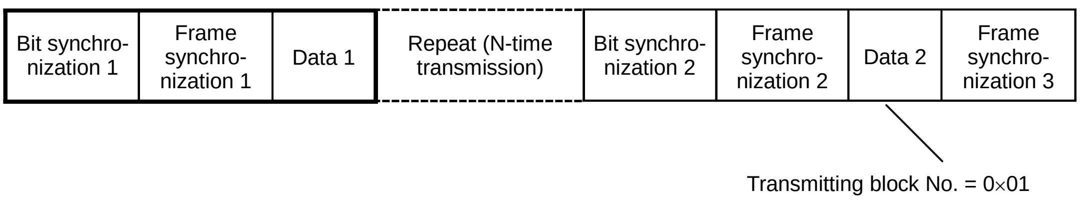
- ECHONET message : ＊＊＊＊＊＊＊＊＊＊＊1＊＊＊＊
- Radio system setup message : ＊＊＊＊＊＊＊＊＊＊＊1＊＊＊＊

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

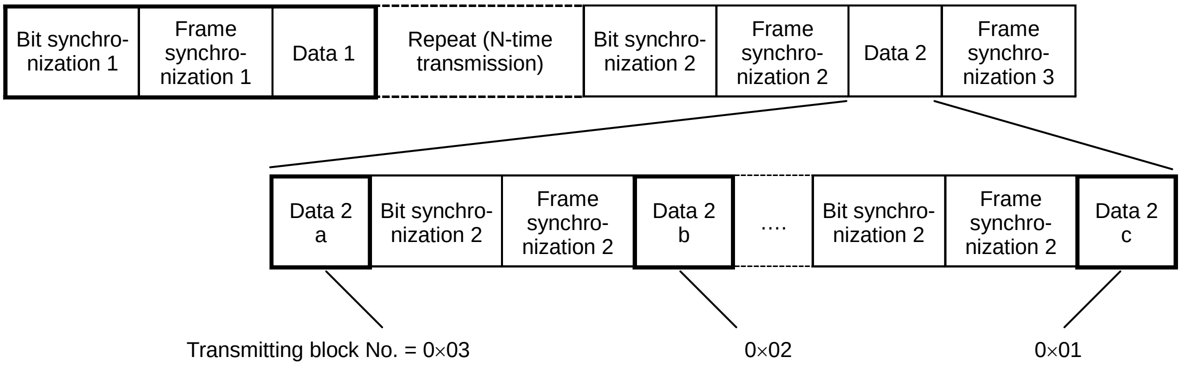
(E) Transmitting block No.

- 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 decremented 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 decremented 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

- 2048 bits (256 bytes) max.
- The information volume to be transmitted by the high-order layer (higher than the lower-layer communication software in the communication layers) shall be in units of 8 bits, and the transmission data block shall be up to 1024 bits (128 bytes).
- A 16-bit error control code shall be added to each 8-bit transmission data x 2 units (= 16 bits).
- 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 determines this based 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 perform a duplication check for the radio system identification code and device identification code in broadcast communication, the receiving side should check that the received transmitting device identification code matches its own device identification code and report 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 instead 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.

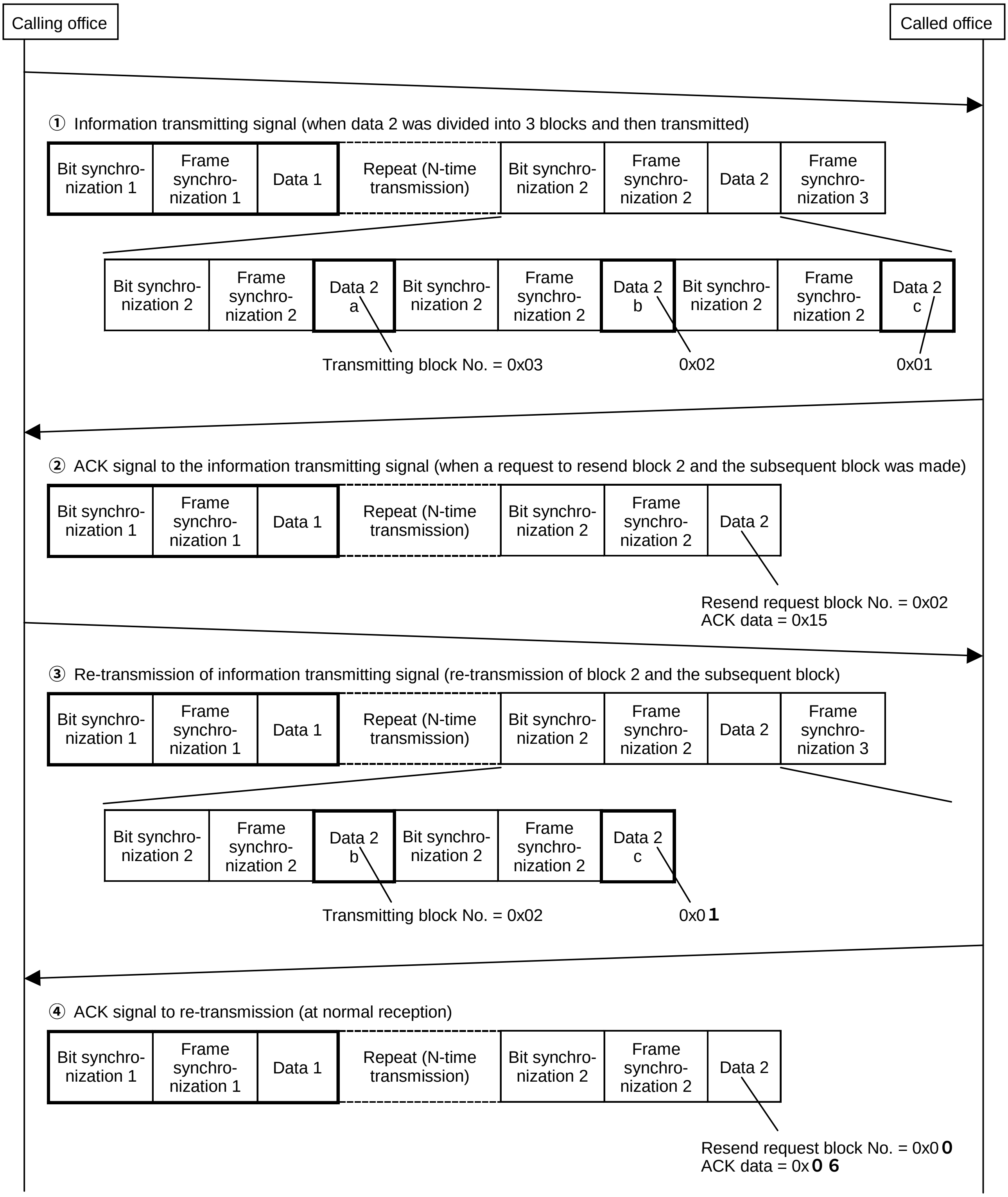
The transmitting side of the information transmitting signal that received this ACK signal resends the data transmitting blocks subsequent to the resent request block No. in the ACK signal.

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 instead waits for re-transmission.

Re-transmission of the information transmitting signal to the ACK signal of the resend request is the same as ordinary resend processing. Here, 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.



(9) 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 communication 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.

STD-T67 and STD-30 establish a limit on 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

Time for Transmission of 16-byte 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.

Time for Transmission of 256-byte 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

Time for Transmission of 16-byte 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 portion exceeds the transmission time limit, 16 bytes cannot be transmitted.

Time for Transmission of 256-byte 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 portion exceeds the transmission time limit, 256 bytes cannot be transmitted.

(10) 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.

For 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.

### 3.4.4 Layer 3

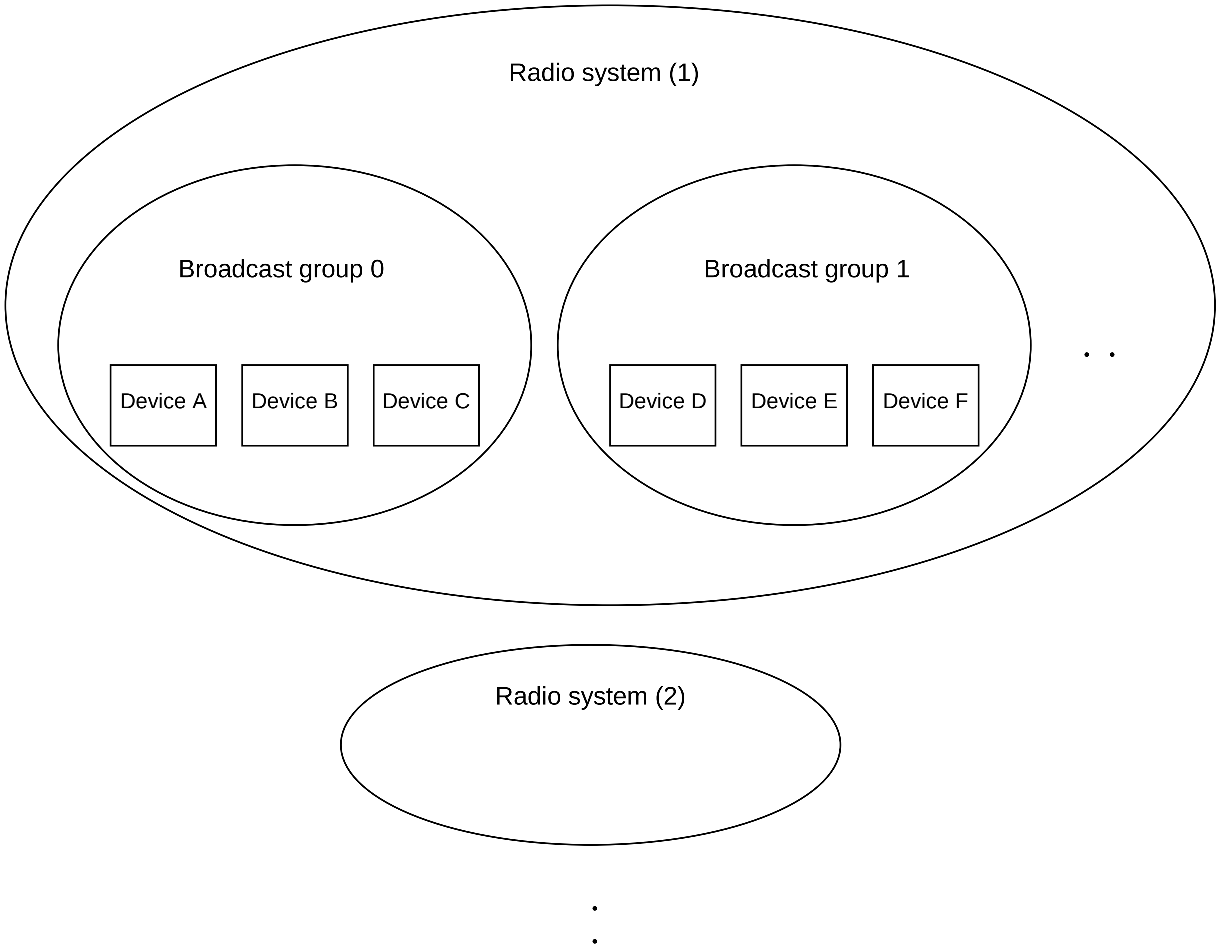
(1) Individual communication

(A) Basic procedure

The "ACK provided" and "Link connection provided" features indicated in the procedure set forth below are available as options.

When communication is performed between a calling office and a called office in 1:1 form, this is called individual communication. Fig. 3.1 shows a basic communication procedure. In this figure, “high-order” means higher than the lower-layer communication 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 3.4.3). The data number is provided only as an example.

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 the transmitted signal is received 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 3.4.2). 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.

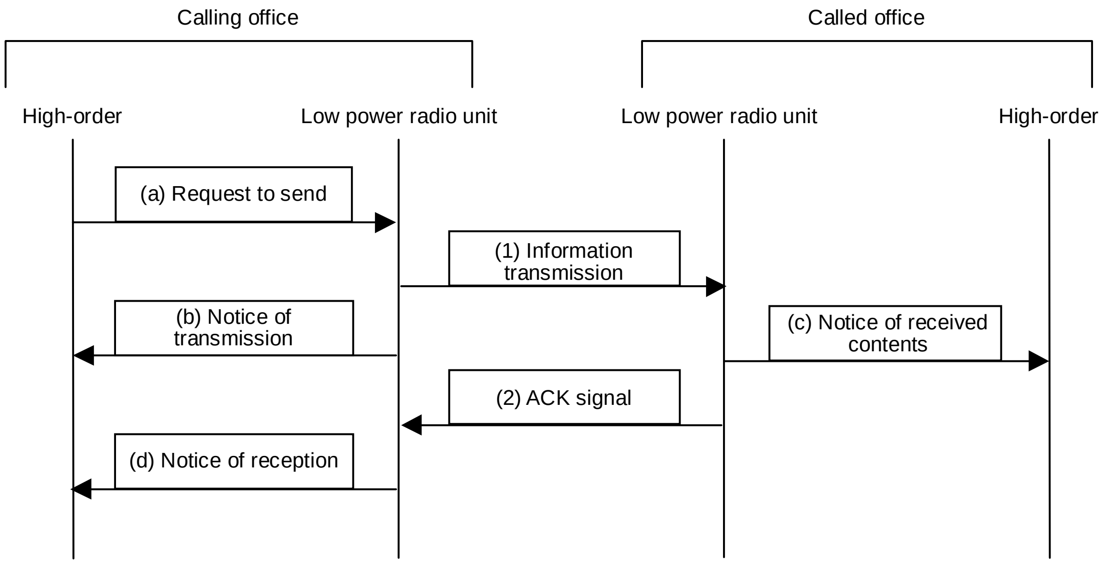



**Fig. 3.1 Basic Communication Procedure**

(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. 3.2 shows a communication procedure at a link connection. In the data in the radio communication section in Fig. 3.2, “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 3.4.3).

As shown in Fig. 3.2, 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. 3.3.

(C) Link establishment

In link establishment status, communication is performed according to the procedure shown in (A) Basic procedure. The communication procedure in link establishment status is shown in Fig. 3.3. In 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. 3.4. 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.

