NXDN®

NXDN Technical Specifications

Part 1:
Air Interface

Sub-part A:
Common Air Interface

NXDN TS 1-A Version 1.3

November 2011

NXDN Forum

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1. General

1.1. Overview

Common Air Interface specifications define the radio interface of a digital mobile radio communications system which is compliant with the requirements for 6.25 kHz spectrum efficiency defined in FCC Part 90 and enforced for frequency bands under 512 MHz (mainly the 150 MHz and 450 MHz bands), and also compliant with the requirements for existing 12.5 kHz spectrum efficiency in frequency bands including the 800 MHz band.

An NXDN system supports a trunked radio system with FDMA (Frequency Division Multiple Access) and conventional system including a direct mode communication by SCPC (Single Channel Per Carrier), and offers wide range of Land Mobile Radio operations which provides a set of features required for the Business & Industry applications as well as for the Public Safety applications.

Trunking method includes Centralized Control Method with dedicated control channel and Distributed Control Method without dedicated control channel, the former of Type-C trunked system is distinguished from the latter of Type-D trunked system.

Unless otherwise noted, a trunked radio system addressed in this document is the former of Type-C trunked system.

1.2. Scope

An NXDN system consists of Trunking Repeater Sites (TRS), Conventional Repeater Sites (CRS) and Subscriber Units (SU) as shown in Figure 1.2-1. The CAI specifications define the radio interface on Reference Point (Um) as shown in Figure 1.2-1. The network interface specifications for connections among sites and the interface between Subscriber Unit and peripheral equipment are outside of applicable scope of this CAI specifications.

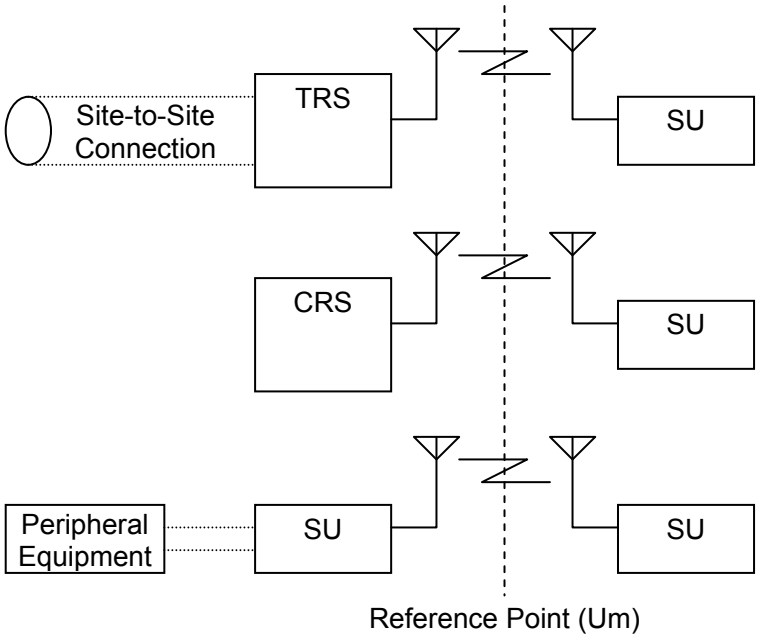


Figure 1.2-1 Reference Point of Radio Interface

2. System Overview

2.1. System Structure

An NXDN system supports architectures for both trunked radio system and conventional system.

A trunked radio system is normally comprised of Trunking Repeater Sites and Subscriber Units, and it can provide the following communication methods: SU to SU communications via a TRS, TRS to SU communications, and SU to SU direct mode communications by use of the Talk Around function in Subscriber Units.

A conventional system is normally comprised of Conventional Repeater Sites and Subscriber Units, and it can provide the following communication methods: SU to SU communications via CRSs, CRS to SU communications, and SU to SU direct mode communications by use of the Talk Around function in Subscriber Units. Furthermore, in a system comprised of Subscriber Units only that provides the most basic operation of a conventional system, direct mode communications is possible.

Hereafter, SU to SU communications are described as a communication mode via TRSs or CRSs, and SU to SU direct mode communications is described as communication that is not via TRSs nor CRSs. There are 2 methods of transmission in the SU to SU direct mode communications: direct mode communications using the Talk Around function in SUs and simple direct mode communications in a group of SUs. When referring to SU direct mode communications, both methods are included because it is difficult to distinguish the difference between them.

Figure 2.1-1 shows a basic trunked radio system diagram.

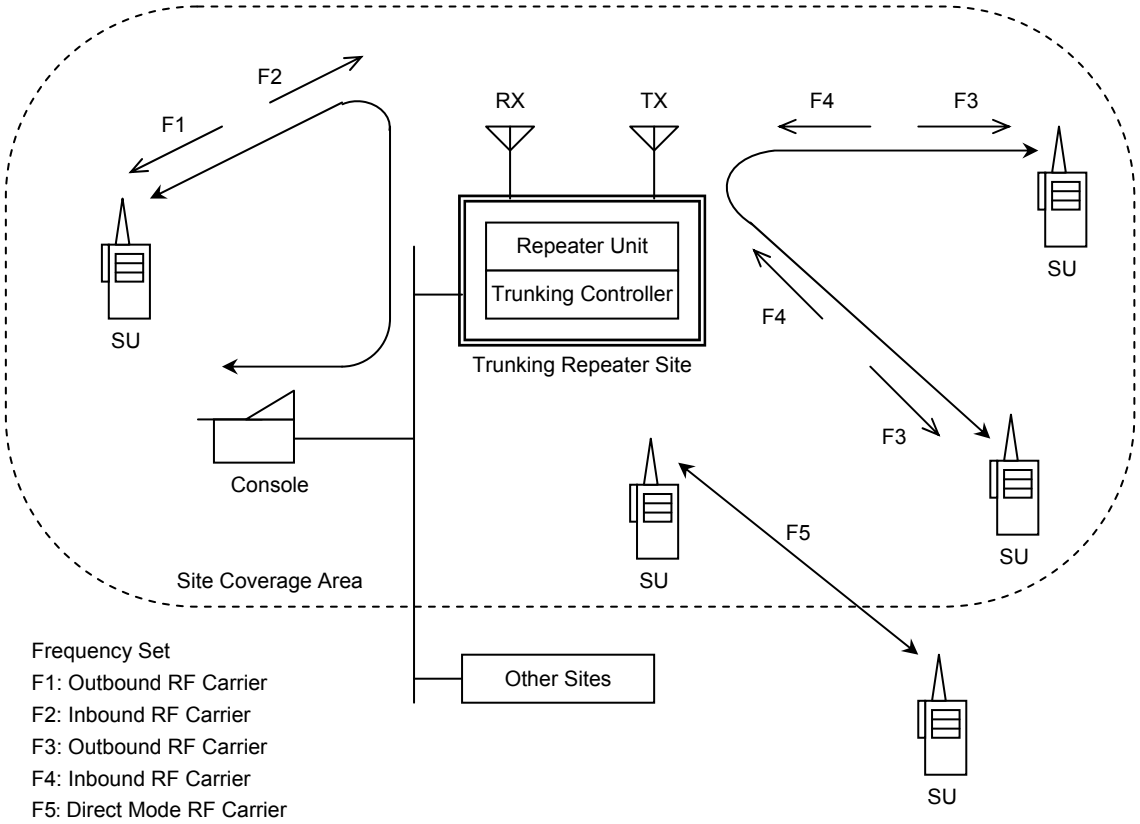


Figure 2.1-1 Basic Concept of NXDN Trunked Radio System

Trunking Repeater Sites, are allocated pairs of inbound (uplink) frequency and outbound (downlink) frequency (Figure 2.1-1 F1/F2, F3/F4) that are used as a control channel or a traffic channel as necessary. The figure also explains the frequency used for direct mode communications by Subscriber Units outside of the coverage area of the Trunking Repeater Site (a frequency that is not used to access Trunking Repeater Sites; (F5) in this figure).

2.1.1. Basic System Structure

This section describes the elements, system type and line structure which comprise an NXDN system.

2.1.1.1. Elements of System Structure

The elements comprising an NXDN system are defined as follows:

Repeater Unit (RU)

A Unit comprised of a receiver and a transmitter, relaying received signals to a transmitter in duplex operation.

Trunking Controller (TC)

Equipment having a centralized control function to manage the radio communication lines.

Trunking Repeater (TR)

Equipment, being comprised of a Repeater Unit and Trunking Controller, to control the line and/or relay signals by using 2 RF frequencies.

Trunking Repeater Site (TRS)

Equipment working as a centralized control facility that consist of 1 or more Trunking Repeaters. At least 1 of the Trunking Repeaters is used as a control channel and others are used as traffic channels to communicate with SUs or relay signals among the SUs in the coverage area.

Conventional Repeater (CR)

Equipment, being comprised of Repeater Units, to relay a signal by using 2 RF frequencies.

Conventional Repeater Site (CRS)

Equipment without the centralized control function comprised of 1 or more Conventional Repeaters. Each Conventional Repeater works independently, and communicates with SUs or relays signals among SUs in the coverage area.

Subscriber Unit (SU)

A SU is categorized as either a Mobile Station or Fixed Station.

Mobile Station (MS)

A Unit that usually moves around on land and communicates with other SUs. There are 2 types of Mobile Stations: a vehicle mounted type and portable type.

Fixed Station (FS)

A fixed unit that communicates with Mobile Stations in order to mainly command them from a dispatcher.

Console

Equipment connected to a TRS or CRS to control the system or to convey messages. It is also referred to as a Equipment connected to a Fixed Station to send commands from a dispatcher.

2.1.1.2. Structure of Trunked Radio Systems

Communication in a trunked radio system normally uses semi-duplex mode in SU-SU communication via a TRS and simplex mode in a direct mode communication.

Structure of a trunked radio system is presented in Figure 2.1-2. This TRS is comprised of 3 channels (TR_1 to TR_3), at least 1 of which is for a control channel and the others for traffic channels.

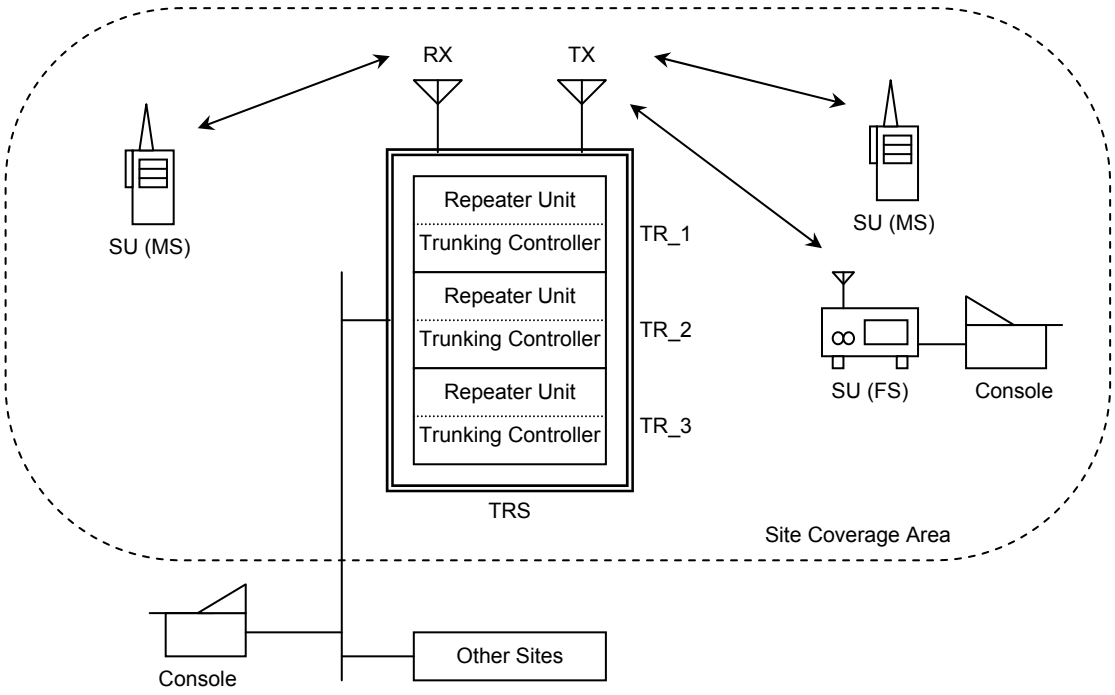


Figure 2.1-2 Structure of NXDN Trunked Radio System

2.1.1.3. Structure of Conventional Systems

Communication in a conventional system normally uses semi-duplex mode in SU-SU communication via a CRS and simplex mode in direct mode communication.

Structure of a conventional system is presented in Figure 2.1-3 and Figure 2.1-4. This system, only using direct mode communication shown in Figure 2.1-4, is also applied in case where the SUs communicate with each other using Talk Around function when they are outside of the TRS coverage area as shown in Figure 2.1-2, or if outside of the CRS coverage area as shown in Figure 2.1-3.

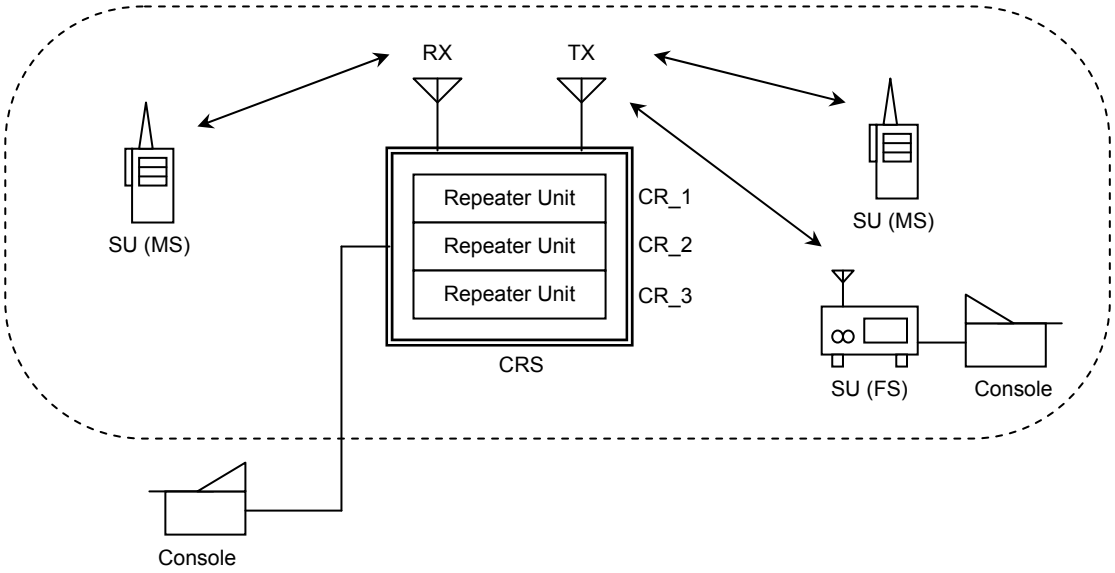


Figure 2.1-3 Structure of Conventional Systems (Communicating through a Repeater)

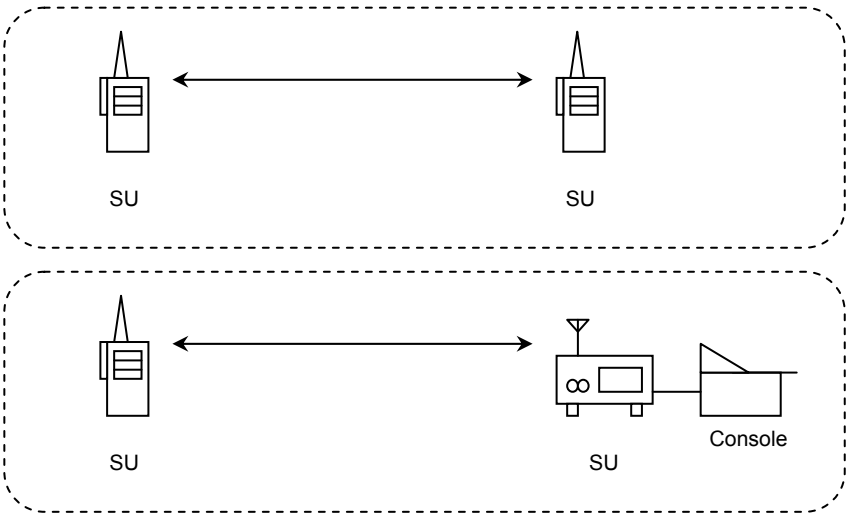


Figure 2.1-4 Structure of Conventional Systems (Direct Communication)

2.1.1.4. Structure of Lines

There are radio lines for radio communication and other lines for accessing another network as a line required for an NXDN system.

RF Line

Radio channels used for communication can be categorized as control channels, traffic channels and direct mode traffic channels.

At a TRS, 1 or more control channels and 1 or more traffic channels that are managed by the control channels are combined to work together.

A control channel assigns traffic channels individually when each call request is placed. The communication contains voice communication and non-voice communication such as data communication.

The number of control channels and traffic channels varies from site to site.

A conventional system is comprised of 1 or more traffic channels.

Other Network Access

In TRSs and CRSs, the following fixed networks can be accessible. However, this document does not define network access specifications.

- Private communication network
- Telecommunications facility (PSTN/ PSDN)
- IP network

Also, multiple TRSs can be interconnected by a network such as an IP network.

2.2. Functions Defined by CAI

A list of service functions provided by the NXDN protocol is presented in Table 2.2-1, and the details shall be specified in the next section. Sets of implemented services may vary depending on the system. Refer to Section 9.6 for detailed classification of service functions.

Categories	Services	Trunked System		Conventional System	
		Multi-site	Single Site	Repeater	Direct
Voice Service	Broadcast Group Call	Yes	Yes	n/a	n/a
	Conference Group Call	Yes	Yes	Yes	Yes
	Individual Call	Yes	Yes	Yes	Yes
	Interconnect Call	Yes	Yes	Yes	n/a
Data Service	Data Call	Yes	Yes	Yes	Yes
	Broadcast Data Call	Yes	Yes	Yes	Yes
	Short Data Call	Yes	Yes	n/a	n/a
	Broadcast Short Data Call	Yes	Yes	n/a	n/a
	Simultaneous Data Call	Yes	Yes	Yes	Yes
Supplementary Service	Status Call	Yes	Yes	Yes	Yes
	Broadcast Status Call	Yes	Yes	Yes	Yes
	Paging	Yes	Yes	Yes	Yes
	Emergency Call	Yes	Yes	Yes	Yes
	Emergency Alert	Yes	Yes	Yes	Yes
	Remote Monitor	Yes	Yes	Yes	Yes
	Remote Stun	Yes	Yes	Yes	Yes
	Late Entry	Yes	Yes	Yes	Yes
System Service	Registration	Yes	Yes	n/a	n/a
	Group Registration	Yes	Yes	n/a	n/a
	Site Roaming	Yes	n/a	n/a	n/a
	System Roaming	Yes	Yes	n/a	n/a
	Composite Control Channel	Yes	Yes	n/a	n/a
	Control Channel Switching	Yes	Yes	n/a	n/a
	Restriction Control	Yes	Yes	n/a	n/a
	Fail Soft	Yes	Yes	n/a	n/a
	Call Queuing	Yes	Yes	n/a	n/a
	Priority Monitor	Yes	Yes	n/a	n/a
	Intermittent Operation	Yes	Yes	n/a	n/a
	Traffic Timer	Yes	Yes	n/a	n/a
Security	Authentication	Yes	Yes	Yes	Yes
	Encryption	Yes	Yes	Yes	Yes

Table 2.2-1 List of Services

2.2.1. Group Voice Call

A SU or console can provide a group voice call intended for calls to multiple SUs. According to group settings, this can provide a conference call for two-way voice calls between selected groups or a broadcast call for one-way voice calls to the selected group.

2.2.2. Individual Voice Call

A SU or console can provide an individual voice call intended for calls to a specified SU.

2.2.3. Interconnect Voice Call

TRSs or CRSs can be connected to telecommunication networks (PSTN/PSDN), which can offer individual or group voice calls between SUs and the PSTN/PSDN.

2.2.4. Data Call

A SU or console can transfer data (e.g. text or AVL data) to an individual or group members. A data call can be sent to one specified SU or a broadcast data call to a group can be selected.

2.2.5. Short Data Call

A SU or console can transfer a small amount of data to an individual or group members. The size of transmission data has a limit because the control channel of a TRS is used. A short data call can be sent to one specified SU or a broadcast short data call to a group can be selected.

2.2.6. Simultaneous Data Call

A SU or console can transfer data at a low speed simultaneously with a voice call during individual voice calls or group voice calls. Separate addresses for voice communication and data communication can be specified.

2.2.7. Status Call

A SU or console can transfer a simple and fixed message to an individual or group members. There are 2 types of message formats: preconfigured particular status messages and user defined free-style status messages. A status call can be sent to one specified SU or a broadcast status call to a group can be selected. There are two types of means to tell the status: Status Inquiry that tells the current status as an answer of inquiry and Status Notice that tells the current status as needed.

2.2.8. Paging

A SU or console can notify the specified SU by audible sound or an indicator that a paging has been placed. Paging is a part of a status call and uses a preconfigured special status message.

2.2.9. Emergency Call & Alert

When a SU is in emergency condition, an emergency voice call or emergency status message can be sent to an individual or group members.

2.2.10. Remote Monitor

A SU or console can monitor status of a specified SU by remotely activating a transmission.

2.2.11. Remote Stun

A SU or console can set a specified SU to an inoperative state remotely. There are three kinds of statuses, Stun, Revival and Kill, and any of them can be used depending on the situation.

2.2.12. Late Entry

Late Entry enables those SUs that access a call after a group call is established to automatically join the group call. This scenario could occur when a SU enters the region from outside the coverage area, or if a SU is turned ON after a group call is established.

2.2.13. Registration

In a trunked radio system, a SU searches for another control channel when the unit is turned ON, or if the receive signal becomes low in standby mode, to select another TRS with better signal conditions, and the SU can register its Unit ID in the new TRS.

2.2.14. Group Registration

In a trunked radio system, a SU can register its group affiliation in the TRS.

2.2.15. Site Roaming

In a trunked radio system that has multiple TRSs, the location registration is updated and traced in TRSs when a SU moves around sites. TRSs broadcast the adjacent site information so that SUs can move among sites appropriately.

2.2.16. System Roaming

If a trunked radio system is constructed using multiple trunked radio systems that have different configurations, the location data is updated and traced in the other trunked radio systems when a SU moves among the different systems, and a temporary ID is allocated to the SU to communicate between different systems.

2.2.17. Composite Control Channel

At a TRS, if a new transmission request is placed when all traffic channels in the site are busy, a control channel may be assigned temporarily as a traffic channel to enable communication.

2.2.18. Control Channel Switching

At a TRS, control channels in the site can be changed periodically or occasionally due to the system status.

2.2.19. Restriction Control

In a trunked radio system, a TRS may set communication restrictions such as a call request by a SU or a talk time limit while communication is congested.

2.2.20. Failsoft

If a TRS fails and loses its channel control, the TRS behaves equivalent to a CRS by repeating the received signal so that it provides minimum service to SUs and allows communications between SUs within the service area.

2.2.21. Call Queuing

At a TRS, if an SU sends a new call request when all traffic channels in the site are busy, the TRS sets the SU queuing state and may keep the SU waiting until the call request is processed.

2.2.22. Priority Monitor

In the state where an SU is making a group call on a traffic channel of a TRS, when a priority group call begins on other traffic channel or a call request of individual call addressing the SU occurs, the SU drops out of the group call and can participate in the priority group call or the individual call.

2.2.23. Intermittent Operation

While a SU is in idle state on a traffic channel of a TRS, it can stop the reception operation during unnecessary frames to receive by determining whether a frame has to be received or not.

2.2.24. Traffic Timer

At a TRS, a TRS can configure the talk time limit for SUs on a traffic channel.

2.2.25. Authentication

Providing a unique Electronic Serial Number (ESN) to each SU, the ESN can be used to authorize a SU and prevent unauthorized usage of the system.

Authentication is usually a function processed on the control channel to prevent an unauthorized access to a trunked radio system. The function similar to this can be applied to a conventional system, and it is called ESN Validation.

2.2.26. Encryption

Contents of voice communication and data communication can be encrypted.

2.3. Transfer Method

The modulation method used in an NXDN system is Nyquist 4-level FSK and its transmission scheme are presented in Table 2.3-1.

System Parameter	Description	
Modulation Scheme	Nyquist 4-Level FSK	
Access Mode	FDMA for trunked radio systems SCPC for conventional systems	
Channel Spacing	6.25 kHz	12.5 kHz
Transmission Rate	4800 bps	9600 bps
Symbol Rate	2400 symbol/s	4800 symbol/s
Speech Codec Rate	3600 bps	3600 bps (7200 bps option)

Table 2.3-1 Transfer Method Specifications

2.4. Layer Structure

A 3-layer structure as shown in Table 2.4-1 is used in the NXDN radio protocol. The call connection manner of LMR operation is based on an immediate connection by using a PTT switch so that the layer structure of a NXDN does not identify the OSI reference model.

Layer	Layer Name	Description
Layer 1	Basic Interface	This layer is a layer for a basic structure of channels specifies the channel definition and format.
Layer 2	Transfer Control Method	This layer is a special layer for transmission control between opposite stations and specifies the synchronization and identification of the channel, random access method and timing control.
Layer 3	Access Control Method	This layer is a layer for signaling transmission between end systems and specifies the procedures of messages for RF Transmission Management, Mobility Management and Call Control.