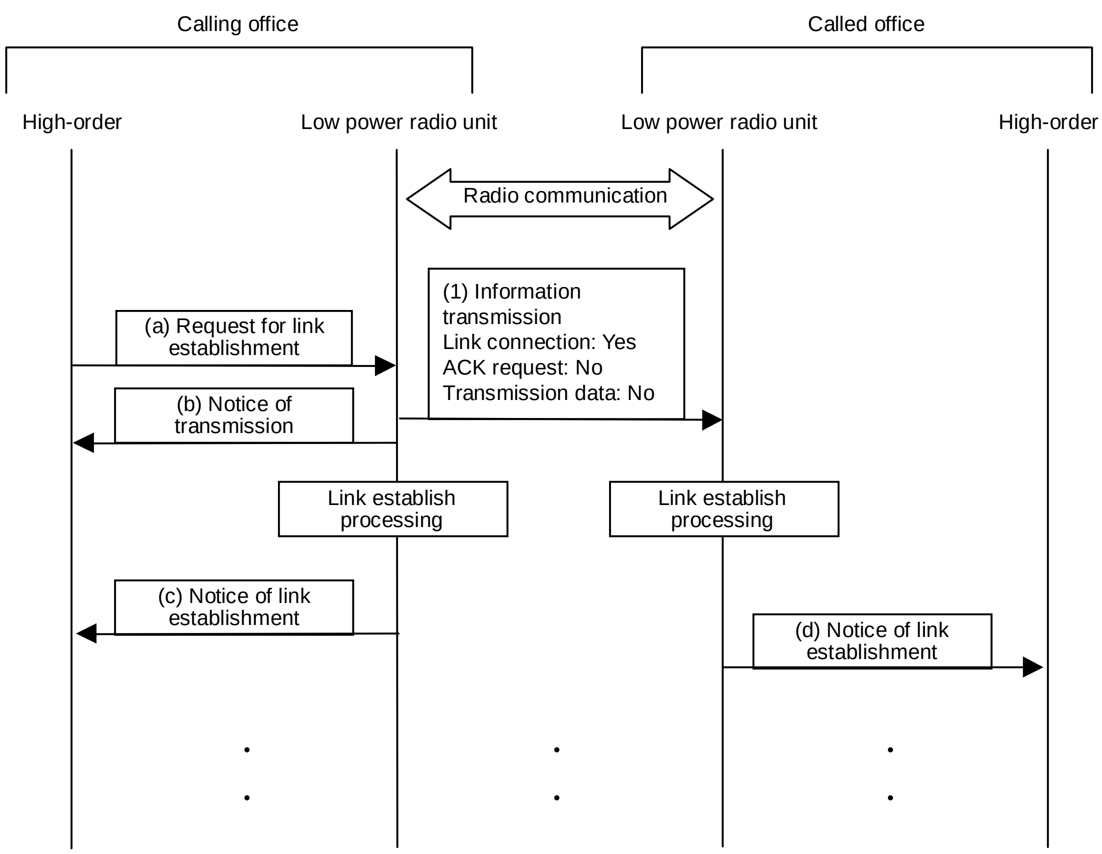



**Fig. 3.2 Communication Procedure at Link Connection**

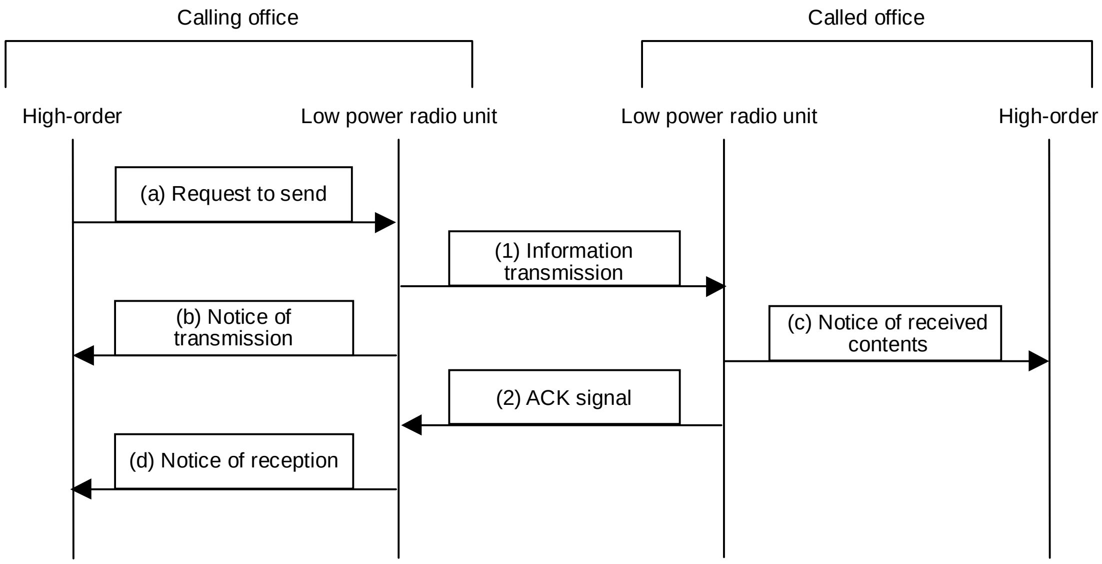



**Fig. 3.3 Communication Procedure in Link Establishment Status**

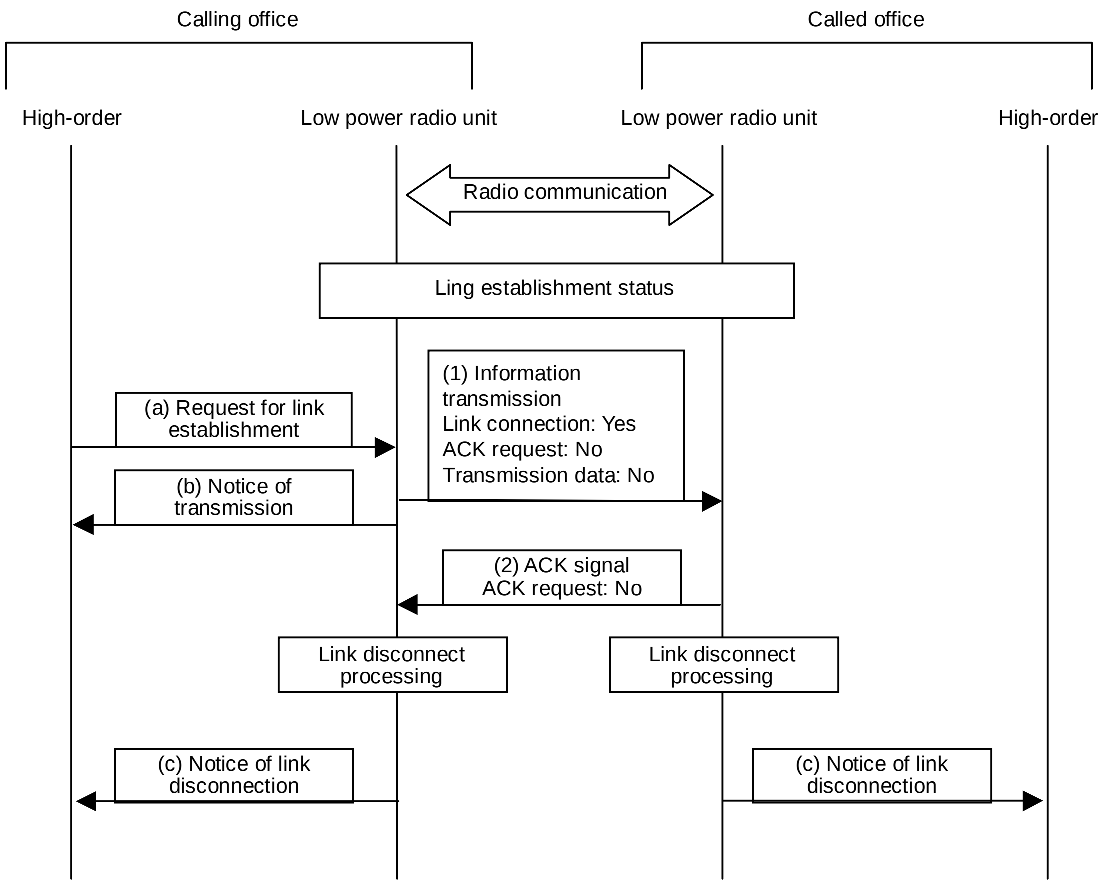



**Fig. 3.4 Communication Procedure at Link Disconnection**

(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. 3.5 shows the communication procedure.

The control codes for 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

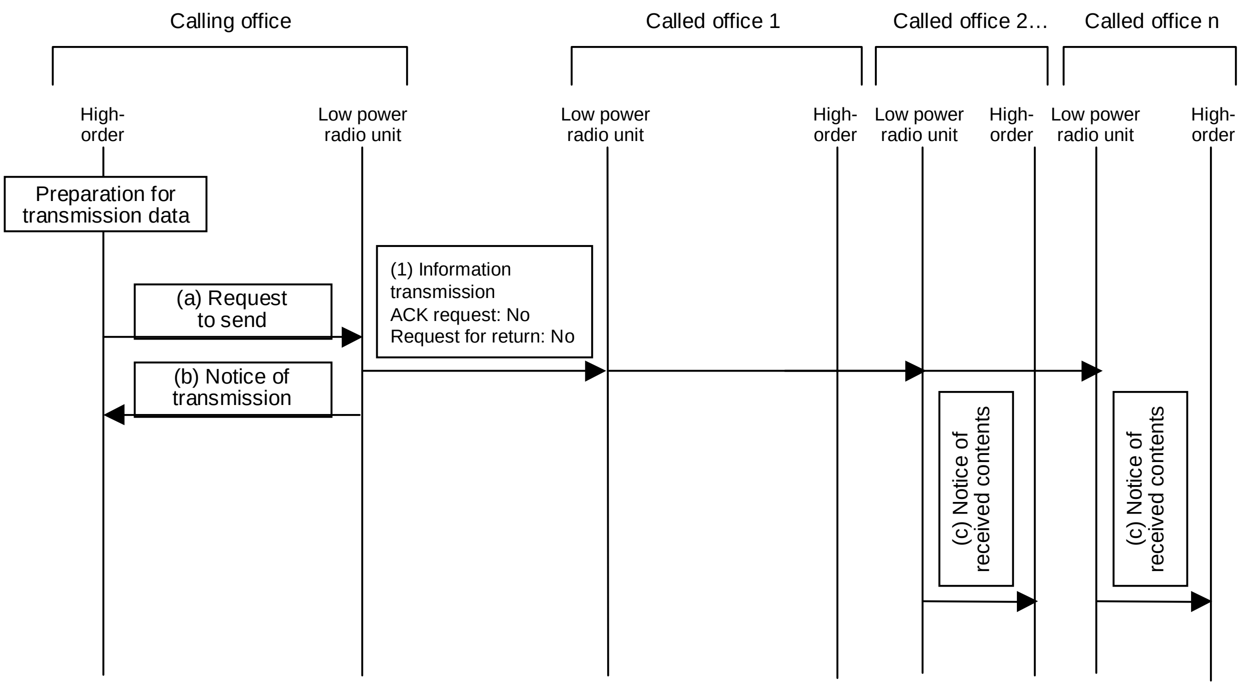



**Fig. 3.5 Broadcast Communication**

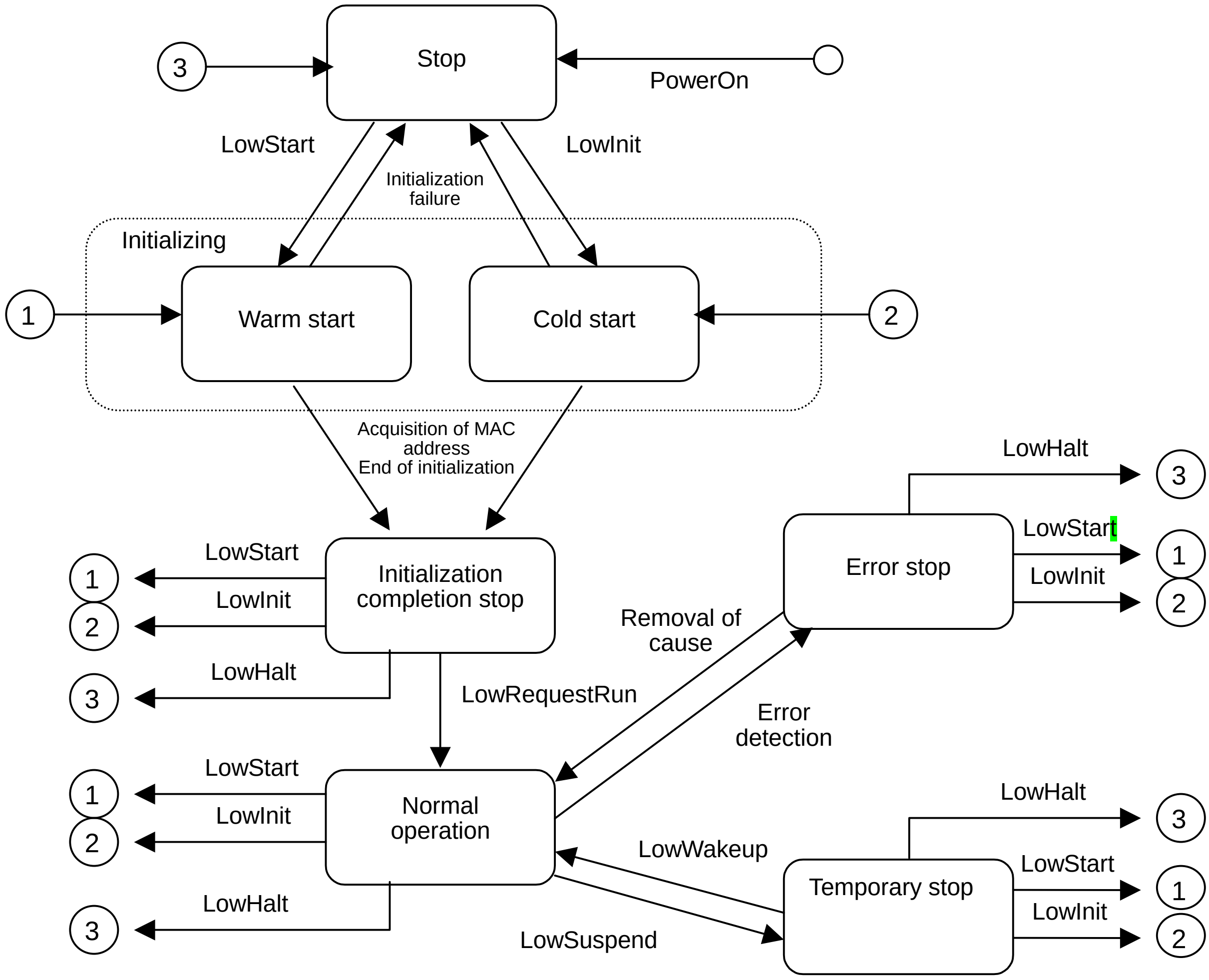
# 3.5 Basic Sequence

## 3.5.1 Basic concept

This subsection classifies the discrete lower-layer communication 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.



### 3.5.2 Stop Status

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

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

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

The triggers for state transition are as follows:

(1) Transition trigger to initialize processing status
This transition is caused by an initialization service (LowStart, LowInit).

### 3.5.3 Initialize processing status

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

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

(1) Trigger and action
① Initializes the transceiver.
② Obtains a unique MAC address in the SUBNET.
- When a warm start is used, the retained MAC address is used to start a MAC acquisition process.
- When a cold start is used, the retained MAC address is discarded, and the master node newly performs a new MAC address acquisition procedure. The retained radio system identification code remains unchanged.

③ Obtains a radio system identification code.

(2) Status acquisition service (LowGetStatus)
In a cold start, returns LOW_STS_INIT as the status. In a warm start, returns LOW_STS_RST.

Triggers for state transition are as follows:

(1) Transition trigger to initialization completion stop status
The transition is caused by initializing the transceiver, getting a MAC address, and getting a radio system identification code.
(2) Transition trigger to stop status
This transition is caused by the initialization failure.

### 3.5.4 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 communication software is initialized. An outline of processing immediately after state transition and an outline of Individual Lower-layer Communication Interface services that initialization completion stop status receives, and related 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) Physical address acquisition service (LowGetMacAddress)
Returns a MAC address.
(4) Profile data acquisition service (LowGetProData)
Returns profile data.

Triggers for state transition are as follows:

(1) Transition trigger to initialization processing state
This transition is caused by the initialization service (LowStart, LowInit).
(2) Transition trigger to normal operation status
This transition is caused by the operation start instruction service (LowRequestRun).
(3) Transition trigger to stop status
This transition is caused by the end service (LowHalt).

### 3.5.5 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 communication software. An outline of processing immediately after state transition and an outline of the Individual Lower-layer Communication Interface services that normal operation status receives, and related processing, are described below.

(1) Trigger and action

Waits for an Individual Lower-layer Communication Interface service.

(2) Status acquisition service (LowGetStatus)

Returns LOW_STS_RUN as status.

(3) Physical address acquisition service (LowGetMacAddress)

Returns a MAC address.

(4) Profile data acquisition service (LowGetProData)

Returns profile data.

(5) Data transmission service (LowSendData)

Translates the received Protocol Difference Absorption Processing Block data into lower-layer communication software data and outputs it to the transmission medium.

(6) Data reception service (LowRecvData)

Translates the lower-layer communication 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.

Triggers for state transition are as follows:

(1) Transition trigger to stop status

The transition is caused by the end service (LowReset).

(2) Transition trigger to initialize processing state

This transition is caused by the initialization service (LowStart, LowInit).

(3) Transition trigger to error stop status

The transition is caused by the occurrence of an error.

(4) Transition trigger to suspension state

This transition is caused by the suspension service (LowSuspend).

### 3.5.6 Error stop status

The error stop status signifies a status in which 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 error stop status receives, and related processing, are described below.

(1) Trigger and action
Performs error processing.

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

Triggers for state transition are as follows:

(1) Transition trigger to stop status
The transition is caused by the end service (LowHalt).

(2) Transition trigger to initialize processing status
This transition is caused by the initialization service (LowStart, LowInit).

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

### 3.5.7 Suspension status

The 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 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.

Triggers for state transition are as follows:

(1) Transition trigger to normal operation status
This transition is caused by the end service (LowHalt).

(2) Transition trigger to normal operation state
This transition is caused by the operation restart service (LowWakeUp).

(3) Transition trigger to initialize processing state
This transition is caused by the initialization service (LowStart, LowInit).

# Chapter 4 Extended HBS Communication Protocol Specification

## 4.1 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: predecessor to JEITA, which was formed by the merger of EIAJ and JEIDA in November 1, 2000). 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 a rule, if standards established in the past are available and still effective, ECHONET uses them where applicable. The EIAJ standard includes layers 1 to 7 of the OSI communication layer configuration as well as multiple information channels for the transmission of audio and video, in addition to equipment control channels. The pair cable protocol for ECHONET includes the lower-layer layers (layers 1 to 3) and provisions on control channels and part of the provisions of layer 7. However, the ET-2101 standard relates to specifications of the lower-layer medium specifying the co-existence of both CT and AVC systems (e.g., the mounting of four sets of twisted pair cables, the use of 8-pin modular jacks as connectors, etc.) and includes some excessive specifications for actual system construction that place constraints on the equipment. 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 added. The principal differences with ET-2101 are as follows:

(1) One pair of twisted pair cable is allowed.

(2) 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 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. As a rule, however, ET-2101 specifications are followed whenever possible.

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

## 4.2 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. The applicable specifications are described below.

Note: Principal differences with ET-2101

1) One pair of pair cables shall also be allowed.
2) A maximum length of 1 km shall be allowed in consideration of medium and small buildings.
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.
   - “5.2.1 Transmission media and number of transmission pairs” provides detailed specifications.

2) Cable length
   - The ET-2101 standard “3.1.2 Cable length” is applied, and a part is additionally specified.
   - “5.2.2 Cable length” provides detailed specifications.

3) Topology
   - The ET-2101 standard “3.1.3 Topology” is applied.

4) Information socket shape (including compatibility with signals)
   - The ET-1201 standards “3.1.4 Information socket shape” and “3.1.6 Compatibility between information sockets and signals” are applied. A part is additionally specified.
   - “5.2.3 Information socket shape (including compatibility with signals)” provides detailed specifications.

5) Number of information sockets
   - The ET-2101 standard “3.1.5 Number of information sockets” is applied.

### 4.2.1 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)

### 4.2.2 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. |

### 4.2.3 Topology

Bus system

### 4.2.4 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.

### 4.2.5 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.

### 4.2.6 Compatibility between information sockets and signals

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

## 4.3 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, the specification for the cable diameters specified in "4.2.2 Cable length" is also provided for "Load resistance of control channel cable" to be additionally specified.

### 4.3.1 Characteristic impedance of cable

| | |
|---|---|
| Short-conductor cable with cable diameter of 0.65 mm: | 300Ω |
| Short-conductor cable with cable diameter of 1.2 mm: | 150Ω |
| Stranded cable with 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 more than 200 m and as much as 1 km.

### 4.3.2 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 cable length of 200 m or less
A 75Ω resistor or a 39Ω load resistance is connected to the terminal.

(2) For cable length of more than 200 m and as much as 1 km
A 100Ω resistor is connected to each terminal.