Table 2.4-1 Layer Structure

3. Modulation

3.1. General Description

This section defines the Modulation method for an NXDN system.

3.2. Modulation Method

The modulation method is 4-level FSK. By using 4-level FSK with nonlinear modulation, Class C power amplifiers used for analog FM modulation can still be used. Furthermore, VCO direct modulation circuits used for analog FM can be used for modulators and the frequency detectors used for analog FM can be used as demodulators, hence most of circuitries of existing analog FM equipment can be utilized in common.

An outline of a modulator and a demodulator using a 4-level FSK is presented in Figure 3.2-1 and Figure 3.2-2.

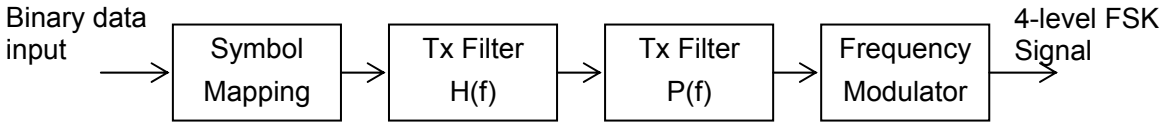


Figure 3.2-1 Diagram of 4-level FSK Modulator

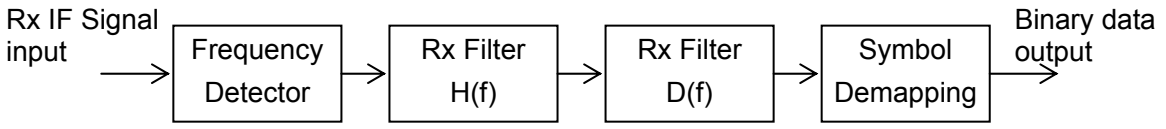


Figure 3.2-2 Diagram of 4-level FSK Demodulator

3.3. Symbol Mapping

The serial binary data sequence is processed as dibits selecting every 2 bits from the start and converted to 4 types of symbols corresponding to 4 types of dibits.

The relationship among dibit, symbol and frequency deviation are presented in Table 3.3-1.

Dibit	Symbol	Deviation for 4800 bps	Deviation for 9600 bps
01	+3	+1050 Hz	+2400 Hz
00	+1	+350 Hz	+800 Hz
10	-1	-350 Hz	-800 Hz
11	-3	-1050 Hz	-2400 Hz

Table 3.3-1 Symbol Mapping Table

3.4. Baseband Filter for Modulator

The symbol sequence is limited the baseband bandwidth using a transmission filter and then transferred to the modulator. Signals routed to the filter at 1/Symbol Rate intervals are impulse signals that are scaled to the symbol level in the Table 3.3-1. For the baseband bandwidth limits, the following formulas expressing H(f) as a square root raised cosine spectrum and P(f) as a sinc function spectrum are used. H(f) and P(f) have linear-phase characteristics.

$$|H(f)| = \begin{cases} 1 & , \quad 0 \le |f| < (1-\alpha)/2T \\ \cos\left[(T/4\alpha)(2\pi|f| - \pi(1-\alpha)/T)\right] & , \quad (1-\alpha)/2T \le |f| < (1+\alpha)/2T \\ 0 & , \quad (1+\alpha)/2T \le |f| \end{cases}$$

$$|P(f)| = \sin(\pi f T)/\pi f T \qquad , \quad 0 \le |f| \le (1+\alpha)/2T$$

Where; T = 416.7μs (2400 symbol/s) or 208.3μs (4800 symbol/s); roll-off factor α= 0.2.

3.5. Baseband Filter for Demodulator

A frequency demodulated signal is limited the baseband bandwidth using a reception filter. For the reception baseband bandwidth limits, the formulas expressing H(f) as a square root raised cosine spectrum (same as for transmission filter) and D(f) as an inverse sinc function spectrum are used. D(f) has linear-phase characteristics.

$$|D(f)| = \pi f T / \sin(\pi f T) \qquad , \quad 0 \le |f| \le (1+\alpha)/2T$$

Where; T = 416.7μs (2400 symbol/s) or 208.3μs (4800 symbol/s); roll-off factor α = 0.2.

3.6. Reference Deviation of 4-level FSK

The modulation sensitivity of the modulator shall be adjusted to have the nominal frequency deviation as defined in Table 3.3-1. Under the condition, the reference frequency deviation is acquired by feeding the following bit sequence to the modulator.

・・・01 01 11 11 01 01 11 11 01 01 11 11 01 01 11 11・・・

When the bit sequence is fed to the transmission baseband filter, the output signal should be equal to a sine wave with the 1/4 symbol rate frequency. Therefore, according to the magnitude response of the transmission baseband filter at the given frequency, the peak frequency deviation can be calculated as follows:

4/ π x ±1050 = ±1337 Hz for 4800 bps

4/ π x ±2400 = ±3056 Hz for 9600 bps

4. Basic Interface (Layer 1 Standard)

4.1. Outline

This section defines the basic interface (Layer 1) in an NXDN system. The definition of channel, frame structure and signal format are described. Also the error correction method and scrambler method are defined.

4.2. Channel Configuration

This section defines a RF channel categorized as a physical radio carrier and a functional channel categorized as a logical function unit. For convenience, frequently used abbreviations are also defined.

4.2.1. Definition of RF Channel

The RF channel expressed a physical carrier (channel allocated for the frequency) and has the following types defined: RF Control Channel (RCCH) and RF Traffic Channel (RTCH) used in a trunked radio system, and RF Direct Channel (RDCH) used in a conventional system.

Types of RF Channel are presented in Table 4.2-1.

RF Channel Type	Abbreviation
RF Control Channel	RCCH
RF Traffic Channel	RTCH
RF Direct Channel	RDCH

Table 4.2-1 RF Channel Description

4.2.1.1. RF Control Channel

RF Control Channel is used for location registration, system information broadcasts, paging and call request reception in a trunked radio system, and controls SUs to migrate to another RF Control Channel or RF Traffic Channel.

The term "RF Control Channel" is abbreviated to "RCCH". Hereinafter, it is referred to as "RF Control Channel" or "RCCH".

4.2.1.2. RF Traffic Channel

RF Traffic Channel is used for speech data (voice-coding data) transmissions and user data transmissions in a trunked radio system. The term "RF Traffic Channel" is abbreviated to "RTCH". Hereinafter, it is referred to as "RF Traffic Channel" or "RTCH".

When an RF Channel is used not only for traffic but also control, the RF Channel is handled as a composite control channel which the channel name is "RTCH_C".

4.2.1.3. RF Direct Channel

RF Direct Channel is used for speech data (voice-coding data) transmissions and user data transmissions in a conventional system.

The term "RF Direct Channel" is abbreviated to "RDCH". Hereinafter, it is referred to as "RF Direct Channel" or "RDCH".

4.2.2. Definition of Functional Channel

A functional channel is not specified as a channel on a physical frequency, but it is a logical channel sorting transmission data by functional unit.

This section defines Functional Channel Types and their abbreviations.

Functional Channel Types are described in Table 4.2-2 .

Functional Channel Type	Abbreviation
Broadcast Control Channel	BCCH
Common Control Channel	CCCH
User Packet Channel	UPCH
User Data Channel	UDCH
Slow Associated Control Channel	SACCH
Fast Associated Control Channel 1	FACCH1
Fast Associated Control Channel 2	FACCH2
Voice Channel	VCH
Link Information Channel	LICH

Table 4.2-2 Description of Functional Channels

4.2.2.1. Broadcast Control Channel

This channel is a unidirectional channel used on RCCH and broadcasts control information from a Trunking Repeater to a Subscriber Unit. The control information contains information about location registration and the system structure.

The term "Broadcast Control Channel" is abbreviated to "BCCH". Hereinafter, it is referred to as "Broadcast Control Channel" or "BCCH".

4.2.2.2. Common Control Channel

This channel is a bidirectional channel used on RCCH, and temporarily transfers control information or transmits any paging information from a Trunking Repeater to a Subscriber Unit. This channel transfers some data transmission and information about call request in the inbound direction from a Subscriber Unit to a Trunking Repeater.

The term "Common Control Channel" is abbreviated to "CCCH". Hereinafter, it is referred to as "Common Control Channel" or "CCCH".

4.2.2.3. User Packet Channel

This channel is a bidirectional data channel used on RCCH and transfers the control information signal and user packet data. Inbound direction utilizes random access.

The term "User Packet Channel" is abbreviated to "UPCH". Hereinafter, it is referred to as "User Packet Channel" or "UPCH".

4.2.2.4. User Data Channel

This channel is a bidirectional data channel used on RTCH and RDCH and transfers the control information signal and user packet data.

The term "User Data Channel" is abbreviated to "UDCH". Hereinafter, it is referred to as "User Data Channel" or "UDCH".

4.2.2.5. Slow Associated Control Channel

This channel is a bidirectional control channel associated with a voice call on RTCH and RDCH. This channel is always used to transfer signaling information and other in formations at a low speed.

The term "Slow Associated Control Channel" is abbreviated to "SACCH". Hereinafter, it is referred to as "Slow Associated Control Channel" or "SACCH".

4.2.2.6. Fast Associated Control Channel 1

This channel is a bidirectional control channel associated with a voice call on RTCH and RDCH. This channel is temporarily used to transfer signaling information and other in formations at a high speed by “stealing” a Voice Channel (VCH).

The term "Fast Associated Control Channel 1" is abbreviated to "FACCH1". Hereinafter, it is referred to as "Fast Associated Control Channel 1" or "FACCH1".

4.2.2.7. Fast Associated Control Channel 2

This channel is a bidirectional control channel associated with a data call on RTCH and RDCH. This channel is used to transfer signaling information or a part of data at a high speed by “stealing” a UDCH.

The term "Fast Associated Control Channel 2" is abbreviated to "FACCH2". Hereinafter, it is referred to as "Fast Associated Control Channel 2" or "FACCH2".

4.2.2.8. Voice Channel

This channel is a bidirectional channel used on RTCH and RDCH and transfers voice-coding data.

The term "Voice Channel" is abbreviated to "VCH". Hereinafter, it is referred to as "Voice Channel" or "VCH".

4.2.2.9. Link Information Channel

This channel is a bidirectional channel allocated on all RF channels and is designed to transfer the information related to an radio link such as RF channel type and functional channel allocation.

The term "Link Information Channel" is abbreviated to "LICH". Hereinafter, it is referred to as "Link Information Channel" or "LICH".

4.2.3. Relationship of the RF Channel and Functional Channel

Relation between Functional Channel and RF Channel is presented in Table 4.2-3.

As a matter of convenience, functional channels on RCCH are categorized as Common Access Channel (CAC) and functional channels on RTCH and RDCH are categorized as a User Specific Channel (USC).

CAC in the inbound signal can be clarified as Long CAC and Short CAC.

However LICH exists being apart from these categories.

RF Channel	Type	Functional Channel
RCCH	CAC	BCCH
		CCCH
		UPCH
	LICH	LICH
RTCH RDCH	USC	VCH
		UDCH
		FACCH1
		FACCH2
		SACCH
	LICH	LICH

Table 4.2-3 Relation of the RF Channel and Functional Channel

4.3. Frame Structure

Transmission data is based on frame transmissions that allow transmission on every referential unit of time. This section defines the frame structure for frame transmission.

An RF channel has a frame structure with 1 frame per 80 ms at 4800 bps and per 40 ms at 9600 bps.

4.3.1. Basic Frame Structure

4.3.1.1. RCCH

A superframe is defined as N times of frame length and N can be determined arbitrarily.

Adoption of a superframe structure enables intermittent reception.

In a communication via a Trunking Repeater in 4800 bps, the processing offset between a inbound and outbound frame applies 120 ms offset. When a SU receives a signal from the Trunking Repeater and then sends a response to it, the time until the processing is completed needs 200 ms.

In 9600bps, the processing offset applies 80 ms offset. The time of the processing from reception to transmission completion in a SU needs 120 ms.

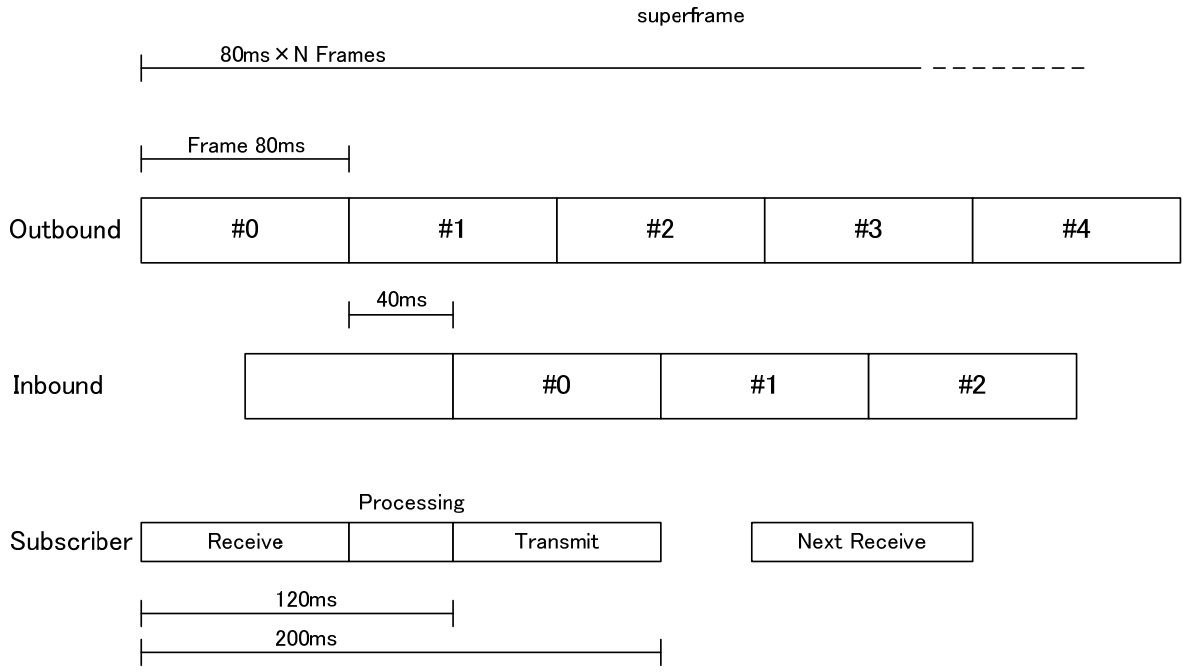


Figure 4.3-1 Frame Structure for RCCH (4800bps)

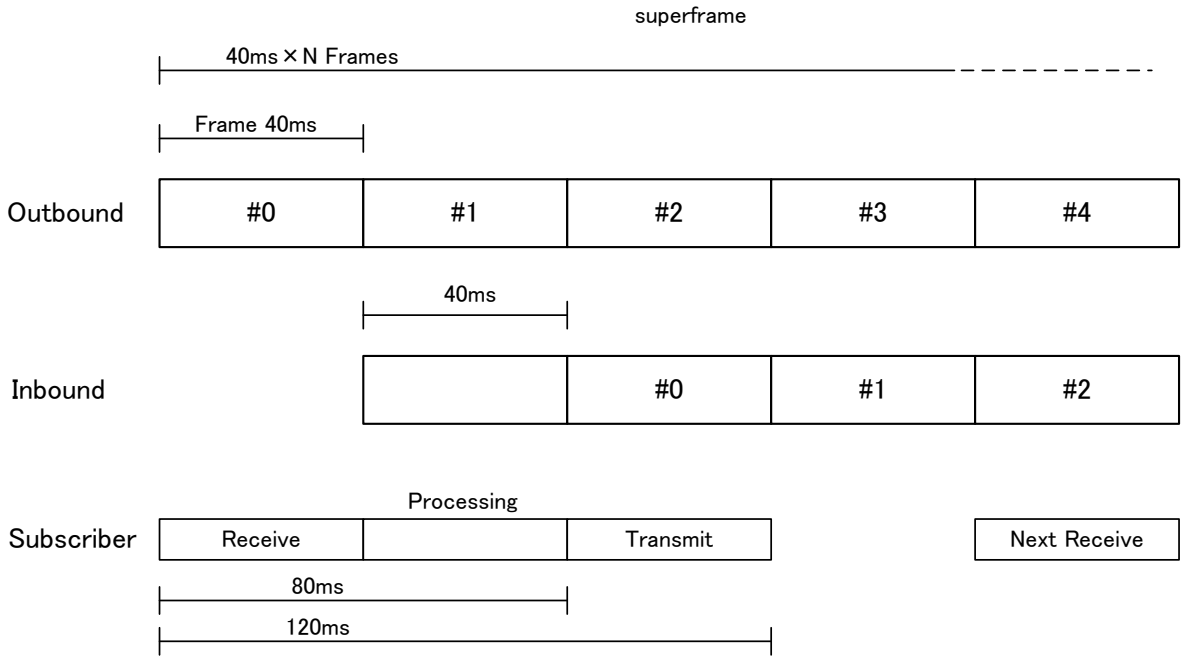


Figure 4.3-2 Frame Structure for RCCH (9600bps)

4.3.1.2. RTCH

For 4800 bps, the frame offset between the inbound and outbound frame is 40 ms.

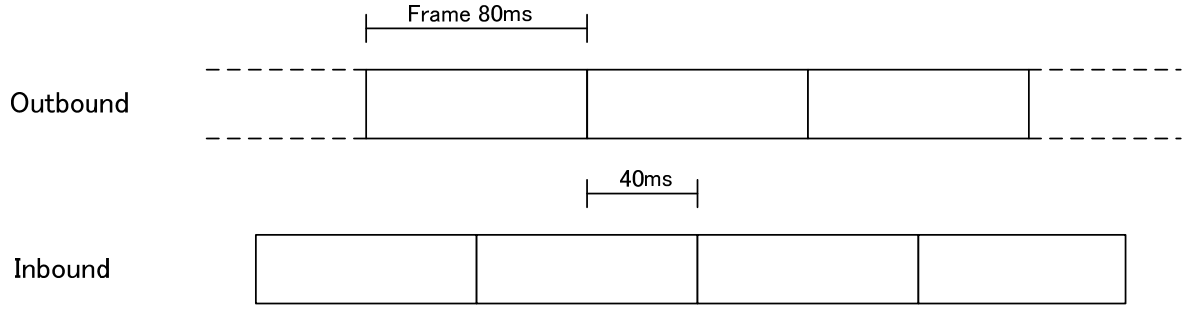


Figure 4.3-3 Frame Structure for RTCH (4800bps)

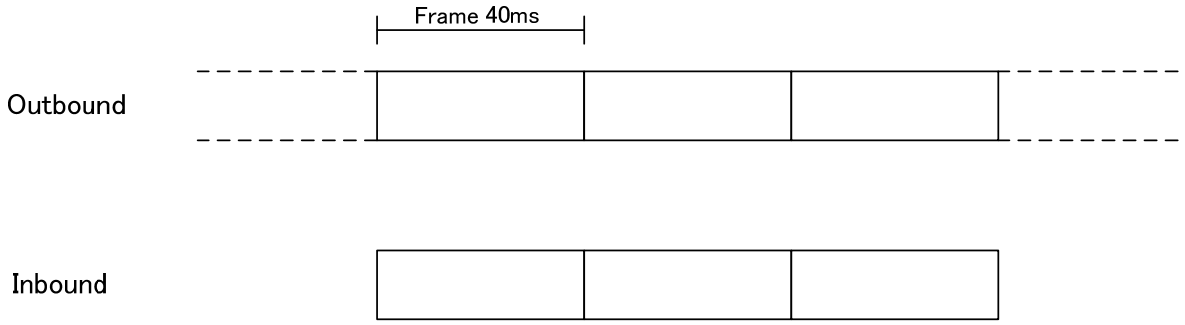


Figure 4.3-4 Frame Structure for RTCH (9600bps)

4.3.1.3. RDCH

When SU-SU communication via a Conventional Repeater in 4800 bps, the frame offset between the inbound and outbound frame is 40 ms. Transmit and Receive frames offset during direct mode communications is not defined.

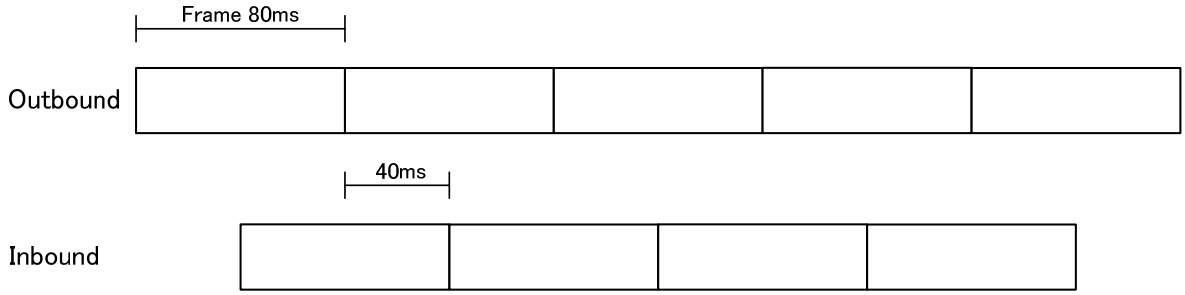


Figure 4.3-5 Frame Structure for RDCH (4800bps)

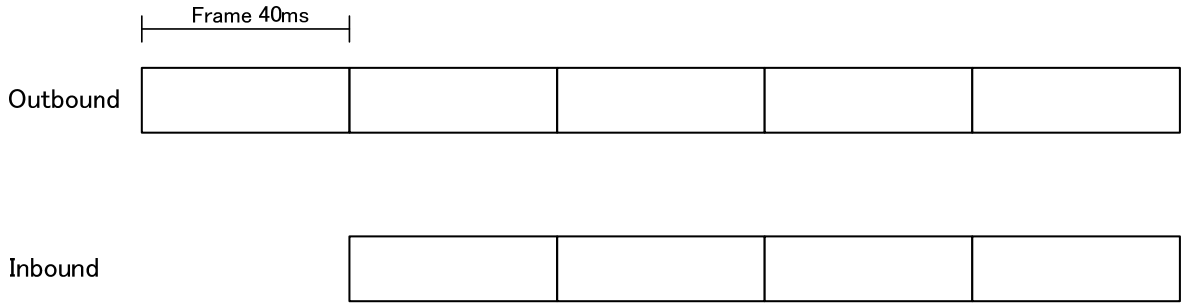


Figure 4.3-6 Frame Structure for RDCH (9600bps)

4.3.2. Mapping to Functional Channel

4.3.2.1. Channel Mapping for RCCH

In the outbound direction of an RCCH in trunked radio system, each functional channel is mapped as described below.

The RCCH has a superframe structure and the length of the superframe is a variable length. The first frame of the superframe is determined by presence of BCCH.

When packet data is transferred on an RCCH, CCCH is substituted by UPCH.

A SU uses random access method on the inbound direction and may use CCCH or UPCH as necessary.

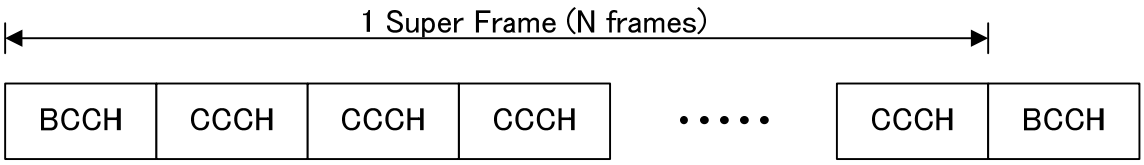


Figure 4.3-7 BCCH/ CCCH Channel Mapping

4.3.2.2. Channel Mapping for RTCH/ RDCH

When a SU makes a voice call on RTCH or RDCH, SACCH is mapped as described below. A superframe structure in a 4-frame unit is adopted during transmission, and non-superframe structure in a single frame unit is adopted at the beginning and end of transmission. Mapping for any other functional channels is not particularly specified.

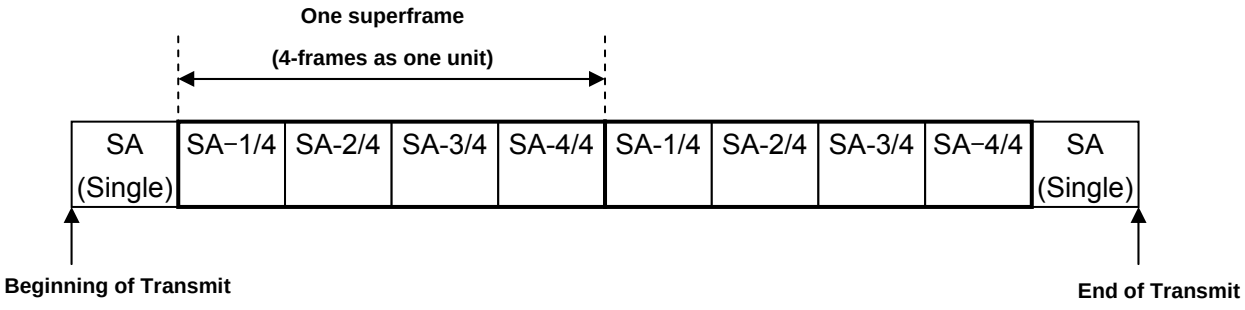


Figure 4.3-8 SACCH Channel Mapping

4.4. Frame Format

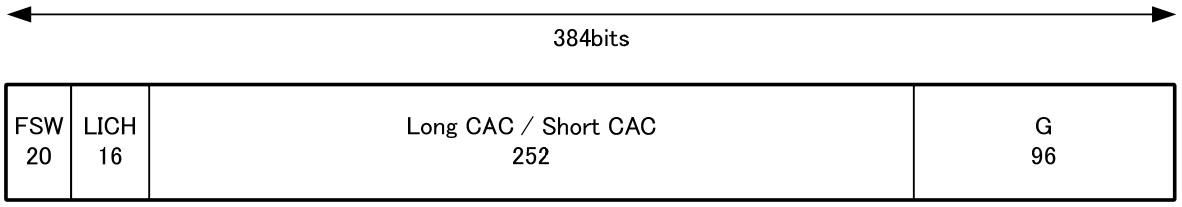
This section defines the signal format in the frame of each RF channel.