### 4.3.3 Transmission rate of control signal

9600bps ± 0.13%

### 4.3.4 Transmission system and transmission waveform of control signal

(1) Transmission system: Base-band transmission

(2) Transmission waveform: AMI (Alternate Mark Inversion) shown in Fig. 4.1 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.

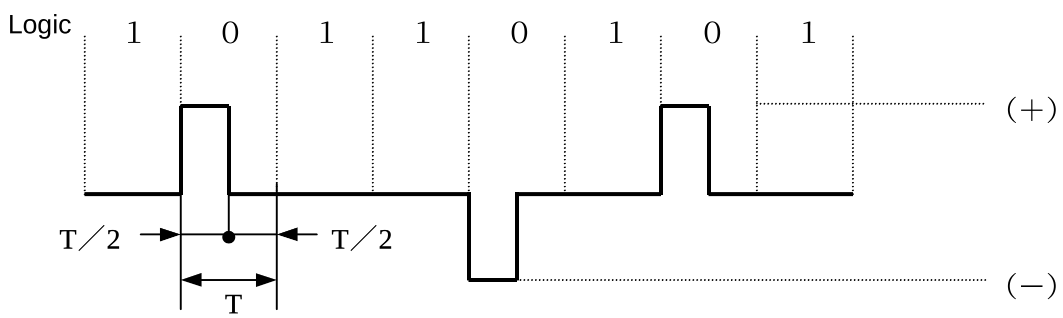



**Fig. 4.1 Transmission Waveform of Control Signal**

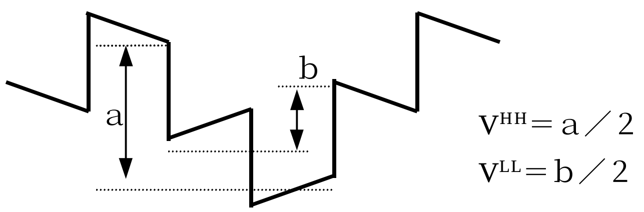
### 4.3.5 Transmitting/receiving level of control signal

The transmitting/receiving level of the control signal shall be as shown in Table 4.1.

**Table 4.1 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.



### 4.3.6 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: 40 Ω 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.

### 4.3.7 Power feed voltage of control channel

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

# 4.4 Logical Layers (Layer 1 Specifications)

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

The following eight items are specified as logical specifications for layer 1. EIAJ ET-2101 (HBS Standard) is fully applied for all of these items. An outline of the specifications is provided 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

## 4.4.1 Control System

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

## 4.4.2 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. 5.2).
(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

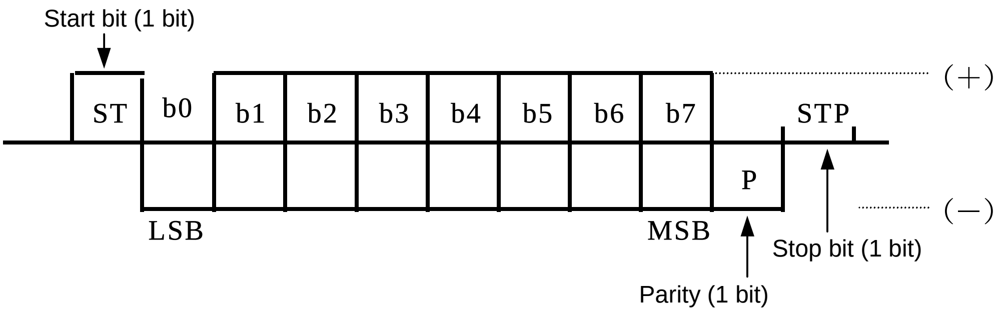
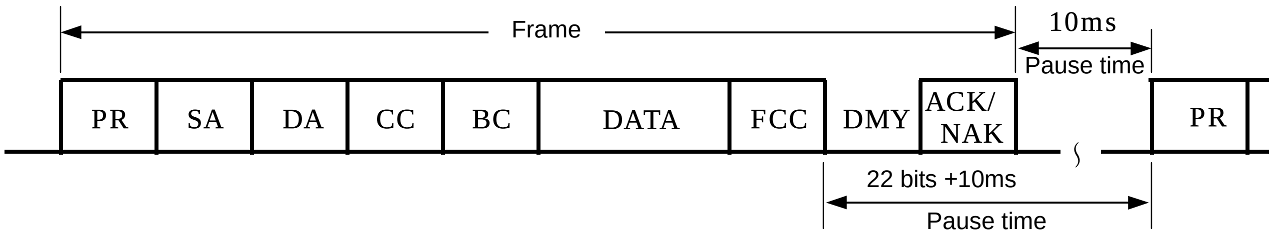



**Fig. 4.2 Character Configuration**

### 4.4.3 Basic format of control signal

Fig. 4.3 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. 4.3 Basic Format of Control Signal**

### 4.4.4 Pause time and pause period

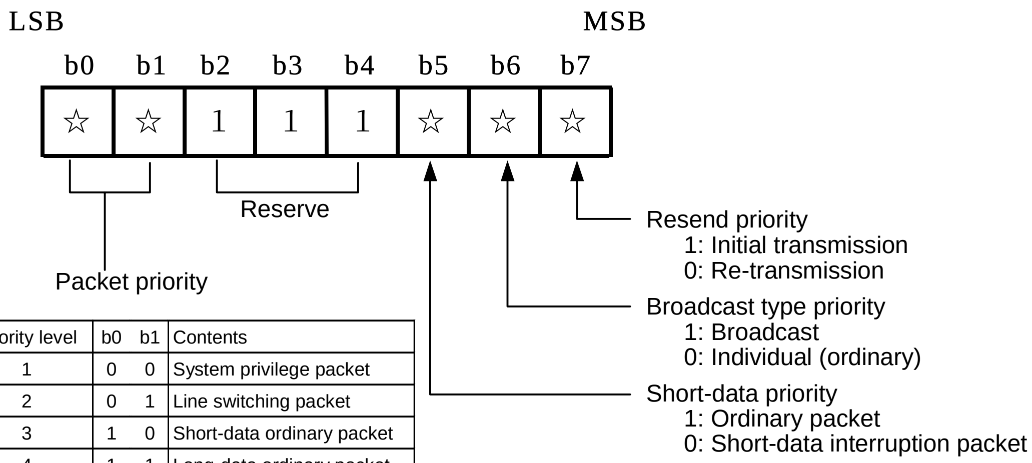
(1) Pause time: 10 ms (96-bit time) from the end of the stop bit of the ACK/NAK code

(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.

### 4.4.5 Packet priority

Packet priority is performed by contention between the priority code PR and the self address SA. Fig. 4.4 shows the 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. 4.4 Priority Code Bit Allocation**

### 4.4.6 Collision detection procedure

Collision detection is performed according to the following procedure to determine the 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. When transmission is re-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 collisions securely when they occur, 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.

### 4.4.7 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 bus from time TF (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.

### 4.4.8 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, the data field of the long data can be interrupted.

(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 because of the break signal does not increment the control code re-transmission count after the pause time, but instead re-transmits the long-data frame 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 receives priority because of contention by the priority bit of the priority code.

After the short-data frame that survived as a result of contention has been transmitted, the long-data frame is transmitted again in or after the pause period.

## 4.5 Logical Specifications (Layer 2 Specifications)

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

Note: The principal differences with the standard are as follows:

1) The address area of the router is additionally specified.
3) Bit settings for application to ECHONET are specified.
4) The size specified for short data is increased from 16 bytes to 32 bytes.
5) Specifications for starting lower-layer transmission media and using maintenance commands 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

### 4.5.1 Address

The size of the self address (SA) and the destination address (DA) shall be 1 byte and conform to Table 4.2 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 4.2 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 |

### 4.5.2 Broadcast, simultaneous broadcast, and group broadcast

Broadcast shall be performed according to the procedure shown below. Here, the address code shall be as shown in Fig. 4.5.

(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. 4.5.)

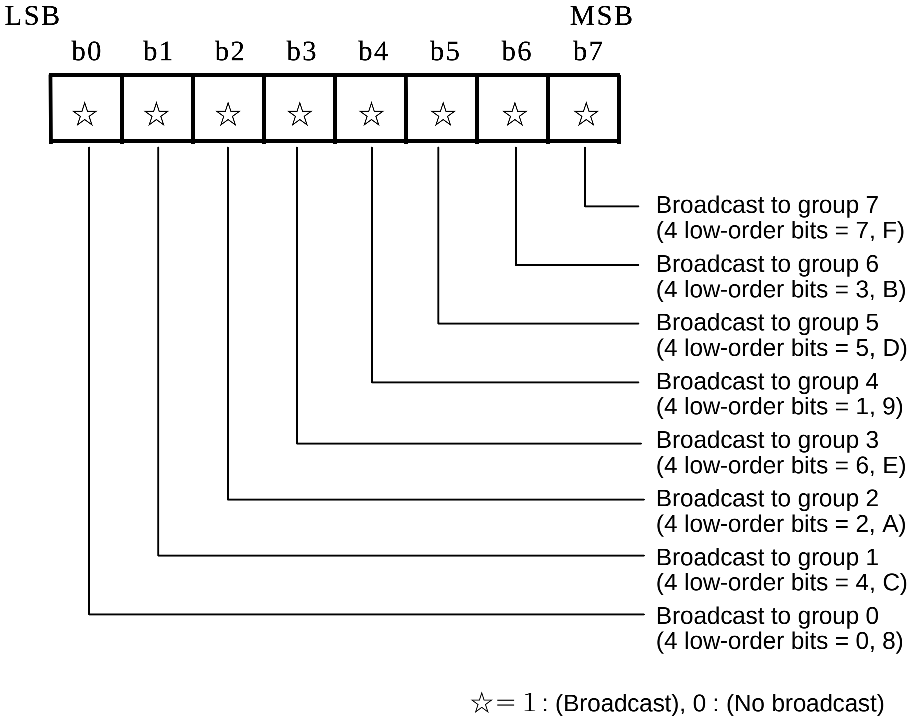



**Fig. 4.5 Bit Specification for Group Broadcast**

### 4.5.3 Control code

The allocation of the control code shall be as shown in Fig. 4.6. 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.

Messages designated as an extended HBS message shall not be delivered to an individual lower-layer communication interface (they shall be processed as extended HBS messages). Messages designated as an ECHONET message (Version 1.0) shall be delivered to the ECHONET communication middleware via an individual lower-layer communication interface. For detailed requirements for b0, b1, b6, and b7, see under "3.3.11 Control code

(CC)" in the ET-2101 standard.

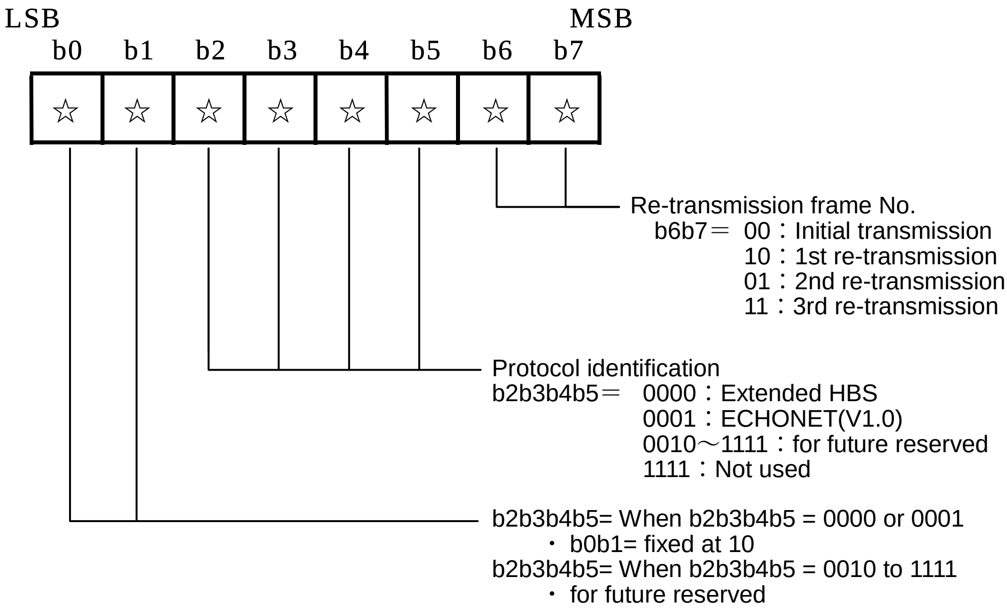


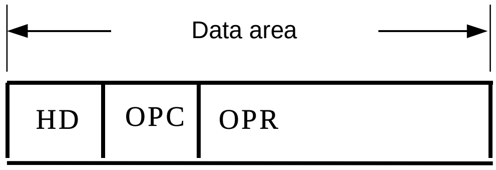

**Fig. 4.6 Control Code Bit Allocation**

### 4.5.4 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.

### 4.5.5 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. 4.7 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. 4.7 Data Area Structure in Extended HBS Specification**

### 4.5.6 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.

### 4.5.7 Dummy code

For the dummy code, one character is assigned as an error check calculation time. During this time, bus idle status is continued without data or 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.

### 4.5.8 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) For 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 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 FCC error and address redundancy detection occur simultaneously, it is indicated that the FCC error notice has priority.

## 4.6 Logical Specifications (Layer 7 Specifications)

Extended HBS does not provide any sub-bus specifications. 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. Extended HBS provides specifications that take into consideration maintenance of lower-layer transmission media as the layer 7 specification. The specifications in this section relate to data contents (see Fig. 4.7) and data sequence in cases where extended HBS has been selected. They consist of the following items:

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

### 4.6.1 Header code (HD)

The header code allocation shall be as shown in Fig. 4.8.

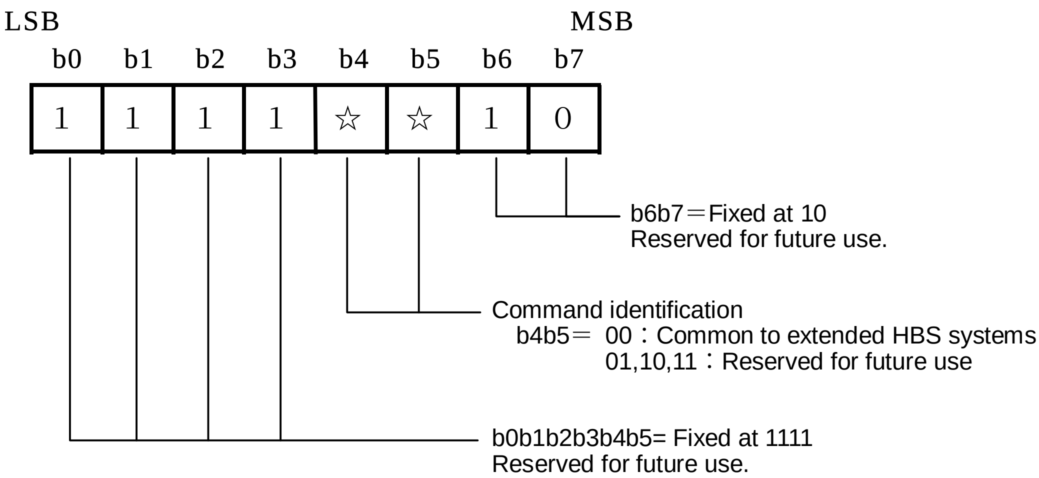



**Fig. 4.8 Header Code Bit Allocation**

### 4.6.2 System common commands

System common commands are defined as those commands 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 process.) |
| Receiving destination, free adoption: | May ignore. |

Table 4.3 shows an OPC code allocation table, and Appendix 4.2 of this section describes detailed specifications for each command, including OPR.

**Table 4.3 OPC Code Allocation Table**

| | 8 | 9 | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|---|
| 0 | Reset | | Startup start | | | | | |
| 1 | | | Startup check | | | | | |
| 2 | | OK | Startup completion | | | | | |
| 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.

### 4.6.3 Communication sequence

Two communication sequences are described:

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. 4.9. 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. 4.9 shall be observed.

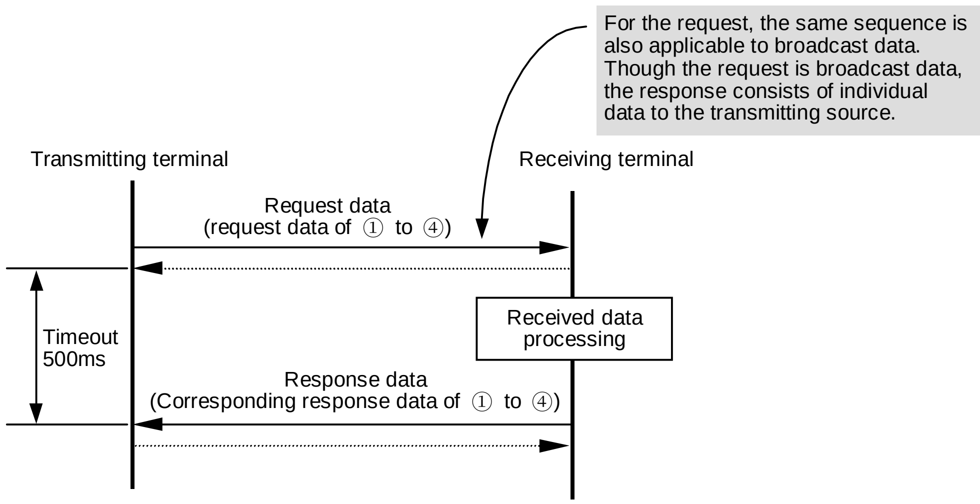



**Fig. 4.9 Basic Communication Sequence**

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

The two commands shown below are used for physical address setting at startup. 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.