The frame of each channel has a duration of 80 ms at 4800 bps and 40 ms at 9600 bps.

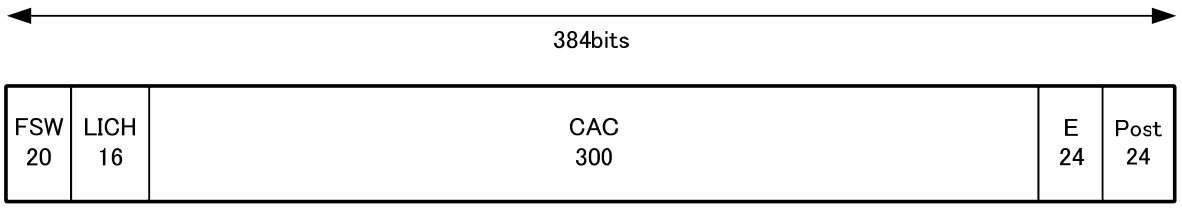
4.4.1. RCCH

Format of 1 frame (384 bits) on the RCCH is described below.

(1) Inbound Direction



(2) Outbound Direction



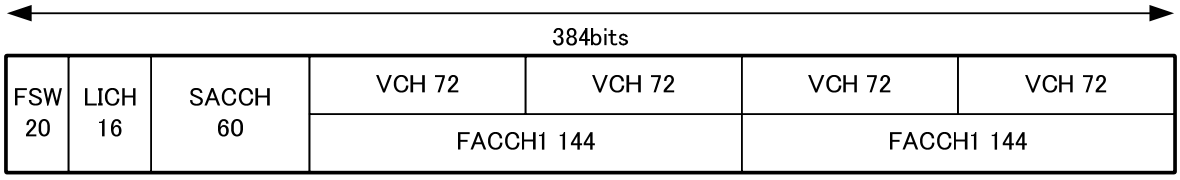
CAC: BCCH/ CCCH/ UPCH
Long CAC: CCCH/ UPCH
Short CAC: CCCH
FSW: Frame Sync Word
LICH: Link Information Channel
G: Guard Time
E: Collision Control Field
Post: Post Field

Figure 4.4-1 RCCH Frame Format

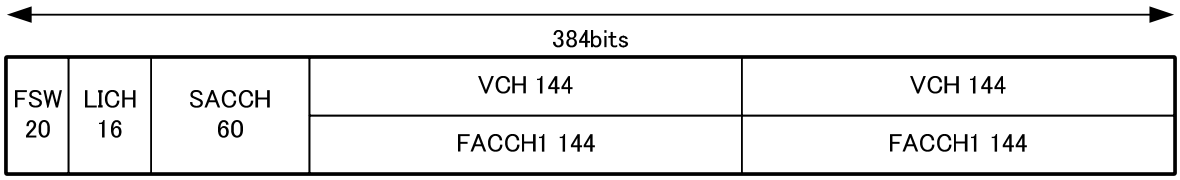
4.4.2. RTCH/ RDCH

4.4.2.1. Voice Communication on RTCH

Format of 1 frame (384 bits) on the RTCH during voice communication is described below.



4800bps / 9600bps(Half Rate) System



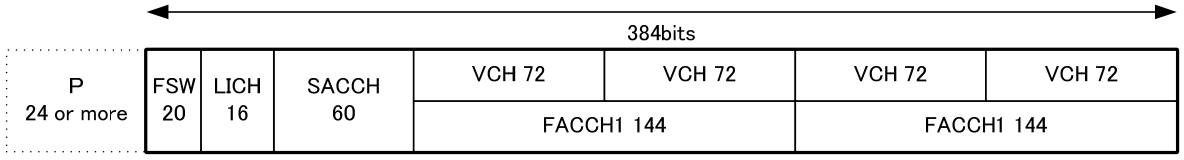
9600bps(Full Rate) System

FSW: Frame Sync Word
LICH: Link Information Channel
SACCH: Slow Associated Control Channel
VCH: Voice Channel
FACCH1: Fast Associated Control Channel 1

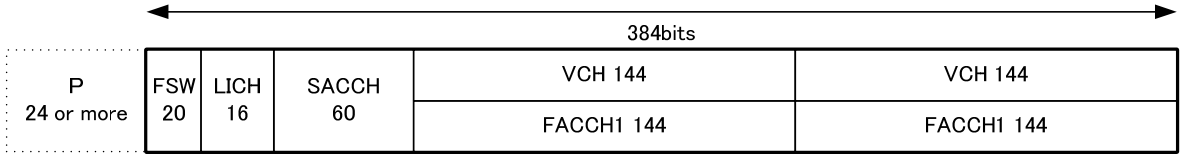
Figure 4.4-2 RTCH Frame Format for Voice Communication

4.4.2.2. Voice Communication on RDCH

Format of 1 frame (384 bits) on the RDCH during voice communication is described below.



4800bps / 9600bps(Half Rate) System



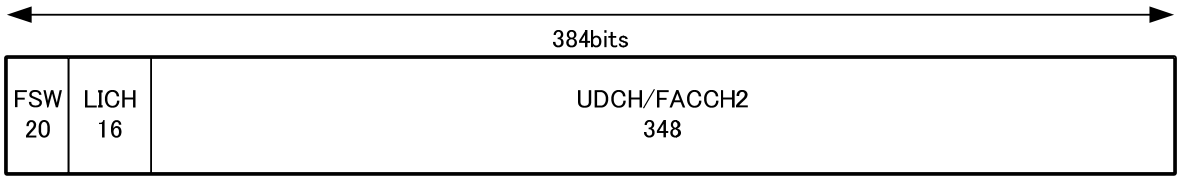
9600bps(Full Rate) System

FSW: Frame Sync Word
LICH: Link Information Channel
SACCH: Slow Associated Control Channel
VCH: Voice Channel
FACCH1: Fast Associated Control Channel 1
P: Preamble (Additional conditions shall vary whether it is an initial transmission. Details are defined hereinafter.)

Figure 4.4-3 RDCH Frame Format for Voice Communication

4.4.2.3. Data Communication on RTCH

Format of 1 frame (384 bits) on the RTCH during data communication is described below.

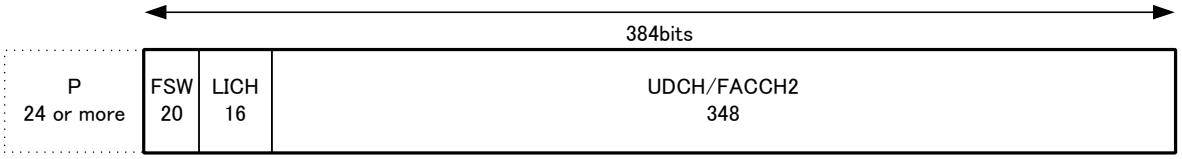


FSW: Frame Sync Word
LICH: Link Information Channel
UDCH: User Data Channel
FACCH2: Fast Associated Control Channel 2

Figure 4.4-4 RTCH Frame Format for Data Communication

4.4.2.4. Data Communication on RDCH

Format of 1 frame (384 bits) on the RDCH during data communication is described below.



FSW: Frame Sync Word
LICH: Link Information Channel
UDCH: User Data Channel
FACCH2: Fast Associated Control Channel 2
P: Preamble (Additional conditions shall vary whether it is an initial transmission. Details are defined hereinafter.)

Figure 4.4-5 RDCH Frame Format for Data Communication

4.4.3. Preamble

Preamble shall be appended at the start of transmission on an RDCH to facilitate an initial synchronization capture in receivers. The Preamble pattern shall be as defined in Table 4.4-1.
The receivers can use this fixed pattern to detect a synchronization signal along with an FSW.
The length of Preamble is defined as 24 bits, but a longer Preamble is also acceptable.
A symbol pattern in this case shall repeatedly employ the pattern of “+3 +3 -3 -3”.

Transmission Order		
Arbitrary	First 3 symbols	Last 9 symbols
+3, +3, -3, -3 …	Symbol: +3, +3, +3	Symbol: -3, +3, -3, +3, +3, -3, -3, -3, +3
	HEX : 5775FD	

Table 4.4-1 Preamble

4.4.4. Frame Sync Word

Frame Sync Word shall be 10 symbols (20 bits) described in the following table.

	Transmission Order→
Symbol	-3, +1, -3, +3, -3, -3, +3, +3, -1, +3
HEX	CDF59

Table 4.4-2 Frame Sync Word

4.4.5. Information Elements of Post Field

Post Field is a fixed pattern comprised of 3 symbols (6 bits) in the first half and 9 symbols (18 bits) in the last half.

The receiver can use this fixed pattern of 9 symbols in the last half to detect a synchronization signal along with an FSW.

Transmission Order→	
First 3 symbols	Last 9 symbols
Symbol: +3, +3, +3	Symbol: -3, +3, -3, +3, +3, -3, -3, -3, +3

Table 4.4-3 Post Field Information

4.5. Channel Coding

This section describes channel coding for each functional channel. Channel coding represents an error detection method, an error correction method, an interleave technique, and bit mapping. Refer to Section 4.5.4 for the signal transmission order, and refer to Section 4.5.5 for the CRC coding.

4.5.1. Channel Coding on the RCCH

4.5.1.1. CAC (Outbound)

(1) Coding Procedure

As defined in Figure 4.5-1.

(2) Error Detection Code

16 bits CRC

Generator Polynomial: $X^{16} + X^{12} + X^5 + 1$

(3) Fixed Bit Insertion

Four tail bits, all set equal to zero, shall be appended to the end of the bit sequence preceding the error correction coding.

(4) Error Correction Code

The convolutional code shall encode the bit sequence after appending the tail bits as shown below.

The output bits must be read alternately in the order of G1, G2.

Convolutional code (Constraint Length K = 5) with Coding rate R =1/2

Generator Polynomial: $G_1(D) = 1 + D^3 + D^4$

$G_2(D) = 1 + D + D^2 + D^4$

(5) Punctured Coding

Punctured Coding shall process the bit sequence after convolutional encoding as shown below.

The output bits shall be erased according to the erase bit positions shown on the following puncturing matrix.

Puncturing Matrix:

$$\begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 & 0 & 1 \end{pmatrix}$$

(6) Interleaving

Interleaving between frames is not used.

In the interleaving, the number of information bits is 155 bits and the interleaving depth is 25.