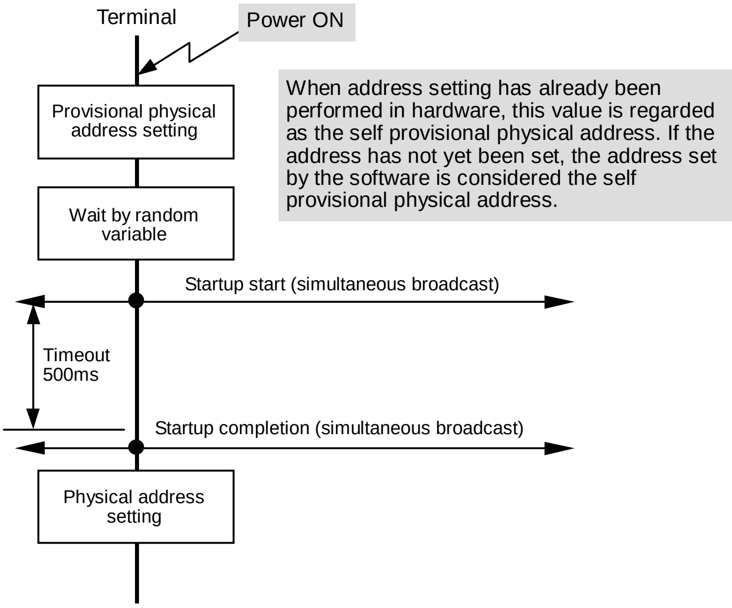
① Startup start (A0)

② Startup check (A1)

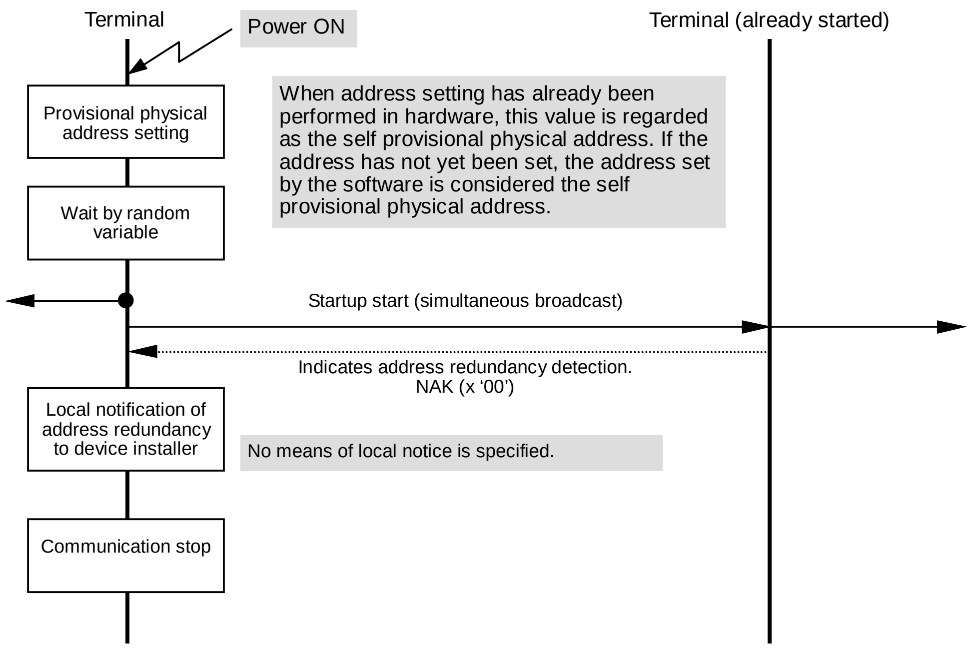
③ Startup completion (A2)

The communication procedures to be performed in various cases are described below:

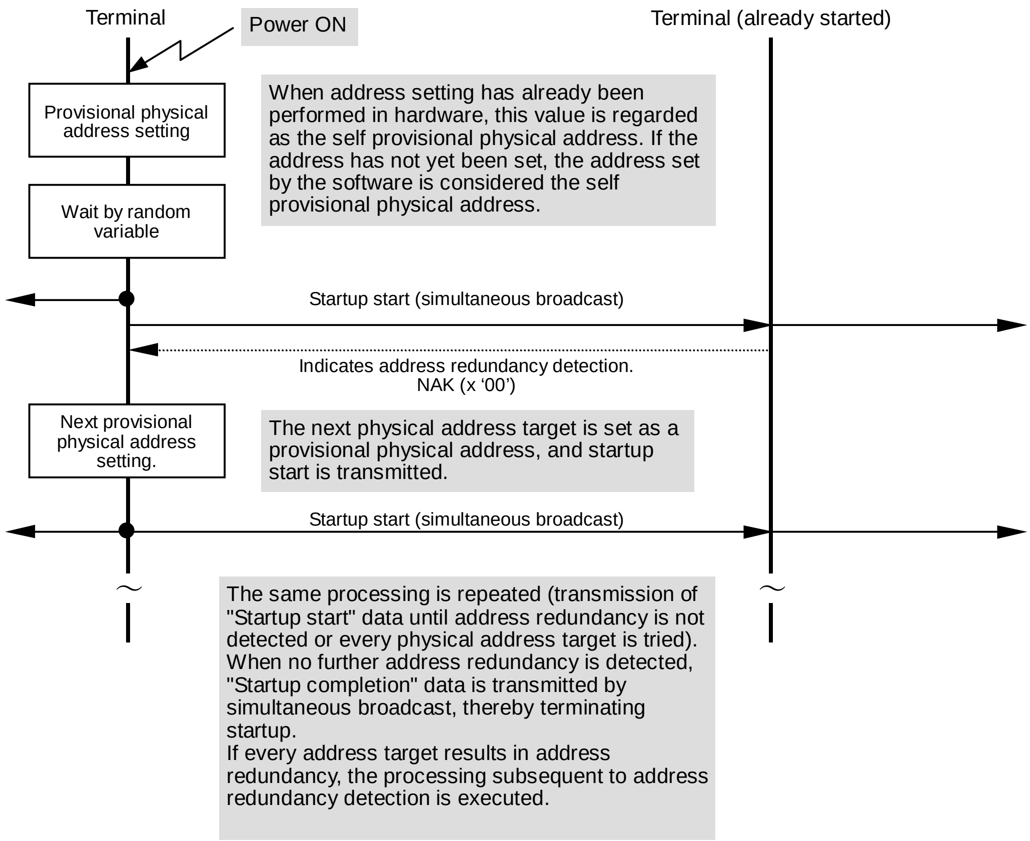
<CASE 1> ① Other terminals do not exist.
② Other terminals exist, but there is no address redundancy.




<CASE 2> ③ Other terminals exist, 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.



## 4.7 Basic Sequence (Software Internal State Transition Specification)

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

This section includes the following:

- State transition diagram
- Sequence descriptions of various states indicated in the state transition diagram

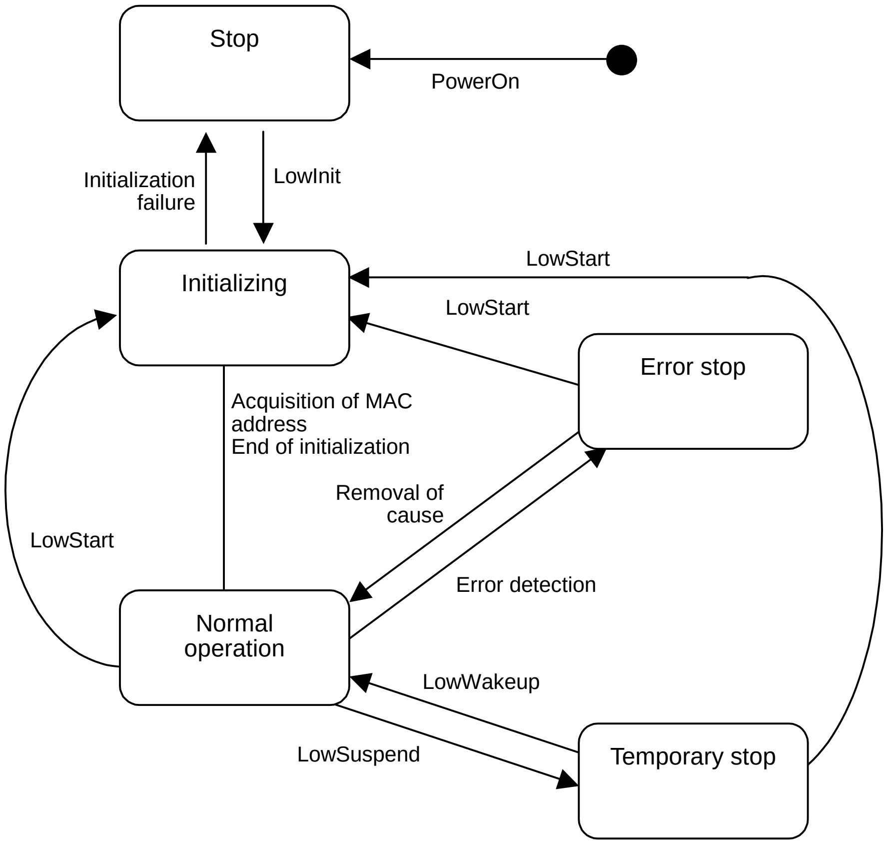
The function names used in Sections 4.7.1 to 4.7.6 correlate to those used in the state transition diagram shown below.

### 4.7.1 Basic concept

This subsection classifies the discrete lower-layer communication software status as shown below, and provides 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.


Stop
PowerOn
Initialization failure
LowInit
Initializing
LowStart
LowStart
Error stop
Acquisition of MAC address
End of initialization
Removal of cause
LowStart
Error detection
Normal operation
LowWakeup
LowSuspend
Temporary stop

### 4.7.2 Stop Status

Stop status signifies a status in which lower-layer communication 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 stop status receives, and related 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, the transition is made to 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.

### 4.7.3 Initialize processing status

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

An outline of processing immediately after state transition and an outline of Individual Lower-layer Communication Interface services that initialize processing status receives, and related 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 "4.6.3 Communication sequence" is executed to obtain 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 initialization completion stop status

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

(4) Transition trigger to stop status

This transition is caused by the initialization failure.

### 4.7.4 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 communication software. An outline of processing immediately after state transition and an outline of the Individual Lower-layer Communication Interface service that normal operation status receives, and related 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 determined at the MAC address level whether or not this data is addressed to the self address. 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 least these three status types shall be distinguished as a return value.

(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 communication software profile object”. This service is not specified as a discrete service for each property but instead is provided in the lower-layer communication 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 or non-synchronization with the “Data transmission service” shall be indicated in the software mounting specification but not specified here. (However, we recommend conformance with 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 received data exists, this data is delivered as a response. If received data does not exist, “No reception” is returned as a response. However, this lower-layer communication software may notify reception through the Individual Lower-layer Communication Interface to deliver the data. This shall be provided in the lower-layer communication 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 the completion of transmit processing, leading to stop status. When data is being received, processing is stopped immediately, leading to suspension status.

(7) Initialization service (LowStart) acquisition processing

When "Initialization service" is called through the Individual Lower-layer Communication Interface and data is being transmitted, processing is stopped after the completion of transmit processing, leading to initialize processing status. When data is being received, processing is stopped immediately, leading to 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 communication software is notified, transition is set to error stop status.

### 4.7.5 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 error stop status and an outline of the Individual Lower-layer Communication Interface services that error stop status receives, and related processing, are described below.

(1) Outline of error stop status

In 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 stop" is returned as the status.

(3) Initialization service (LowStart) acquisition processing

When "Initialization service" is called through the Individual Lower-layer Communication Interface, a response is returned if the processing is possible, leading 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.

### 4.7.6 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 related processing, are described below.

(1) Outline of suspension status

In 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, “Suspend” is returned as the status.

(3) Initialization service (LowStart) acquisition processing

“When “Initialization service” is called through the Individual Lower-layer Communication Interface, a response is returned if processing is possible, leading 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, leading to normal operation status.

## Appendix 4.1 Documents Cited

(1) "EIAJ ET-2101 Home Bus System" published by JEITA

| |
|---|
| JEITA, General Affairs Department (Service Center)<br>TEL: 03-3518-6422 |

(2) "EIAJ ET-2101 Home Bus System (Supplement)" published by JEITA

| |
|---|
| JEITA, General Affairs Department (Service Center)<br>TEL: 03-3518-6422 |

(3) "EIAJ-RC-5202 Information Sockets for Home Bus System" published by JEITA

| |
|---|
| JEITA, General Affairs Department (Service Center)<br>TEL: 03-3518-6422 |

## Appendix 4.2 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 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 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 and transmits the startup start command.

10. Startup completion command
   (1) OPC code: x ‘A2’
   (2) OPR code: MAC address of self (1 byte)
   (3) Other: Command is transmitted when 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 OPR of loop request command
   (3) Other: Response command to loopback request command

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

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

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

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

# Chapter 5 IrDA Control Communications Protocol Specification

## 5.1 System Overview

### 5.1.1 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. 5.1 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.

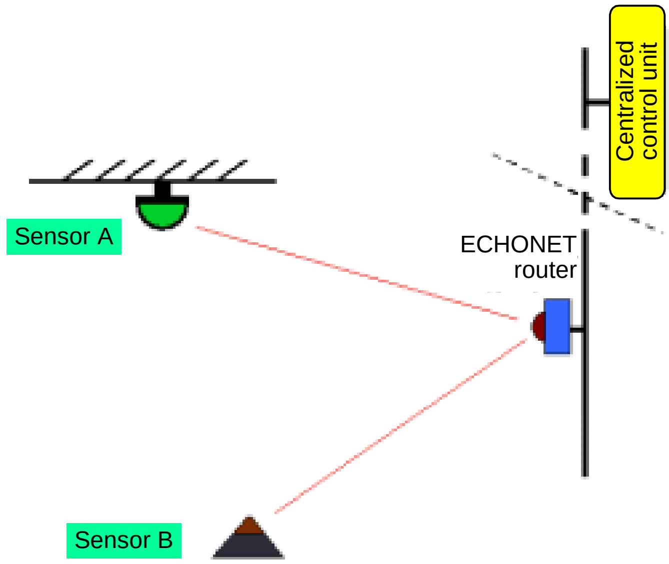



**Fig. 5.1 IrDA Control Application Example**

### 5.1.2 Scope of the specification

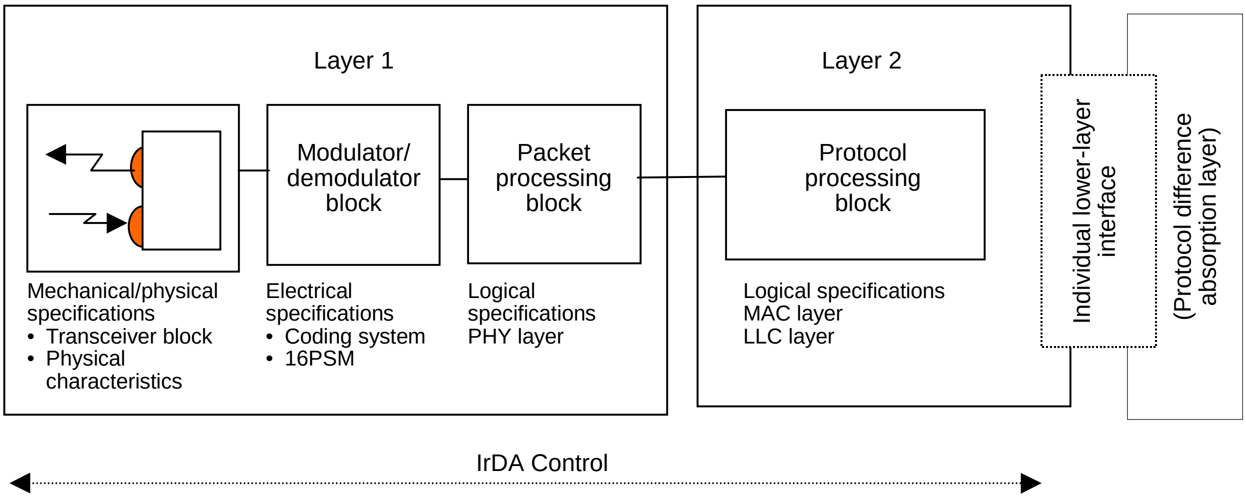



**Fig. 5.2 IrDA Control Positioning in ECHONET**

Fig. 5.2 is a conceptual diagram that illustrates the positioning of IrDA Control 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 the IrDA Control specification.

In addition, solutions to problems (address translation, broadcast processing, etc.) resulting from the accommodation of IrDA Control as an ECHONET transmission medium have been specified. These are described in “5.5 Basic Sequence”, “5.6 Accommodation Specification”, and “Part 7 ECHONET Communication Device Specification, Chapter 6 IrDA Control Router”.

## 5.2 Mechanical/Physical Specifications

### 5.2.1 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 consisting of a 1.5 MHz sub-carrier
- Communication distance: 8 m standard
- Transmission rate: 75 kbps
- Response time: 138 ms standard

For details, see the IrDA Control Specification
(These specifications can be found at
http://www.irda.org/standards/specification.asp.)

### 5.2.2 Topology

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

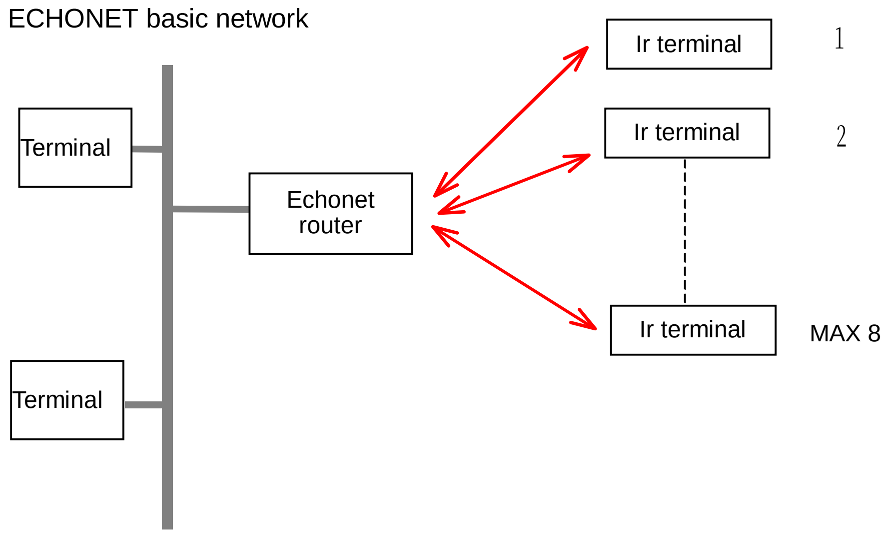



**Fig. 5.3 Subnet Topology Using IrDA Control**

## 5.3 Electrical Specifications

### 5.3.1 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 5.1 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. 5.4.

Example

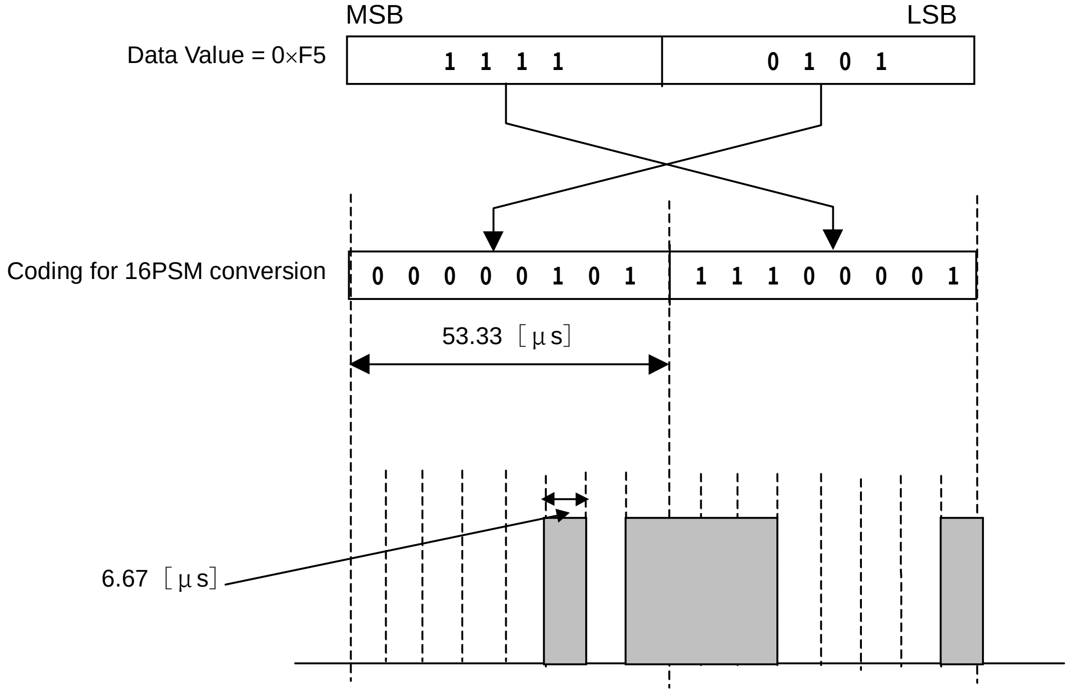



**Fig. 5.4 Coding Example**

For details, refer to the IrDA Control Specification.

# 5.4 Logical Specifications

## 5.4.1 Overall Data Structure Image

The relationship between the IrDA Control data structure and 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 is then transmitted as a PHY layer packet. Details of each layer are described in the following sections.

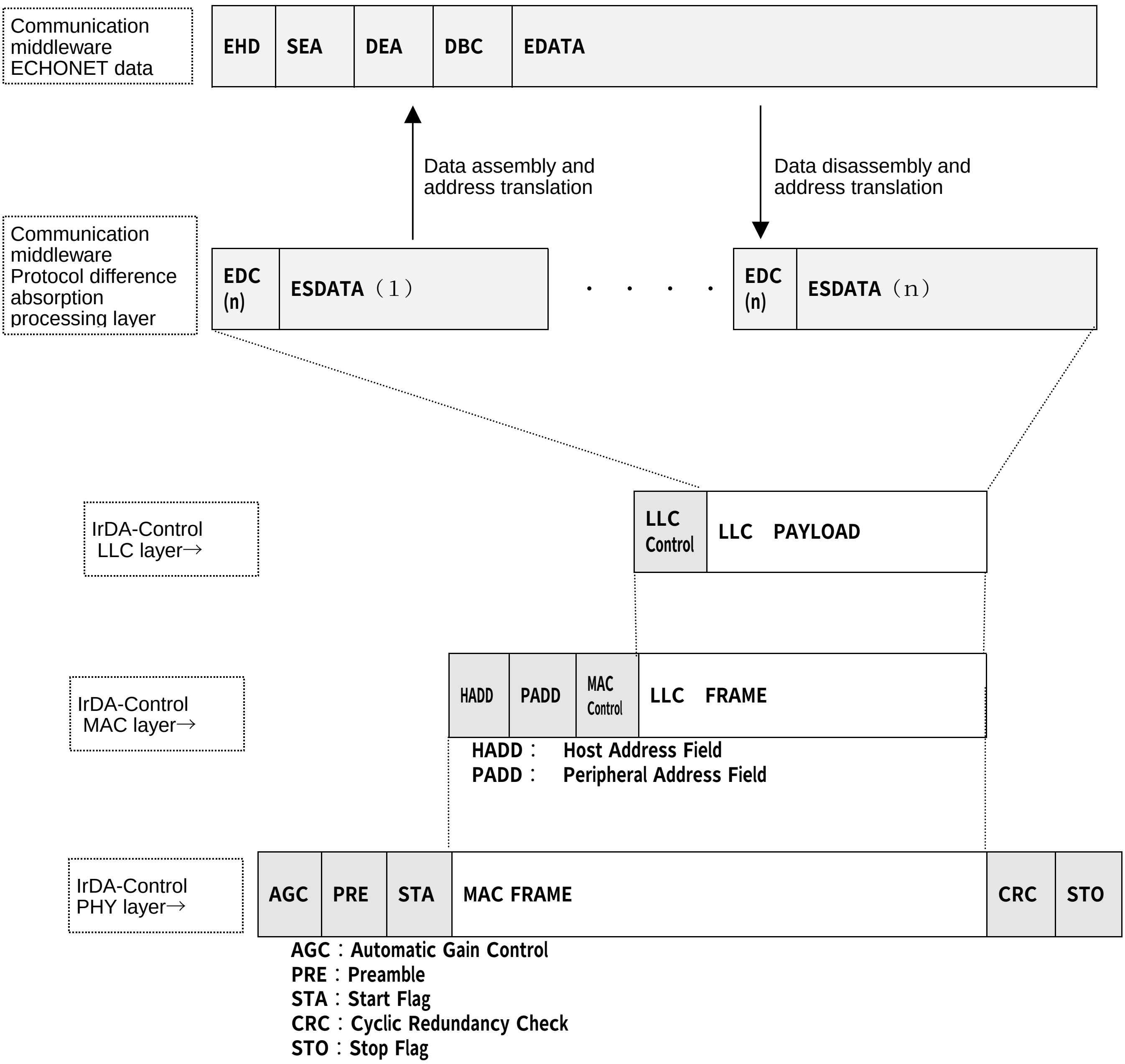



**Fig. 5.5 Relationship Between Layers**

### 5.4.2 Layer 1 (PHY layer)

IrDA Control is divided into two types of packet structure based on the 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. 5.6 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.

### 5.4.3 Layer 2 (MAC layer)

The contents of the MAC frame are as follows.

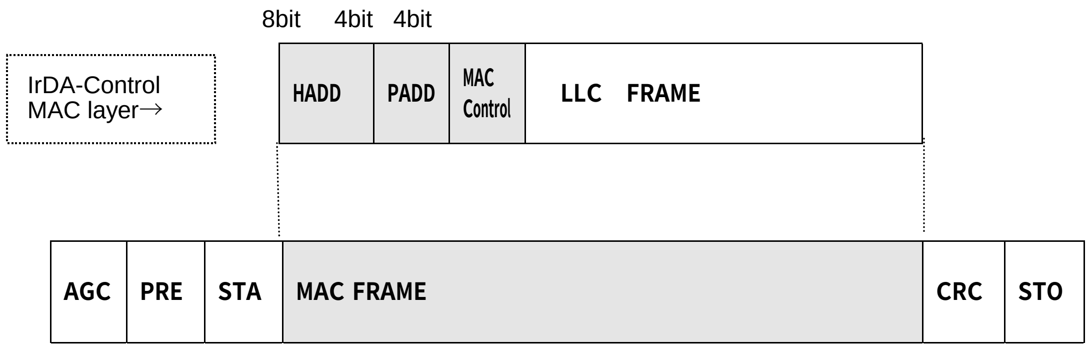



**Fig. 5.7 MAC Frame Structure**

(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 5.2 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 | — | — |

In the above table, "D7" indicates bit 7. This chapter uses "D*" to represent bits in accordance with the conventions of the IrDA standard.

### 5.4.4 Layer 2 (LLC layer)

The contents of the LLC layer are as follows:

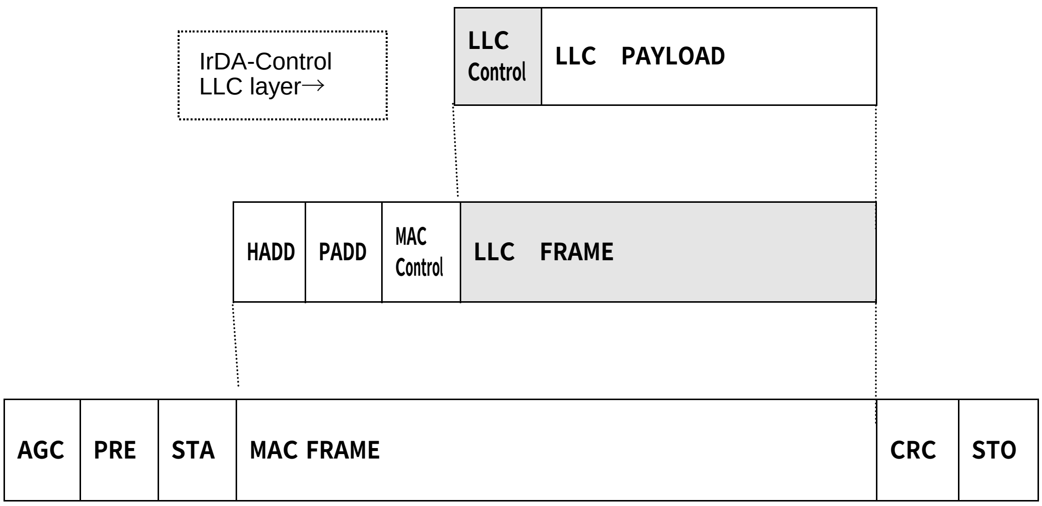



**Fig. 5.8 LLC Frame Structure**

**Table 5.3 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 5.4 shows Pipe types and Table 5.5 shows the relationship between Endpoint values and Pipe types.

**Table 5.4 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 5.5 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 moving from the host toward a peripheral. An “In Packet” is a packet moving from a peripheral toward the host.

### 5.4.5 Packet accommodation

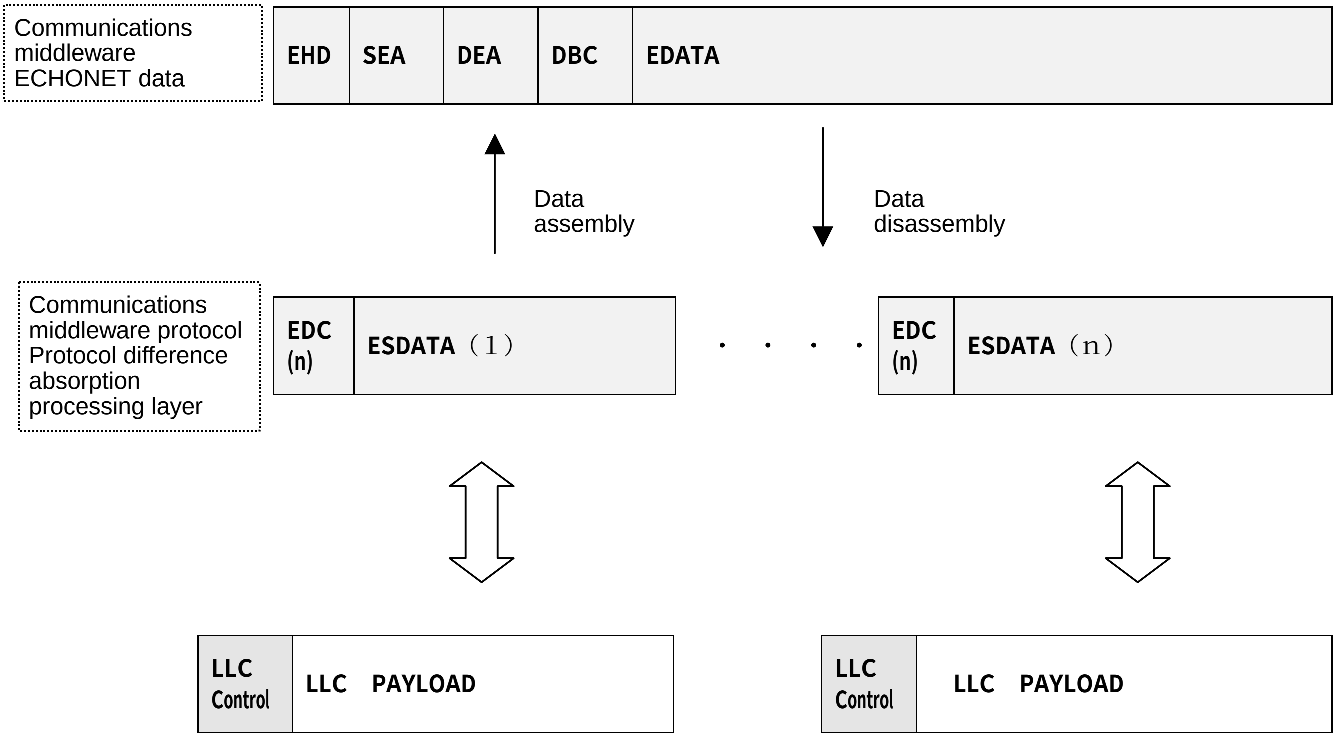



**Fig. 5.9 Relationship Between LLC Payload and ECHONET Data**

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

# 5.5 Basic Sequence

## 5.5.1 Basic concept

In this section, the lower-layer communication software status for IrDA Control protocol is classified as follows, and an outline of the sequence for each status is provided:

① Stop
② Cold start
③ Warm start
④ Communication stop (enumeration completed)
⑤ Normal operation (bind completed)
⑥ Error stop
⑦ Suspension

The following diagram shows the state transition of items ① to ⑦ in the lower-layer communication software for IrDA Control.

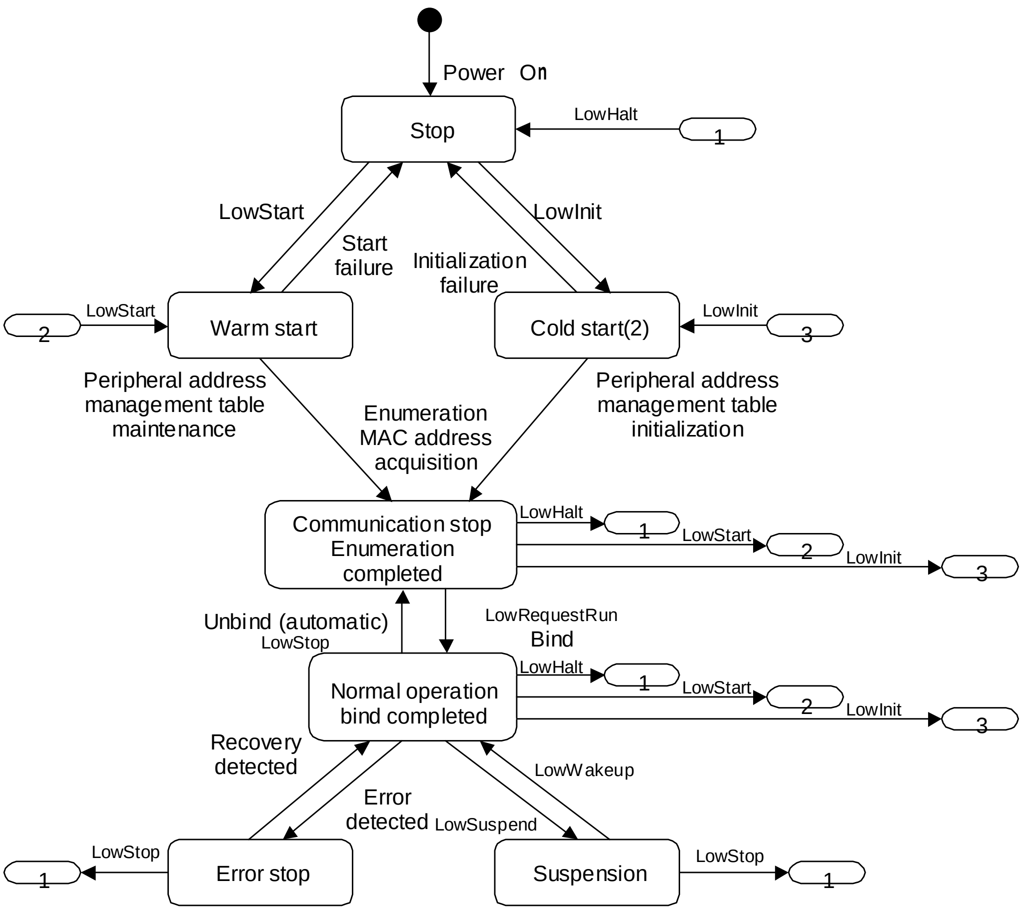



**Fig. 5.10 Sequence Transition Diagram**

### 5.5.2 Stop Status

Stop status signifies a status in which no lower-layer communication 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 stop status receives, and related processing, are described below.