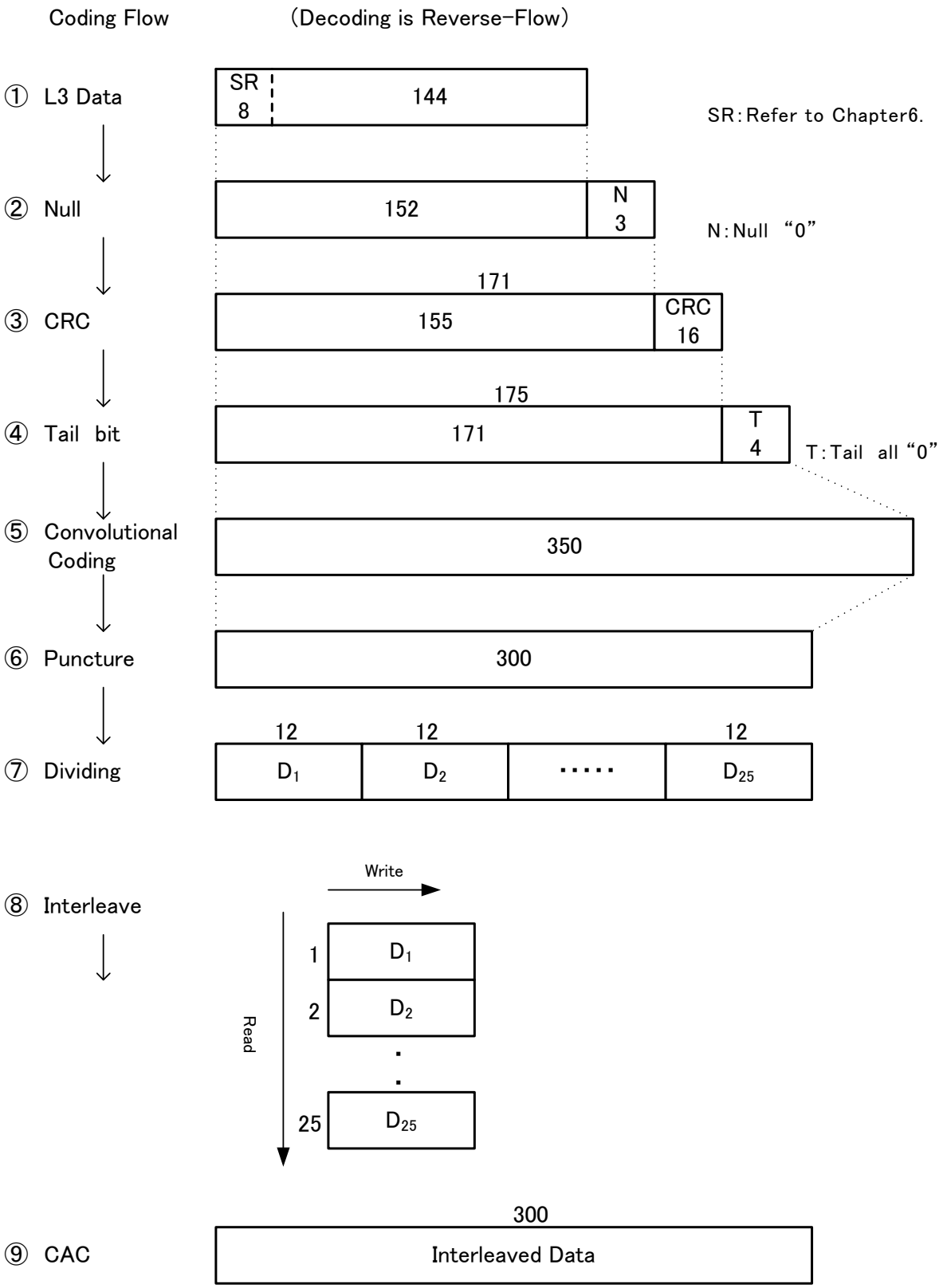


Figure 4.5-1 CAC Coding Flow

4.5.1.2. Long CAC (Inbound)

(1) Coding Procedure

As defined in Figure 4.5-2.

(2) Error Detection Code

16 bits CRC

Generator Polynomial: $X^{16} + X^{12} + X^5 + 1$

(3) Fixed Bit Insertion

Four tail bits, all set equal to zero, shall be appended to the end of the bit sequence preceding the error correction coding.

(4) Error Correction Code

The convolutional code shall encode the bit sequence after appending the tail bits as shown below.

The output bits must be read alternately in the order of G1, G2.

Convolutional code (Constraint Length K = 5) with Coding rate R =1/2

Generator Polynomial: $G_1(D) = 1 + D^3 + D^4$

$G_2(D) = 1 + D + D^2 + D^4$

(5) Punctured Coding

Punctured Coding shall process the bit sequence after convolutional encoding as shown below.

The output bits shall be erased according to the erase bit positions shown on the following puncturing matrix.

Puncturing Matrix:

$$\begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & \end{pmatrix}$$

(6) Interleaving

Interleaving between frames is not used.

In the interleaving, the number of information bits is 136 bits and the interleaving depth is 21.

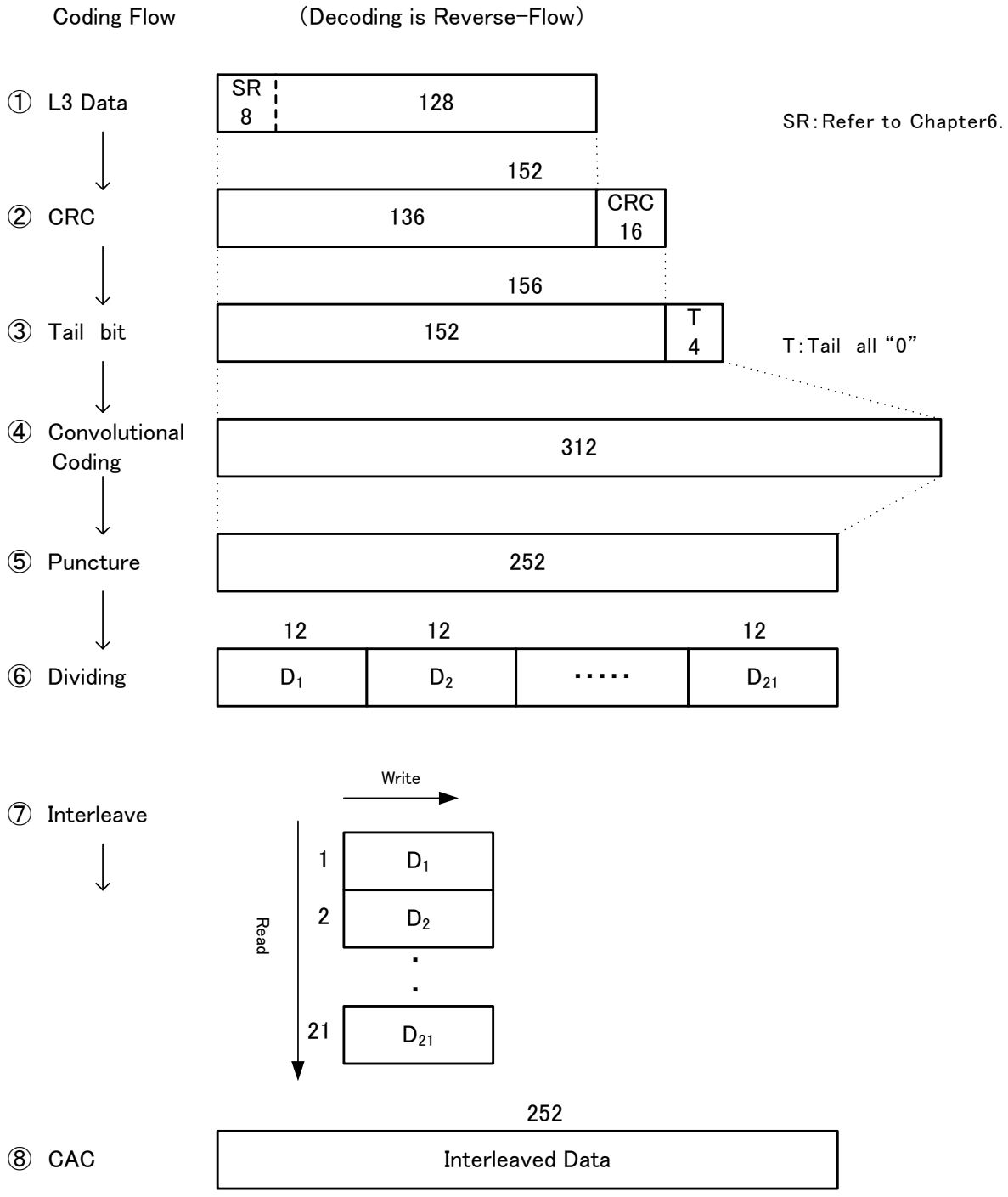


Figure 4.5-2 Long CAC Coding Flow

4.5.1.3. Short CAC (Inbound)

(1) Coding Procedure

As defined in Figure 4.5-3.

(2) Error Detection Code

16 bits CRC

Generator Polynomial: $X^{16} + X^{12} + X^5 + 1$

(3) Fixed Bit Insertion

Four tail bits, all set equal to zero, shall be appended to the end of the bit sequence preceding the error correction coding.

(4) Error Correction Code

The convolutional code shall encode the bit sequence after appending the tail bits as shown below.

The output bits must be read alternately in the order of G1, G2.

Convolutional code (Constraint Length K = 5) with Coding rate R = 1/2

Generator Polynomial: $G_1 (D) = 1 + D^3 + D^4$

$G_2 (D) = 1 + D + D^2 + D^4$

(5) Punctured Coding

None

(6) Interleaving

Interleaving between frames is not used.

In the interleaving, the number of information bits is 106 bits and the interleaving depth is 21.

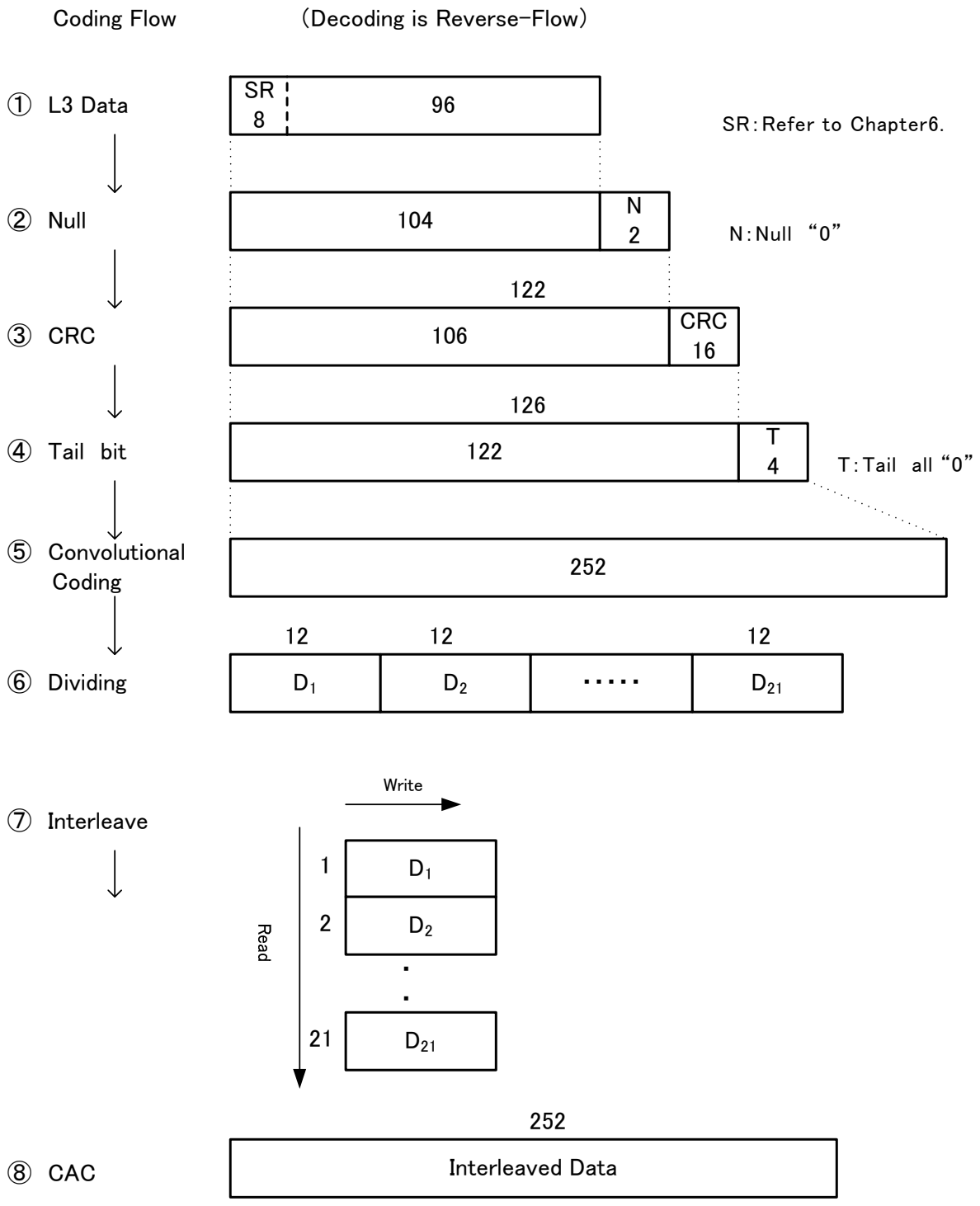


Figure 4.5-3 Short CAC Coding Flow

4.5.2. Channel Coding on the RTCH/ RDCH

Channel coding on VCH is described in another section.

4.5.2.1. SACCH

(1) Coding Procedure

As defined in Figure 4.5-4.

(2) Error Detection Code

6 bits CRC

Generator Polynomial: $X^6 + X^5 + X^2 + X + 1$

(3) Fixed Bit Insertion

Four tail bits, all set equal to zero, shall be appended to the end of the bit sequence preceding the error correction coding.

(4) Error Correction Code

The convolutional code shall encode the bit sequence after appending the tail bits as shown below.

The output bits must be read alternately in the order of G1, G2.

Convolutional code (Constraint Length K = 5) with Coding rate R = 1/2

Generator Polynomial: $G_1 (D) = 1 + D^3 + D^4$

$G_2 (D) = 1 + D + D^2 + D^4$

(5) Punctured Coding

Punctured coding shall process the bit sequence after convolutional encoding as shown below.

The output bits shall be erased according to the erase bit positions shown on the following puncturing matrix.

Puncturing Matrix:

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & 0 \end{bmatrix}$$

(6) Interleaving

Interleaving between frames is not used.

In the interleaving, the number of information bits is 26 bits and the interleaving depth is 5.

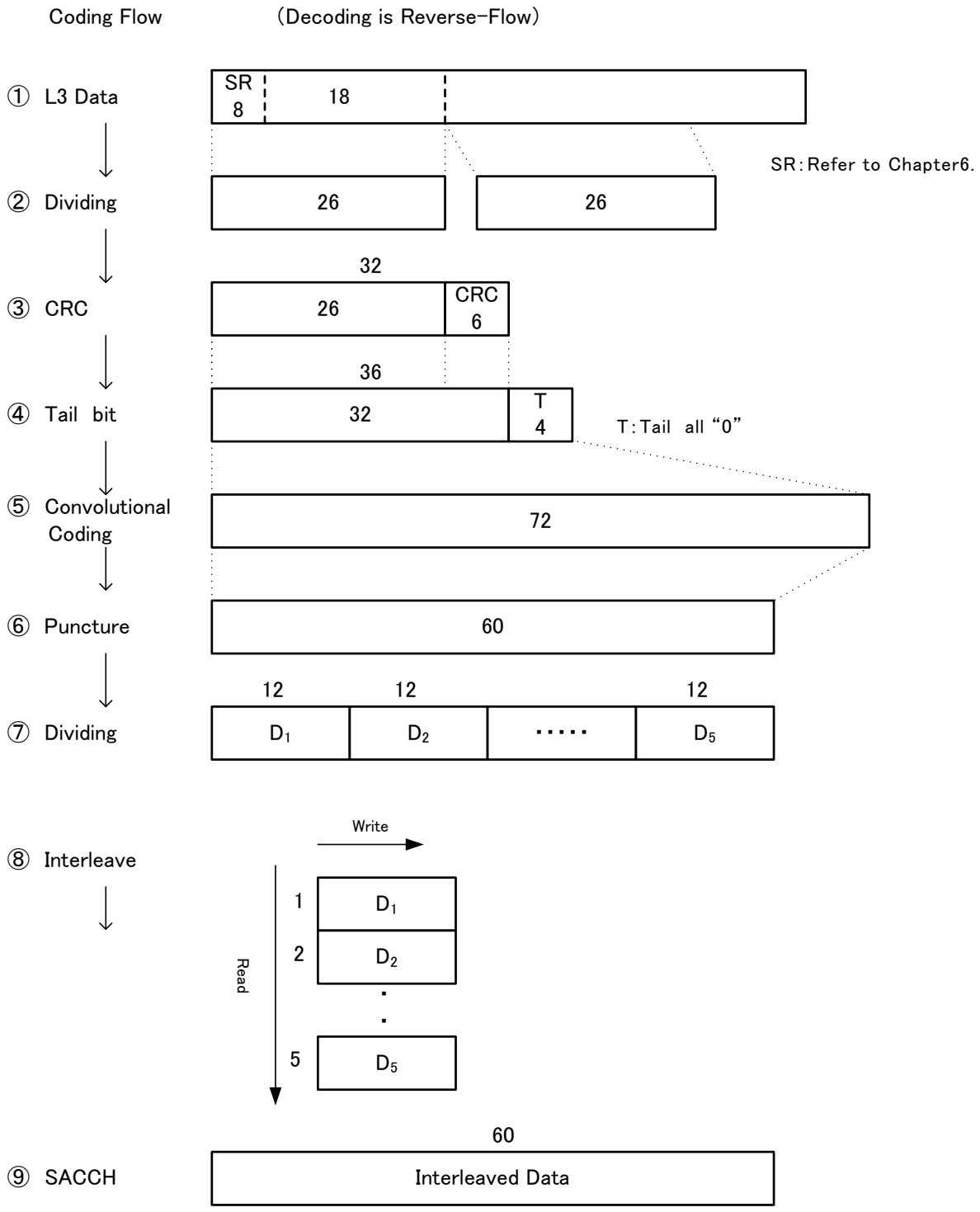


Figure 4.5-4 SACCH Coding Flow

4.5.2.2. FACCH1

FACCH1 is separated into two channels from one information data.

(1) Coding Procedure

As defined in Figure 4.5-5.

(2) Error Detection Code

12 bits CRC

Generator Polynomial: $X^{12} + X^{11} + X^3 + X^2 + X + 1$

(3) Fixed Bit Insertion

Four tail bits, all set equal to zero, shall be appended to the end of the bit sequence preceding the error correction coding.

(4) Error Correction Code

The convolutional code shall encode the bit sequence after appending the tail bits as shown below.

The output bits must be read alternately in the order of G1, G2.

Convolutional code (Constraint Length K = 5) with Coding rate R = 1/2

Generator Polynomial: $G_1(D) = 1 + D^3 + D^4$

$G_2(D) = 1 + D + D^2 + D^4$

(5) Punctured Coding

Punctured coding shall process the bit sequence after convolutional encoding as shown below.

The output bits shall be erased according to the erase bit positions shown on the following puncturing matrix.

Puncturing Matrix:

$$\begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

(6) Interleave

Interleaving between frames is not used, but a interleaving between two functional channels is executed.

In the interleaving, the number of information bits is 80 bits and the interleaving depth is 9.

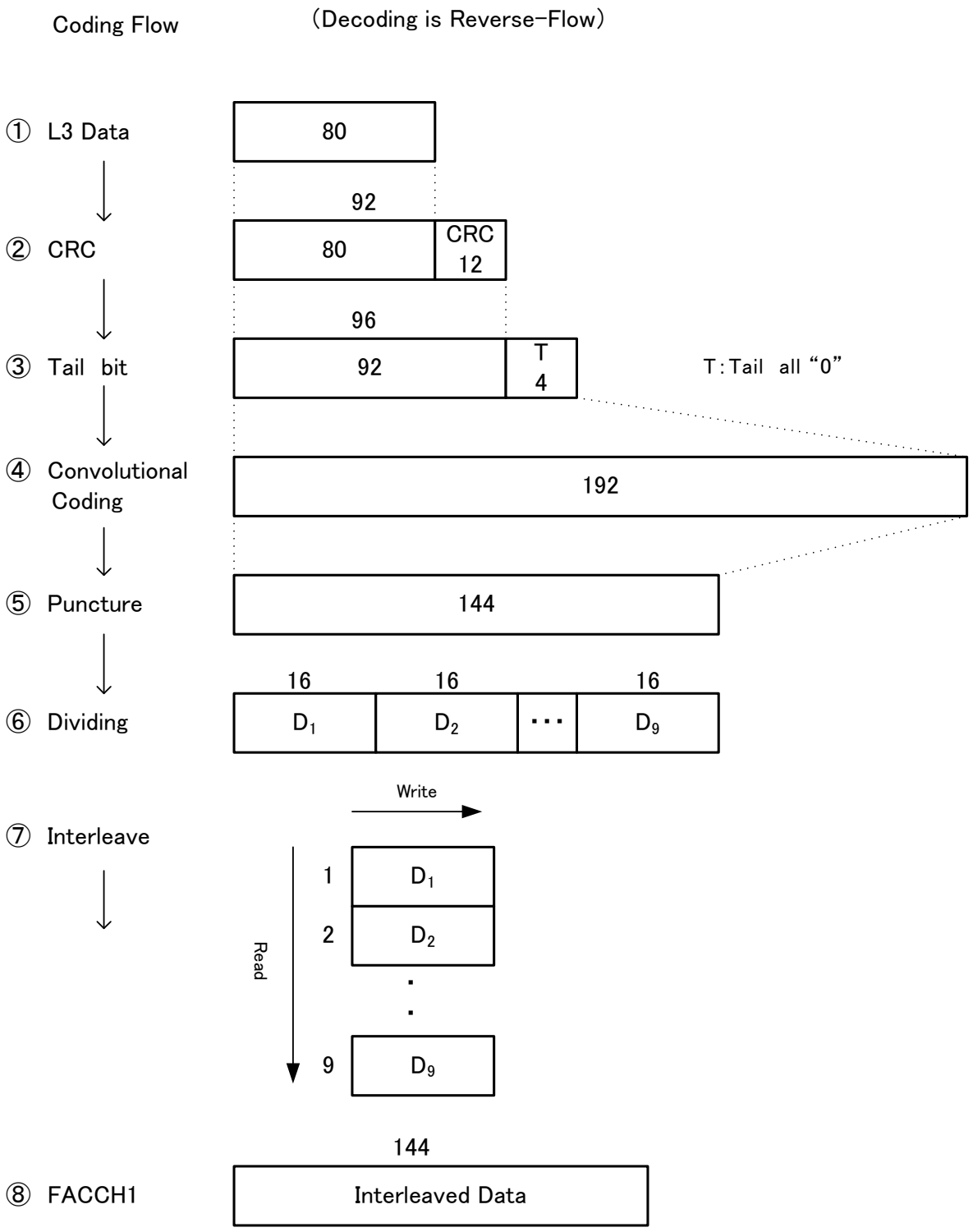


Figure 4.5-5 FACCH1 Coding Flow

4.5.2.3. UDCH/ FACCH2

(1) Coding Procedure

As defined in Figure 4.5-6.

(2) Error Detection Code

15 bits CRC

Generator Polynomial: $X^{15} + X^{14} + X^{11} + X^{10} + X^7 + X^6 + X^2 + 1$

(3) Fixed Bit Insertion

Four tail bits, all set equal to zero, shall be appended to the end of the bit sequence preceding the error correction coding.

(4) Error Correction Code

The convolutional code shall encode the bit sequence after appending the tail bits as shown below.

The output bits must be read alternately in the order of G1, G2.

Convolutional code (Constraint Length K = 5) with Coding rate R = 1/2

Generator Polynomial: $G_1 (D) = 1 + D^3 + D^4$

$G_2 (D) = 1 + D + D^2 + D^4$

(5) Punctured Coding

Punctured coding shall process the bit sequence after convolutional encoding as shown below.

The output bits shall be erased according to the erase bit positions shown on the following puncturing matrix.

Puncturing Matrix:

$$\begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 & 0 & 1 \end{pmatrix}$$

(6) Interleaving

Interleaving between frames is not used.

In the interleaving, the number of information bits is 184 bits and the interleaving depth is 29.

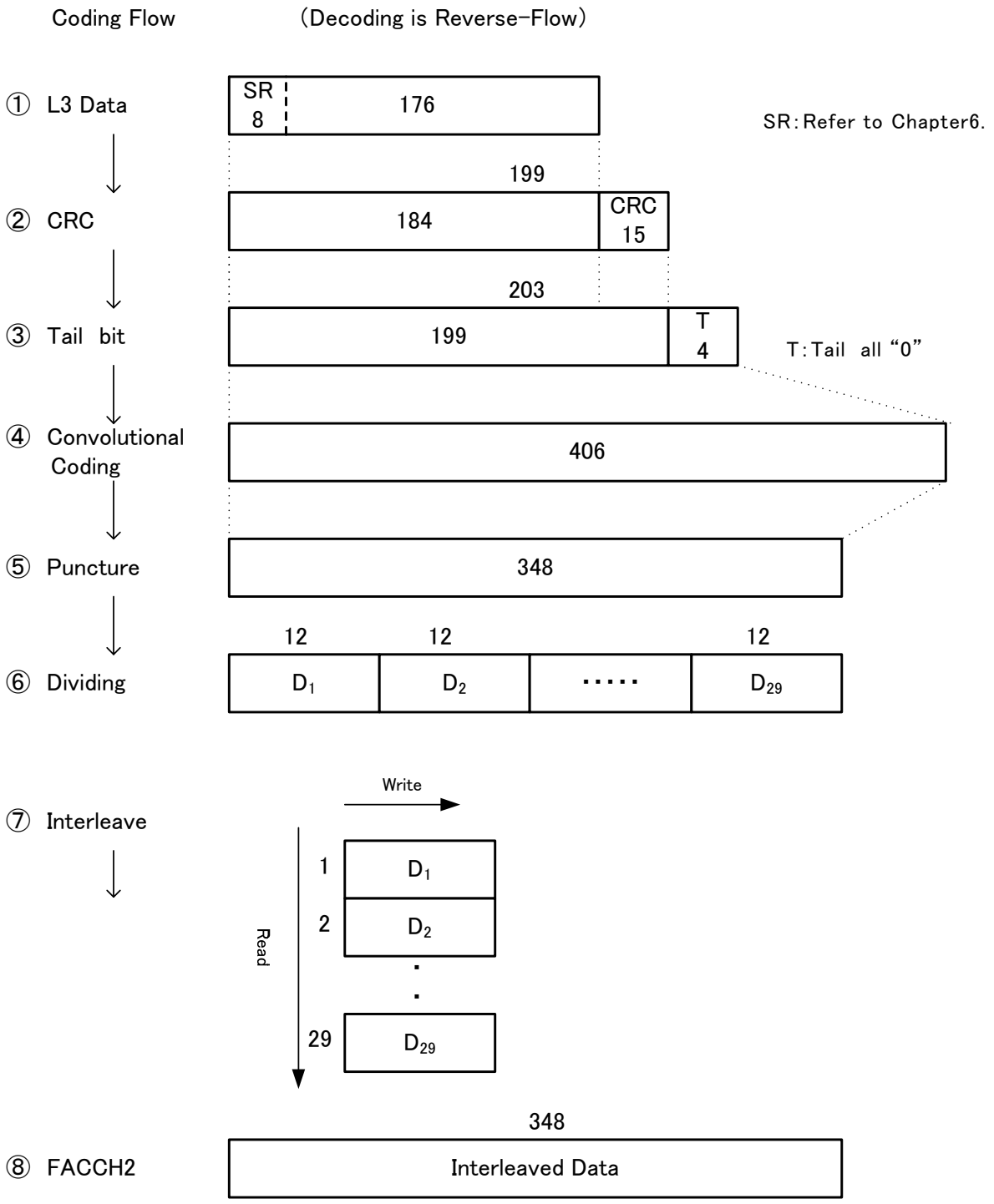


Figure 4.5-6 UDCH/ FACCH2 Coding Flow

4.5.3. LICH

(1) Coding Procedure

As defined in Figure 4.5-7.