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

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

The triggers for state transition are as follows:

(1) Transition trigger to the cold start
This transition is caused by the initialization request service (LowInit).

(2) Transition trigger to the warm start
This transition is caused by the reset request service (LowStart).

### 5.5.3 Cold start

In the cold start state, the Lower-layer Communications Software is initialized. When the IrDA Control protocol is used, the peripheral address management table is initialized to wait for the following individual lower-layer communication interface services:

(1) Trigger and action

① Initializes the software.

② Initializes the peripheral address management table.

③ Acquires a MAC address.

The host's MAC address shall be the same as HADD. For the peripheral MAC address, after the host-to-peripheral information exchange procedure called "enumeration" is performed, the host uses the obtained information to assign a virtual MAC address (address correlating to NodeID on a 1:1 basis) and writes the virtual MAC address in the peripheral address management table it manages (details provided below).

(2) Status acquisition service (LowGetStatus)

Returns LOW_STS_INIT as the status.

Triggers for state transitions are shown below:

(1) Transition trigger to communication stop status

This transition is caused by the completion of enumeration.

(2) Transition trigger to stop status

This transition is caused by an initialization failure.

**An outline of enumeration is shown below.**

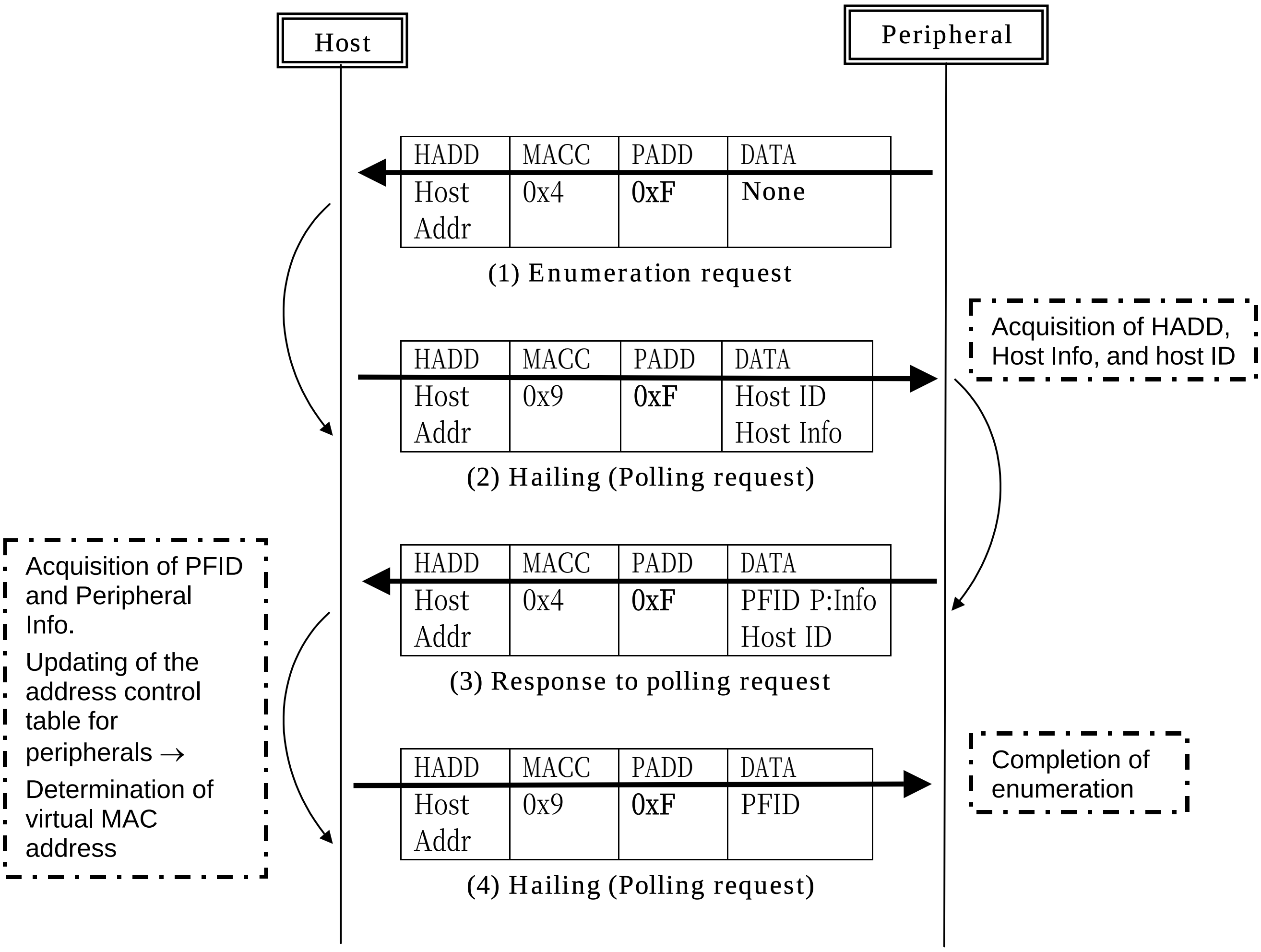



**Fig. 5.11 Enumeration Procedure**

(1) A peripheral makes an enumeration request.
MACC = 0x4 is a polling request command. Here, 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 5.6 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) |
| ・<br>・<br>・<br>・ | ・<br>・<br>・<br>・ | ・<br>・<br>・<br>・ | ・<br>・<br>・<br>・ |
| Peripheral ⑧ | xxxxxx-xxxx-xxxxxxxxxx | 0x08 | For example, (0xA) |
| (Peripheral ⑨)<br>・<br>・<br>・ | 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.

### 5.5.4 Warm start

In the warm start state, the Lower-layer Communications Software is initialized without initializing the peripheral address management table managed by the host, and the following individual lower-layer communication interface services are awaited:

(1) Trigger and action

① Initializes the software.

② Acquires a MAC address.

The host's MAC address shall be the same as HADD. For the MAC address of a peripheral, after the enumeration procedure is performed, the peripheral address management table managed by the host is searched for the peripheral's peripheral ID that was derived from enumeration.

If no matching peripheral is found in the peripheral address management table and the peripheral address management table is not full, the host assigns a new virtual MAC address and updates the peripheral address management table.

If no matching peripheral is found in the peripheral address management table and the peripheral address management table is full, a start failure results and the status changes to stop status.

If any matching peripheral is found in the peripheral address management table, the associated virtual MAC address written in the management table is used as the peripheral's MAC address.

(2) Status acquisition service (LowGetStatus)

Returns LOW_STS_INIT as the status.

Triggers for state transitions are shown below:

(1) Transition trigger to communication stop status

This transition is caused by the completion of enumeration.

(2) Transition trigger to stop status

This transition is caused by an initialization failure or occurs when the maximum management count of the peripheral address management table is exceeded.

### 5.5.5 Communication stop status

In communication stop status, an operation start request from the communication middleware is awaited after the completion of lower-layer communication software initialization. This section outlines the process to be performed upon a state transition, describes the individual lower-layer communication interface services acceptable during communication stop status, and gives an overview of the associated processes.

(1) Trigger and action
Waits for an individual lower-layer communication interface service.
(2) Status acquisition service (LowGetStatus)
Returns LOW_STS_INIT as the status.
(3) Physical address acquisition service (LowGetMacAddress)
Returns HADD for the host or "virtual MAC address" for a peripheral.
(4) Profile data acquisition service (LowGetProData)
Returns profile data.

Triggers for state transitions are shown below:

(1) Transition trigger to the normal operation
This transition is caused by the operation start service (LowRequestRun).
This transition caused by LowRequestRun varies depending on whether it is initiated by the IrDA host or IrDA peripheral. If an IrDA peripheral operation is invoked by LowRequestRun, a bind is performed immediately so that the status changes to normal operation state. If an IrDA host operation is invoked by LowRequestRun, on the other hand, the transition to normal operation state occurs only when a means of communication start from the host is incorporated in compliance with Section 5.6, "Accommodation Specification".
(2) Transition trigger to stop status
This transition is caused by the stop service (LowHalt).
(3) Transition trigger to the cold start
This transition is caused by the initialization request service (LowInit).
(4) Transition trigger to the warm start
This transition is caused by the reset request service (LowStart).

**The bind procedure is shown below.**

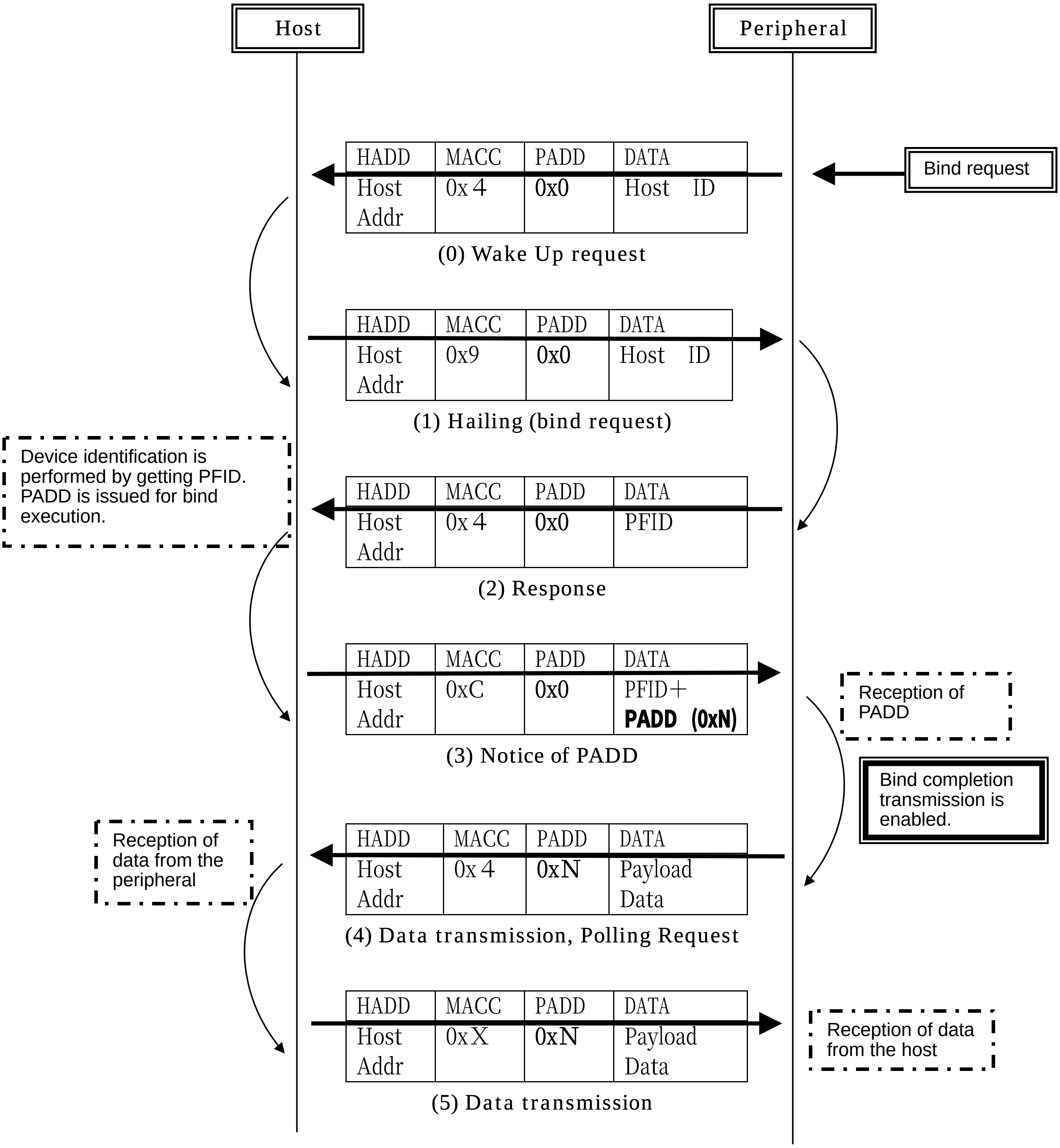



**Fig. 5.12 Bind Procedure**

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

(0) The peripheral transmits a Polling Request to the host.
Here, 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.

### 5.5.6 Operation status

The 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 communication 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 related processing, are described below.

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

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

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

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

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

(6) Data reception service (LowRecvData)
Translates the lower-layer communication software data received from the transmission medium into protocol difference processing block data and outputs it to the Protocol Difference Absorption Processing Block.

Triggers for state transition are as follows:

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

(2) Transition trigger to communication stop status
This transition is caused by the end service (LowStop). Or, an unbind is performed (to undo a bind) after the elapse of a predetermined time in accordance with the IrDA Control protocol to invoke an automatic transition to communication stop status.

(3) Transition trigger to warm start
This transition is caused by the reset request service (LowStart).

(4) Transition trigger to cold start
This transition is caused by the initialization request service (LowInit).

(5) Transition trigger to error stop status
This transition occurs when a lower-layer communication medium detects an error.

(6) Transition trigger to suspension status
This transition is caused by the lower-layer communication unit stop service (LowSuspend).

### 5.5.7 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 initialization completion stop status receives, and related processing, are described below.

(1) Trigger and action
Performs error processing.

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

Triggers for state transition are as follows:
(1) Transition trigger to stop status
This transition is caused by the end service (LowHalt).

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

### 5.5.8 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 related processing, are described below.

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

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

Triggers for state transition are as follows:

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

(2) Transition trigger to stop status
This transition is caused by the end service (LowHalt).

## 5.6 Accommodation Specification

### 5.6.1 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.

### 5.6.2 Handling of individually specified messages within a subnet

When an IrDA Control communication medium is used, individually specified messages within a subnet are discarded by the "received message judgment process", which is described in Part 2, Chapter 6, "ECHONET Communications Processing Block Processing Specifications".

Therefore, when IrDA Control is used, the above problem shall be corrected by furnishing an appropriate bridge processing block between the "message reception/assembly process" and "message division/transmission process" of the preceding "Protocol Difference Absorption Processing Block".

Before the release of Version 2.10, the above problem was avoided according to the stipulations set forth in Part 7, "ECHONET Communications Equipment Specification", Chapter 6, "IrDA Control Router". After the release of Version 2.10, however, the use of a bridge process in the above "Protocol Difference Absorption Processing Block" is permitted.

### 5.6.3 Recommended conditions for host and peripherals

The IrDA Control standard does not permit the host to start communicating with peripherals that are completely initialized and stopped (not bound or unbound upon a bind timer timeout).

The ECHONET standard recommends that a means for bind maintenance be implemented by incorporating a means of starting communications from the host, a means of issuing a host's request for the start of communications to a peripheral, or a function for transmitting a WakeUp request at regular intervals between the unbound host and peripherals.

However, this recommendation is void if the host does not need to start communications when, for instance, bidirectional remote control is used for peripherals.

### 5.6.4 Mandatory conditions for host and peripherals

It is imperative that a function for retaining a controller's request in the host's receive buffer for a predetermined period of time be implemented in situations where the host cannot communicate with a peripheral in response to a request message from another subnet controller, etc.

Detailed stipulation are provided in Part 7, "ECHONET Communications Equipment Specification", Chapter 6, "IrDA Control Router".

# Chapter 6 LonTalk® Communication Protocol Specification

## 6.1 System Overview

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

Fig. 6.1 shows a typical node configuration formed with a Neuron® chip. Since protocol processing does not depend on transmission media, a wide variety of transmission media are supported, as indicated below.

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

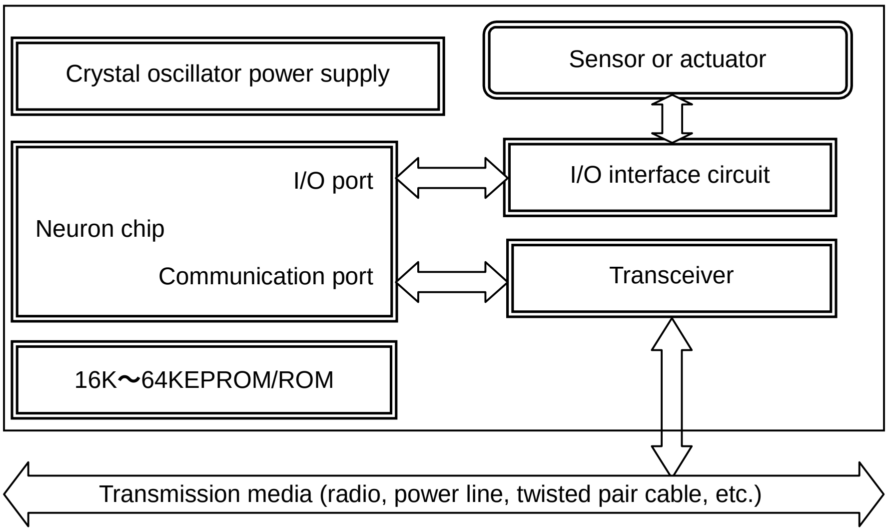



**Fig. 6.1 Typical Node Configuration with Neuron Chip**

Basically, use of the Neuron® Chip permits free design of an individual transceiver, taking into consideration 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 need special protocol processing because of legal requirements; the designer need only 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 communication software to support the layers subsequent to the individual lower-layer communications interface and also as the equivalent to layers 2 and 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. Explicit messages are used for communications. Versions 1.0, 2.0, 2.1 and 2.11 do not specify the use of network variables.

### 6.1.1 Organization of Chapter 6

Sections 6.1 to 6.5 summarize the specifications related to LonTalk® in ECHONET.

6.1 System Overview
6.2 Mechanical/Physical Characteristics
6.3 Electrical Characteristics
6.4 Logical Specifications
6.5 Basic Sequence

Sections 6.6 and after summarize the transceiver specifications. The item numbers in each section correspond to the section numbers in Section 6.1 to 6.5. (X >= 6)

6.X.1 System overview
6.X.2 Mechanical/physical characteristics
6.X.3 Electrical characteristics
6.X.4 Logical specifications
6.X.5 Basic sequence

Additional specifications are provided in Sections 6.X.6 and after.

## 6.2 Mechanical/Physical Specifications

Nodes must use devices that can implement the LonTalk® protocol and must be based on the Neuron® chip. Legal requirements or other standards related to the mechanical/physical characteristics and specifications of cabinet, connector shape, cable, antenna, etc., are to be adhered to. The following specifications shall be provided as the ECHONET Standard for each transmission medium as required. Details are provided in 6.X.2 after Section 6.6.

- Connector shape
- Transmission media
- Topology

## 6.3 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. Legal requirements or other standards related to electrical characteristics and specifications are to be adhered to. The following specifications shall be provided as the ECHONET Standard for each transmission medium, as required. Details are provided in 6.X.3 after Section 6.6.

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

## 6.4 Logical Specifications

Layer 1 processing is performed by the transceiver, and layer 2 and 3 processing is performed by the Neuron® Chip. The Neuron® Chip 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.

### 6.4.1 Layer 1

In the transceiver, the PPDU (Physical Protocol Data Unit) of LonTalk® is treated as the data portion of the communication format specified for each transmission medium. Basically, frames are converted into a data format such as that shown in Fig. 6.2 for communication. The header or footer is a general term for the preamble, address data, control code, etc. native to and specified for each transmission medium. Details are provided in 6.6.4 after Section 6.6. Processing native to the transmission media is described in and after 6.6.5.

Upon a request to send from the Neuron® Chip or at the start of transmission, carrier sense and transmission timing adjustment (serving as transmission media protocol processing) are performed, and the transmission media modulate the transmission media communication basic data to perform communication. 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 Neuron® Chip. When the transceiver must stop new data transmission from the Neuron® Chip during header/footer processing, it notifies the Neuron® Chip of its BUSY status. When the transmission of new data is permitted, it clears BUSY and notifies READY.

| | | |
|---|---|---|
| Header | Data (LonTalk®PPDU) | Footer |

**Fig. 6.2 Transmission Media Communication Basic Data Format**

### 6.4.2 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. 6.3 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, 2.0, 2.1, 2.11)
  11: Encl.PDU = APDU
  AddFmt: 2bit Specifies format of address data.
  Len: Specifies length of address data.
  Address: Neuron® Chip address data 24 bits min. or 72 bits max.
  Domain: 0bit Neuron® Chip domain: 0 (Not specified in Ver 1.0, 2.0, 2.1, 2.11)

Addressing method (in Neuron® Chip)

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

Address length (in Neuron® Chip)

- Domain: 0
- SUBNET: 8bit
- Node: 8bit (1 to 127: Effective set value is 1 to 126.)
- Group: 8bit

The message code and address type are stipulated as follows:
Address length for subnet: 8 bits (ID: fixed at 0x01)

| Outgoing message | Message code | Address type |
|---|---|---|
| ECHONET frame | 0x04 | BROADCAST |
| | | SUBNET_NODE |

### 6.4.3 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 entire ECHONET data is placed in the DATA area of the APDU. When the Protocol Difference Absorption Processing layer divides the data, EDC(n) + (ESDATA)(n) is placed in the DATA area. Here, data processing takes place n times. However, this is independent of the data content and format.

The data size that can be handled by layer 3 varies depending on how the software is installed. Individual lower-layer communication interfaces notify the higher layer of the maximum buffer size in advance. The send buffer shall have a minimum value of 34 bytes, since the maximum value for an ECHONET message is 262 bytes and the maximum message division value is 8. Further, since the maximum data value that can be handled by a Neuron® chip is 228 bytes, the higher layer will be informed of a maximum processable data length of 228 bytes even when a 229-byte or larger send buffer is available. A 228-byte or larger receive buffer (255-byte) shall be furnished.

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

**Fig. 6.4 Layer 3 Data Format (1)**

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

**Fig. 6.5 Layer 3 Data Format (2)**

## 6.5 Basic Sequence

This section describes the following items:

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

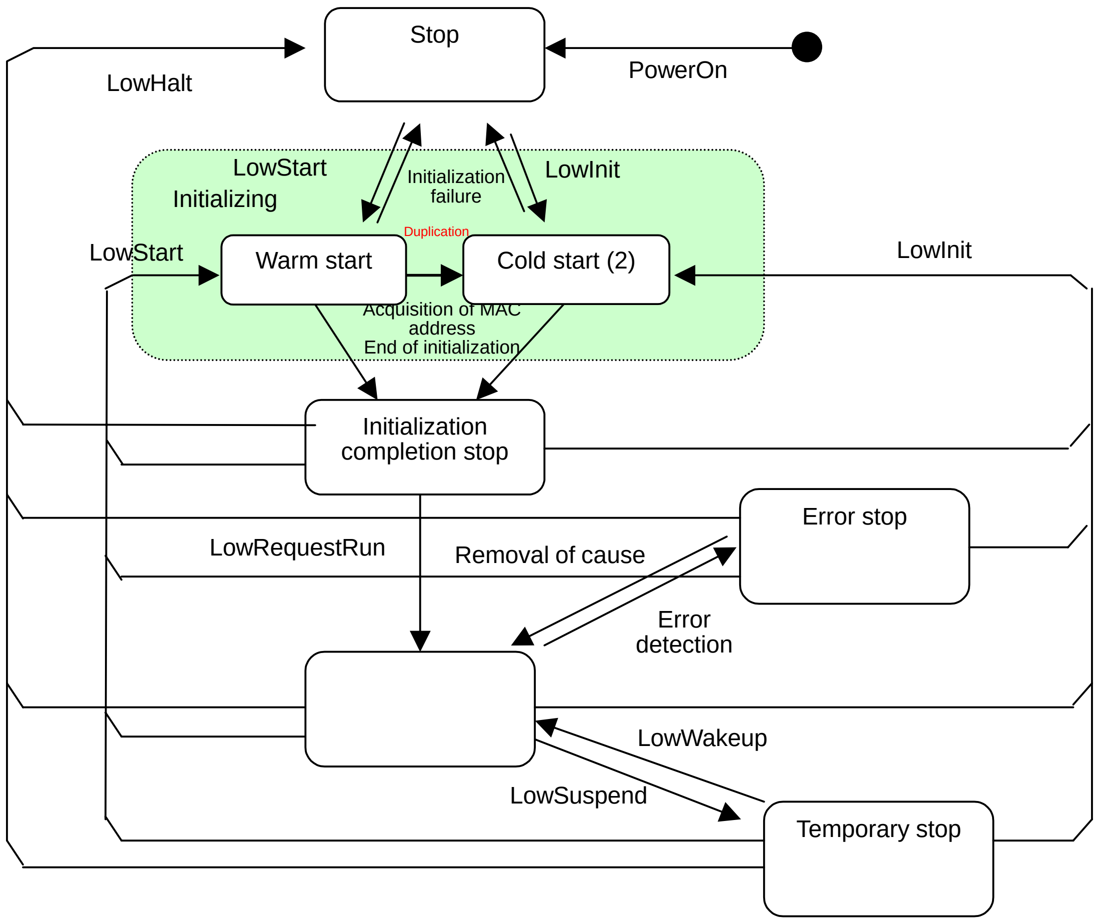
### 6.5.1 Basic concept

This subsection outlines the sequence in each state by classifying the LonTalk® Individual lower-layer communication software status as follows:

① Stop status
② Initialization processing status
③ Initialization completion stop status
④ Normal operation status
⑤ Error stop status
⑥ Suspension status

The diagram below illustrates the state transition for each status.

The transceiver state transition includes a portion operating in non-synchronization with the Neuron® Chip, and is therefore described for each transceiver in 6.X.5 after Section 6.6.


Stop
PowerOn
LowHalt
LowStart
Initializing
Initialization failure
LowInit
Duplication
LowStart
Warm start
Cold start (2)
LowInit
Acquisition of MAC address
End of initialization
Initialization completion stop
Error stop
LowRequestRun
Removal of cause
Error detection
LowWakeup
LowSuspend
Temporary stop

### 6.5.2 Stop Status

Stop status signifies a status in which no lower-layer communication software operations are performed. This status is established immediately after Power On. An outline of processing immediately after state transition and an outline of individual lower-layer communications interface services that stop status receives, and related 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_HALT (stop status) as the status.

(3) Lower layer communication software type acquisition service (LowGetDevID)
Returns the lower layer communication software type.

Triggers for state transition are as follows:
(1) Transition trigger to initialize processing state
This transition is caused by the initialization service (LowStart, LowInit).

### 6.5.3 Initialize processing status

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

(1) Trigger and action
LowStart and LowInit are indicated by the Communication Middleware.
① Initializes the transceiver.
Transceiver initialization is performed in non-synchronization with the Neuron® Chip.
The Neuron® Chip is notified of a BUSY condition and initialization is effected.
When initialization is completed, READY is notified to the Neuron® Chip.

② Obtains a unique MAC address in the SUBNET.

The Node-ID of the Neuron® Chip is converted into 8 bits, and the converted data with an MSB of “0” is notified as the MAC address.

In the warm start mode, acquisition starts with the retained MAC address used. In the cold start mode, the retained MAC address is discarded to obtain a new MAC address. No group ID operation is performed.

③ Obtains a house code.

Media that support house codes are not supported in Ver 1.0, 2.0, 2.1 or 2.11.

(2) Status acquisition service

In a cold start, returns LOW_STS_INIT as the status. In a warm start, returns LOW_STS_RST.

(3) Lower layer communication software type acquisition service (LowGetDevID)

Returns the lower layer communication software type.

Triggers for state transition are as follows:

(1) Transition trigger to initialization completion stop status

This transition is caused by initializing the transceiver, obtaining a MAC address, and obtaining a radio system identification code.

(2) Transition trigger to stop status

This transition is caused by a MAC address acquisition failure or other error.

### 6.5.4 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 communication software is initialized. An outline of processing immediately after state transition and an outline of individual lower-layer communications interface services that initialization completion stop status receives, and related processing, are described below.

(1) Trigger and action

Waits for individual lower-layer communications interface service.

(2) Status acquisition service (LowGetStatus)

Returns LOW_STS_INITSTOP (initialization completion stop status) as the status.

(3) Physical address acquisition service (LowGetMacAddress)

Returns a MAC address.

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

(5) Lower layer communication software type acquisition service (LowGetDevID)
Returns the lower layer communication software type.

Triggers for state transition are as follows:

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

(2) Transition trigger to initialize processing
This transition is caused by the initialization service (LowStart, LowInit).

### 6.5.5 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 communication software. An outline of processing immediately after state transition and an outline of individual lower-layer communications interface services that normal operation status receives, and related 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 (operation state) as the status.

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

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

(5) Data transmission service (LowSendData)
Translates the received Protocol Difference Absorption Processing Block data into lower-layer communication software data and outputs it to the transmission medium.

An outline of the transmission sequence is provided below.

- Checks the transceiver READY status and outputs a signal.
- Subsequently implements processing according to LonTalk®.
  The sequence between the MAC layer and transceivers differs with the transmission medium.

- The transceiver checks that the transmission request signal of the Neuron® Chip has been cleared and completes the output.
  The BUSY signal is cleared.

(7) Data reception service (LowRecvData)
Translates the lower-layer communication 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 Neuron® Chip.
- Of the received data, only PPDU is transferred to the Neuron® Chip. After completion of reception on the transceiver side, the collision detection signal and the BUSY signal are cleared. After that, processing is implemented according to LonTalk®.
- The received lower-layer communication software data is translated into Protocol Difference Absorption Processing Block data, and the translated data is output to the Protocol Difference Absorption Processing Block.

(8) Lower layer communication software type acquisition service (LowGetDevID)
Returns the lower layer communication software type.

Triggers for state transition are as follows:

(1) Transition trigger to stop status
This transition is caused by the end service (LowHalt).

(2) Transition trigger to suspension status
This transition is caused by the lower-layer communication block stop service (LowSuspend).

(3) Transition trigger to initialize processing status
This transition is caused by the initialization service (LowStart, LowInit).

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

### 6.5.6 Error stop status

Error stop status signifies a status in which 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 error stop status receives, and related processing, are described below.

(1) Trigger and action

This transition is caused by the occurrence of an error. Performs error processing.

(2) Status acquisition service (LowGetStatus)

Returns LOW_STS_SUSPEND_ERROR (error stop status) as the status.

(3) Lower layer communication software type acquisition service (LowGetDevID)

Returns the lower layer communication software type.

Triggers for state transition are as follows:

(1) Transition trigger to stop status

This transition is caused by the end service (LowHalt).

When a message is received, it is discarded. For transmission, the request for message transmission is rejected, and an error is returned to stop the operation.

(2) Transition trigger to initialize processing status

This transition is caused by the initialization service (LowStart, LonInit).

(3) Transition trigger to normal operation status

This transition is caused by removing the cause of the error.

### 6.5.7 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 related processing, are described below.

(1) Trigger and action
This transition is caused by the lower-layer communication unit stop service (LowSuspend).
Stops operation of lower-layer communication software.

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

(3) Lower layer communication software type acquisition service (LowGetDevID)
Returns the lower layer communication software type.

Triggers for state transition are as follows:

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

(2) Transition trigger to stop status
This transition is caused by the end service (LowHalt).

(3) Transition trigger to initialize processing status
This transition is caused by the initialization service (LowStart, LonInit).

### 6.5.8 (Neuron® Chip)Node-ID setting sequence

Node-ID in Section 6.5.8 denotes the Node-ID in the Neuron® Chip and corresponds to the MAC address specified in ECHONET. This Node-ID is uniquely associated with the Node-ID of ECHONET 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 (Neuron® Chip)Node-ID in the SUBNET. The Master (Neuron® Chip)Node-ID shall be 0x7E. (Neuron® Chip)Node-ID = 0x7F is specified as Node-ID undefined status, and others are assigned uniquely to Slaves in the SUBNET. Master/Slave operations are the same in relationships with portions higher than the Protocol Difference Absorption Processing layer. However, the distinction between both is specified as required for communication processing after the transceiver.

Two methods of (Neuron® Chip)Node-ID setting are specified:

1. Setting by the DIP-sw:
   - Set any optional value between 0x01 to 0x7D uniquely in the SUBNET using I/O ports.

2. Automatic setting by communication port
   1) The Slave issues a service message when its own (Neuron® Chip)Node-ID is undefined.
   2) Upon receiving the service message, the Master refers to its own domain table and sends free address data to the Slave that issued the service pin message. Here, NEURON_ID is specified as the slave address (MAC address notification message).
   3) Upon receiving the address data, the Slave rewrites its own domain table and sets its own (Neuron® Chip)Node-ID.
      If, in this instance, no notification is sent from the Master within 10 seconds after process 1) or an illegal message format is encountered in 2), the subsequent operations are canceled.
   4) The slave sends a confirmation signal to the master with SUBNET_NODE specified (MAC address confirmation message).
   5) In response to the confirmation signal, the master transmits an ACK message. If no notification is sent from the slave within 10 seconds after process 2) or an illegal message format is encountered in 4), the subsequent operations are canceled.
   6) The slave receives ACK. The entire (Neuron® Chip) Node-ID acquisition sequence is now completed. If no notification is sent from the master within 10 seconds after process 4) or an illegal message format is encountered in 5), an abnormal end occurs.
   - If NO_ID is received from a transceiver when ID acquisition is completed, it is concluded that the node has moved from one subnet to another. The current

(Neuron® Chip) Node-ID is then invalidated to start a (Neuron® Chip) Node-ID acquisition process.

The range of addresses that can be registered with a DIP switch, etc. is differentiated from the range of automatically selectable addresses.

Specifications for message codes, confirmation signals, and ACK values are as follows:

| Outgoing message | Message code | Address type | APDU (data) | |
|---|---|---|---|---|
| Service pin message | 0x7F | BROADCAST | - | |
| MAC address notification message | 0x01 | NEURON_ID specified | 0x01 | MAC |
| MAC address confirmation message | 0x02 | SUBNET_NODE | 0x02 | MAC |
| ACK message | 0x03 | SUBNET_NODE | 0x03 | |

## 6.6 RCR STD-16 Transceiver Specifications

The transceiver is specified for cases in which the specific low-power radio (hereafter referred to as ARIB STD-T67) to which ARIB Standard ARIB STD-T67 is applied is used as a transmission medium.

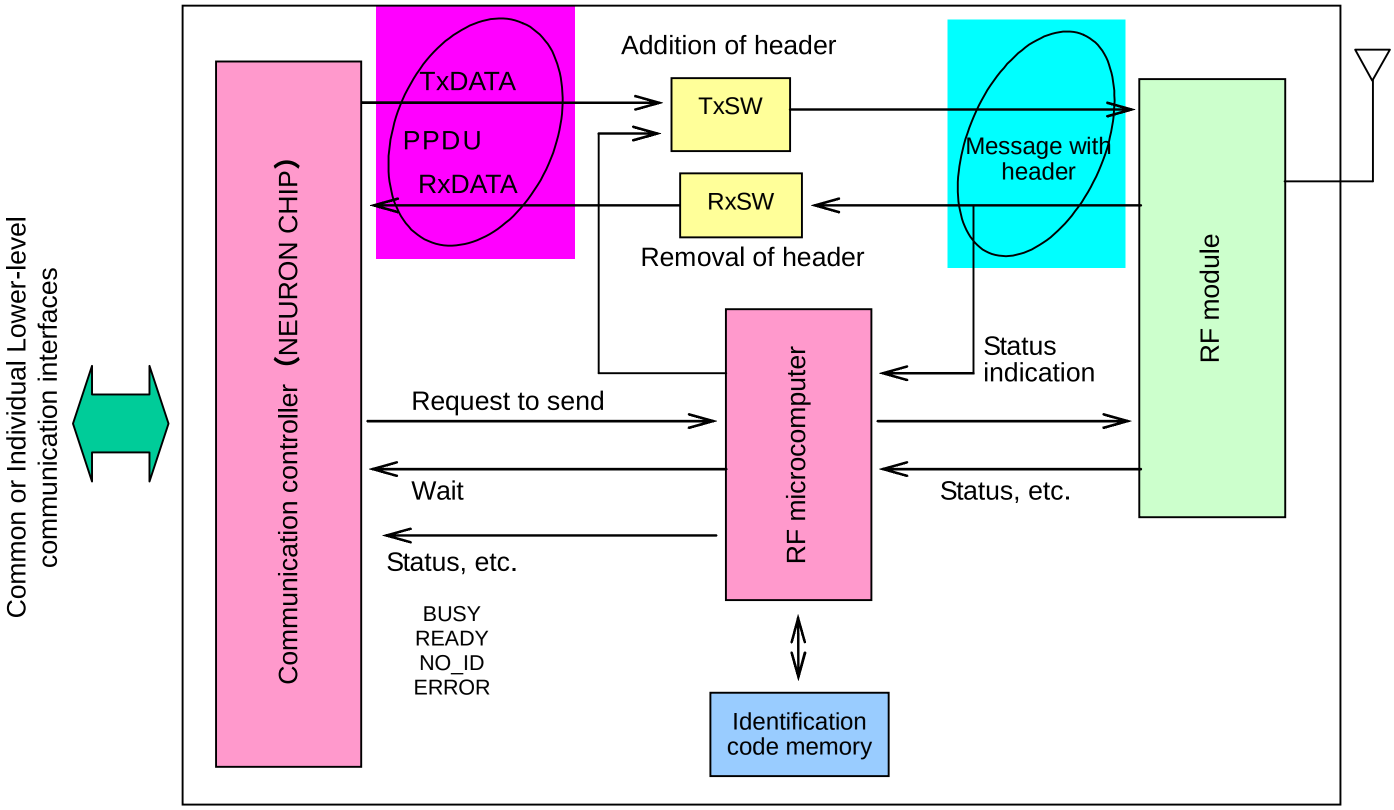
ARIB STD-T67: Radio equipment for telemetering and telecontrol in a specific low-power radio station.

### 6.6.1 System Overview

In order to perform transmit/receive processing to satisfy the ARIB STD-T67, 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 the Neuron® chip and RF module, TxSW for transmission and RxSW for reception for switching messages with a header to be transmitted or received between the PPDU and RF module, auxiliary memory to store necessary control information, and identification codes as indicated in Fig. 6.5.

The RF microcomputer, TxSW, and RxSW described above need not always be microcomputers and switches; they may simply be the corresponding function blocks.




ECHONET does not provide detailed configurations for these.

**Fig. 6.5 Transceiver Configuration**

### 6.6.2 Mechanical/physical specifications

- Connector shape: Antenna type and shape and connector shape are not specified. However, the requirements of ARIB STD-T67 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 6.2 are configured. For channel use, the channel switching system described in Section 6.6.6 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 also be provided.

### 6.6.3 Electrical characteristics

- Electrical characteristics of media: ARIB STD-T67 shall be adhered to.
- Transmission rate: Differential Manchester 2400 bps
- Modulation system (transmission system): Binary FSK (F1D) NRZ
  Further, the frequency shift shall be 2.1 kHz±0.4 kHz.
- Transmitting/receiving sensitivity (level): ARIB STD-T67 shall be adhered to. Further, the code reference sensitivity shall be not higher than 1.4 μV.
- Channel pairs 0 and 1 (channels 7, 26, 27, and 46) shall be used for group ID registration.
- 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 6.2 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 | |

### 6.6.4 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 | | | | | | | LonTalk® PPDU |
|---|---|---|---|---|---|---|---|
| 1st header | | | 2nd header | | | | |
| Bit synchroniza-tion | Frame synchroniza-tion 1 | Identification code | Bit synchroniza-tion | Frame synchroniza-tion 2 | Group ID | Command | |

**Fig. 6.6 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 once. (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.

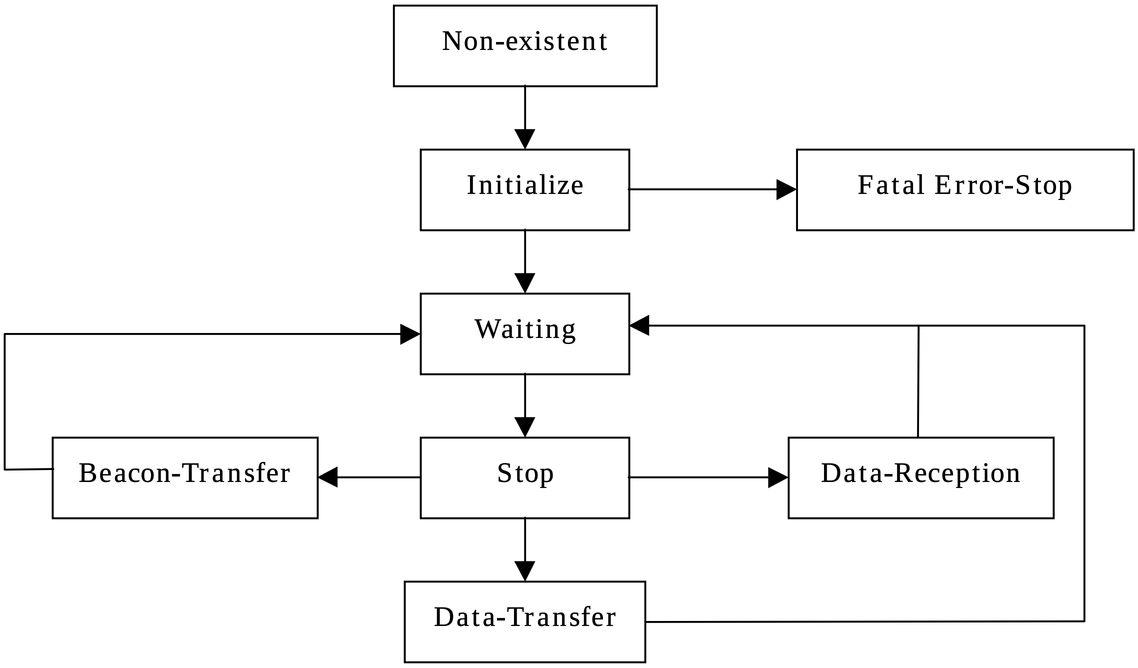
  Frame synchronization 1 signal: “00011011101010000100101100111110”

  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.

| | |
|---|---|
| Group ID registration (GIDCMD=”0010000”) | : Indicates a group ID transmission from the master. |
| Group ID registration response (SIDCMD=”0100000”) | : Indicates a response concerning group ID registration. |
| Transmission test (TSTCMD=”0110000”) | : Indicates an inter-node transmission test. |
| Reference signal (MCACMD=”1000000”) | : Indicates that the outgoing data is a reference signal. |
| LonTalk (LONCMD=”1010000”) | : Indicates that a LON message follows a command. |
| All other items shall be reserved for future use. | |

- 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
- Neuron® chip PPDU LonTalk® message.
- If the command main body is other than LONCMD, the layer 1 message consists of a header only.

### 6.6.5 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 (RF header and LONTALK® PPDU). |
| Fatal Error-Stopping: | Stop at address redundancy detection, stop upon error occurrence, etc. |

### 6.6.6 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 the free channel. When both channels are free, the reference signal is output by chA.

If neither channel is 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.
- The beacon cycle shall not exceed 1 minute.
- The channel shall sequentially change from pair group 1 channel pairs 0 through 8 to pair group 2 channel pairs 0 through 8. This channel transition cycle shall be repeated.

### 6.6.7 Group ID registration

The ARIB STD-T67 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 node (generally a router) in the SUBNET shall be specified as the Master, and the Master node identification code used as a group ID. The other nodes shall be Slaves, with group ID registration 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 using the following format:

| First header | Second header | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Bit synchroni-zation | Frame synchroni-zation | Group ID (master identification code) | ID registration command | | | | | |
| | | | | 1 | GIDCMD | b23~b20 | b19~b16 | BCH | P |

- The slave stores the received group ID into its own memory and responds to the Master according to the following format:
- If the transmission from the Master cannot be confirmed within 12 seconds, the group registration mode is terminated and the operation is stopped.

| First header | Second header | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Bit synchroni-zation | Frame synchroni-zation | Group ID (master identification code) | ID registration response command (Slave) | | | | | |
| | | | | 1 | SIDCMD | b23~b20 | b19~b16 | BCH | P |

- After confirming the response from the slave, the master uses the following format to notify the slave of registration completion and exits the group ID registration mode. However, if the slave does not respond within 10 seconds after ID registration command transmission or if the slave's response contains a mismatched group ID, the master re-attempts the ID registration process. If the response cannot be confirmed after a maximum of four retries (i.e., five attempts including the first one), the master exits the group ID registration mode and returns to normal operation state.

| First header | Second header | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Bit synchroni-zation | Frame synchroni-zation | Group ID (master identification code) | ID registration response command (Master) | | | | | |
| | | | | 1 | SIDCMD | b23~b20 | b19~b16 | BCH | P |

- After issuing a response, the slave confirms the ID registration response command from the master and then exits group ID registration mode. Subsequently, the slave notifies the Neuron® chip of group registration completion and issues a request for (Neuron® chip) Node-ID setup. (Neuron® chip) Node-ID setup is performed with the normal channel pair.

### 6.6.8 (Neuron® Chip) Node-ID setting

The (Neuron® Chip) Node-ID corresponds to the Mac address specified in ECHONET. After group ID registration, (Neuron® Chip) Node-ID setting is performed. See Section 6.5.8.

### 6.6.9 Transmission system

- For a send request (transmission enable) or reference signal from the Neuron® Chip, or upon occurrence of a test signal transmission request event, a collision detection signal and BUSY signal are output to the Neuron® Chip.
- After completion of a procedure such as carrier sense, the RF circuit is switched over to transmission mode and the 1st and 2nd headers are output to the RF via a free channel. In cases other than LONCMD, the RF circuit is switched 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 Neuron® Chip 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 Neuron® Chip attempts re-transmission in the randomized pause time.
- After completion of the RF output, the collision detection signal is cleared after confirming that the Neuron® Chip is not transmitting the PPDU, and then the RF output (modulation input to the RF circuit) is switched over to the Neuron® Chip side.
- After the end of the pause time, the Neuron® Chip transmits the PPDU, and this message is sent to the RF.
- After clearing of the transmission request signal has been confirmed, RF output is terminated.
- The RF circuit is switched to reception mode, and the collision detection signal and BUSY signal are cleared to READY status.

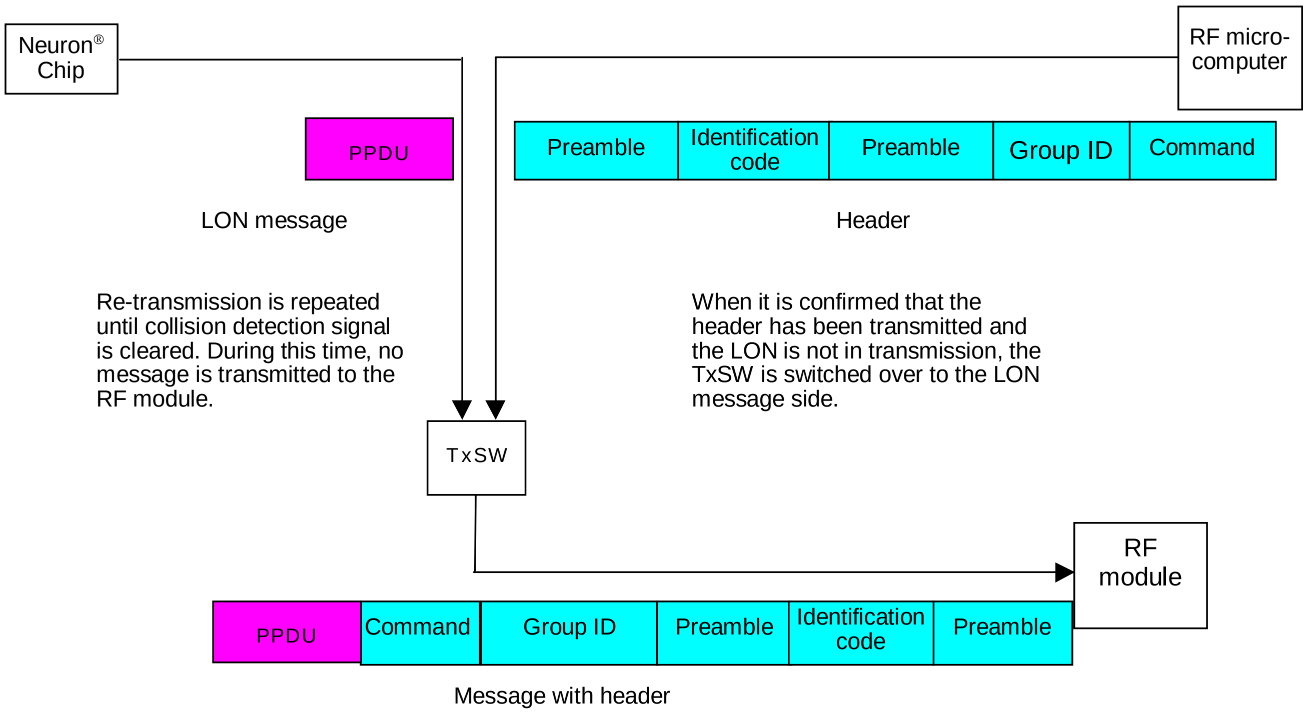



**Fig. 6.7 ARIB STD-T67 Transmission During Neuron Chip Use**

### 6.6.10 Reception system

- After confirming that a receiving carrier exists, the collision detection signal and the BUSY signal are output to the Neuron® Chip, 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 Neuron® Chip 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.

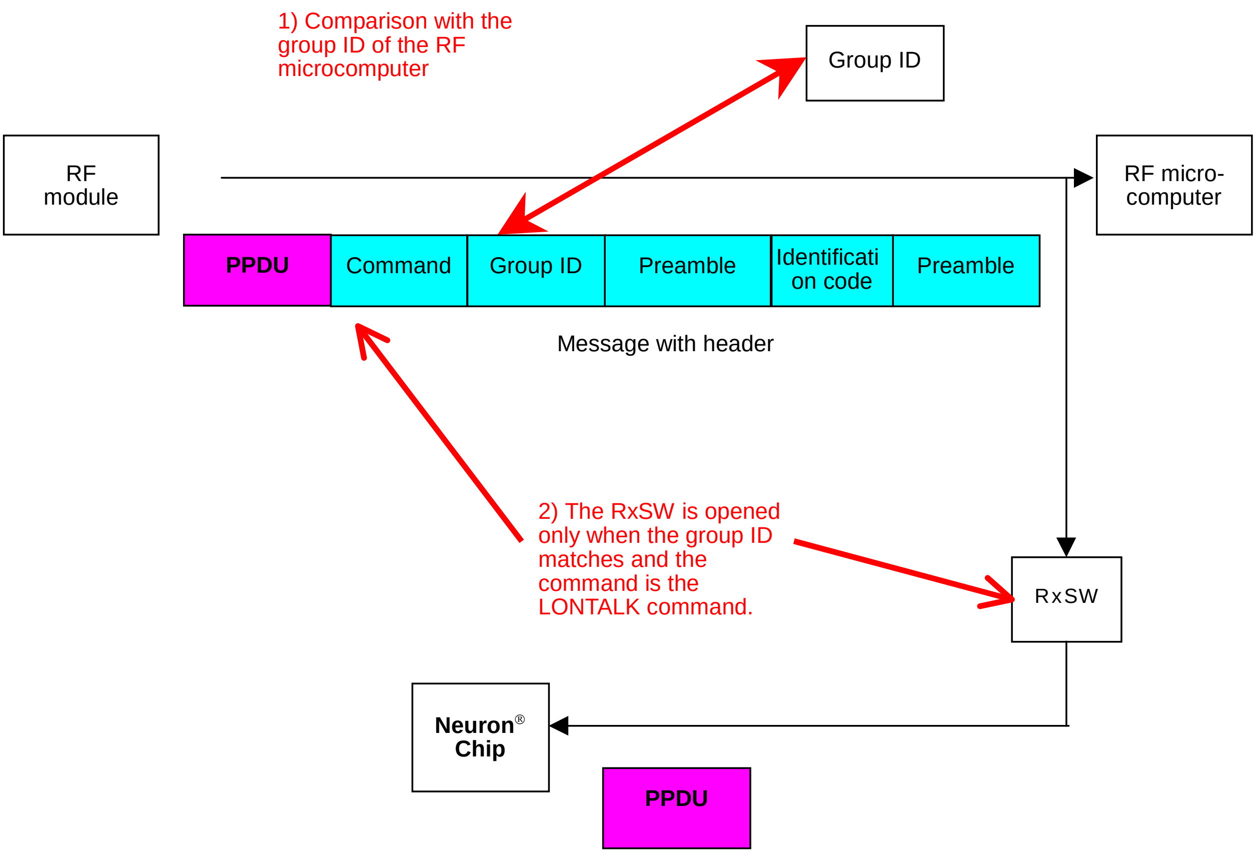



**Fig. 6.8 Image of ARIB STD-T67 Reception during Neuron Chip Use**

# 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)