(2) Error Detection Code

1 bit even parity

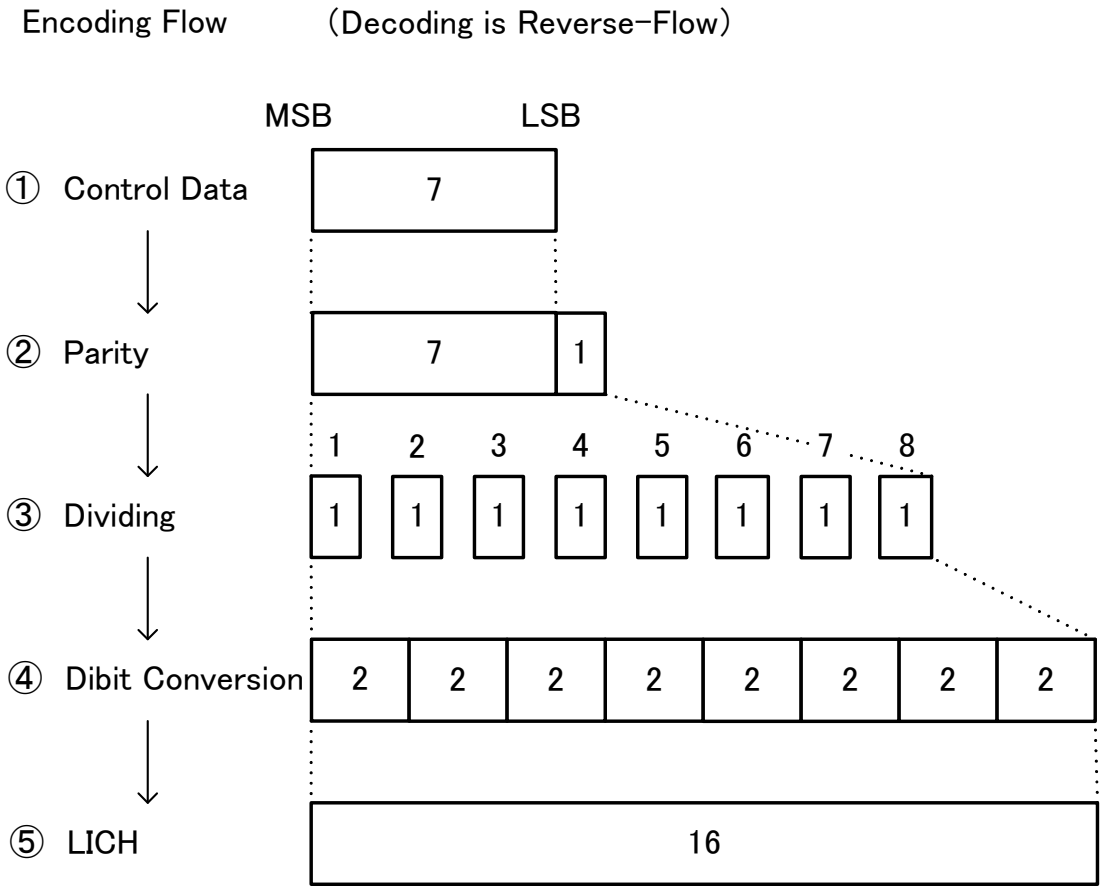
Range of parity shall be 4 most significant bits.

(3) Error Correction Code

None

(4) Interleaving

None



Bit ⟷ Dibit

Coding

Bit	Symbol
0 → 01	+3
1 → 11	−3

Decoding

Symbol	Bit
+3	01 → 0
+1	00 → 0
−1	10 → 1
−3	11 → 1

Figure 4.5-7 LICH Coding Flow

4.5.4. Order of Transmitting Data

This section describes the order of transmission data by referring to the outbound control channel.

The bit structure of the SR information (R7 to R0) and the layer 3 message (D143 to D0) in the layer 3 information are described in Figure 4.5-8 and Figure 4.5-9.

Data readout order shall be from Bit 7 (R7) in the SR information, and from Bit 7 (D143) of Octet 0 in the layer 3 message.

Bit	7	6	5	4	3	2	1	0
	R7	R6	R5	R4	R3	R2	R1	R0

Figure 4.5-8 SR Information Bit Structure

Bit	7	6	5	4	3	2	1	0
Octet0	D143	D142	D141	D140	D139	D138	D137	D136
▪ ▪ ▪					▪ ▪ ▪			
Octet17	D7	D6	D5	D4	D3	D2	D1	D0

Figure 4.5-9 L3 Bit Structure

The following data sequence to which 3 null bits, CRC bits (S15 to S0), and 4 fixed tail bits are appended, is the data sequence before convolutional encoding.

R7･･R0	D143････････････D0	000	S15･･･S0	0000

Figure 4.5-10 Data Before Convolutional Encoding

In convolutional encoding, the data sequence starting from the R7 is entered to the generator polynomials, G1(D) and G2(D) as described in Section 4.5.1.1, and then the generated codeword X2i-1, X2i (i = 1 to 175) is read out in the order of X1, X2...

In punctured coding, the bits corresponding to the position of "0" in punctured matrix shall be periodically erased from the convolutional encoded data sequence, X1, X2 ... X350.

X2i-1	X1	X3	X5	X7	X9	X11	X13 ... X349	1 1 1 1 1 1 1
X2i	X2	X4	X6	X8	X10	X12	X14 ... X350	1 0 1 1 1 0 1

Therefore, X4 and X12 are erased in this case. The data sequence after punctured coding shall be as follows: X1, X2, X3, X5, X6, X7, X8, X9, X10, X11, X13, X14 ... X350.

Assuming that the data sequence after punctured coding is Y1, Y2, Y3 ... Y300, they are allocated as described in Figure 4.5-11, and bit interleaving is executed.

The data sequence after bit interleaving is described in Figure 4.5-12.

As for punctured decoding, dummy bits shall be inserted to the bit position of the reception data sequence corresponding to the bit position erased at the punctured encoding to make the reception data sequence of the same bit length as the original code.

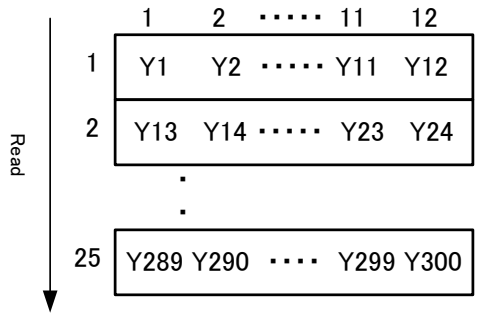


Figure 4.5-11 Interleaving

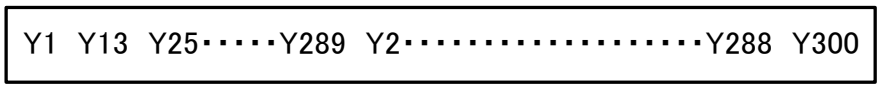


Figure 4.5-12 Interleaved data

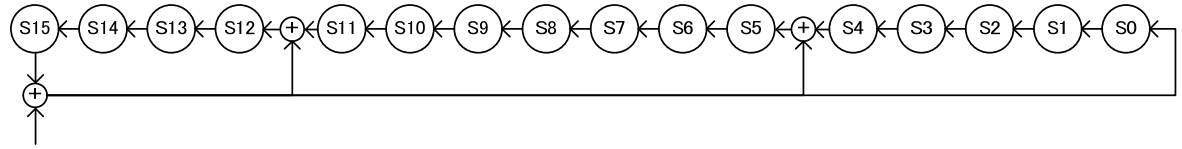
4.5.5. CRC Code

This section describes each CRC code.

The order is determined in descending order from Bit 7 of Octet 0 in layer 3 message as the first bit.

The encoder enters the data to the shift register from the highest order, and generates the shift register value at the time when the last bit is entered. Default values of the shift register shall be set to 1.

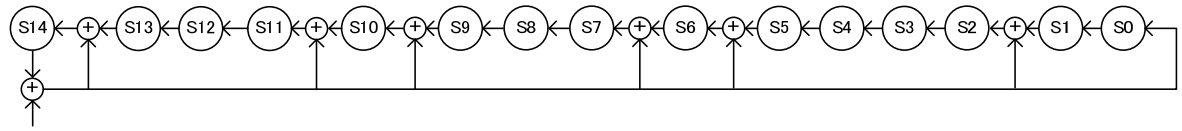
16 bits CRC



Example

CAC Layer 3 155bits	CRC 16bits
b154,b153,b152.....b1,b0	S15,S14....S1,S0

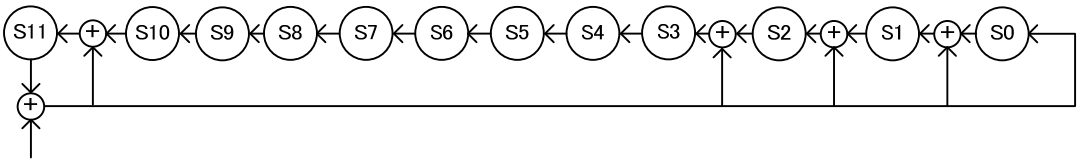
15 bits CRC



Example

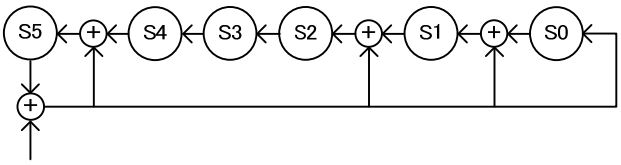
FACCH2 Layer 3 184bits	CRC 15bits
b183,b182,b181.....b1,b0	S14,S13....S1,S0

12 bits CRC



FACCH1 Layer 3 80bits	CRC 12bits
b79,b78,b77.....b1,b0	S11,S10...S1,S0

6 bits CRC



Input

SACCH Layer 3 26bits	CRC 6bits
b25,b24,b23.....b1,b0	S5,S4...S1,S0

Figure 4.5-13 CRC Coder

4.6. Scrambler Method

Control data and voice data, except Frame Sync Word, Guard, Preamble and Post field shall be scrambled.

Scrambling shall be done per symbol and multiply (i.e. sign inversion or noninversion) the symbol sequence by the output from the scrambling generator that is converted the value of 0 into +1 or the value of 1 into -1.

The scrambling generator shall use the following PN code and calculate using the following scramble codes as a default value. Scrambler Code shall be initialized with the default value per frame.

Scramble register	S8	S7	S6	S5	S4	S3	S2	S1	S0
Default value	0	1	1	1	0	0	1	0	0

Table 4.6-1 Default value of Scrambler Code

Generator polynomial: $X^9 + X^4 + 1$

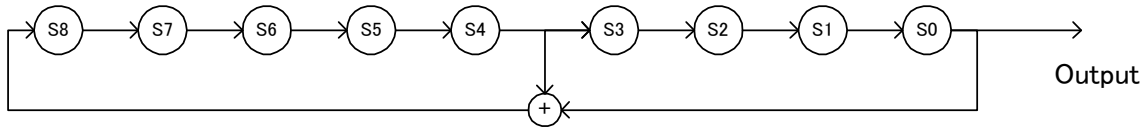


Figure 4.6-1 Scrambling Generator

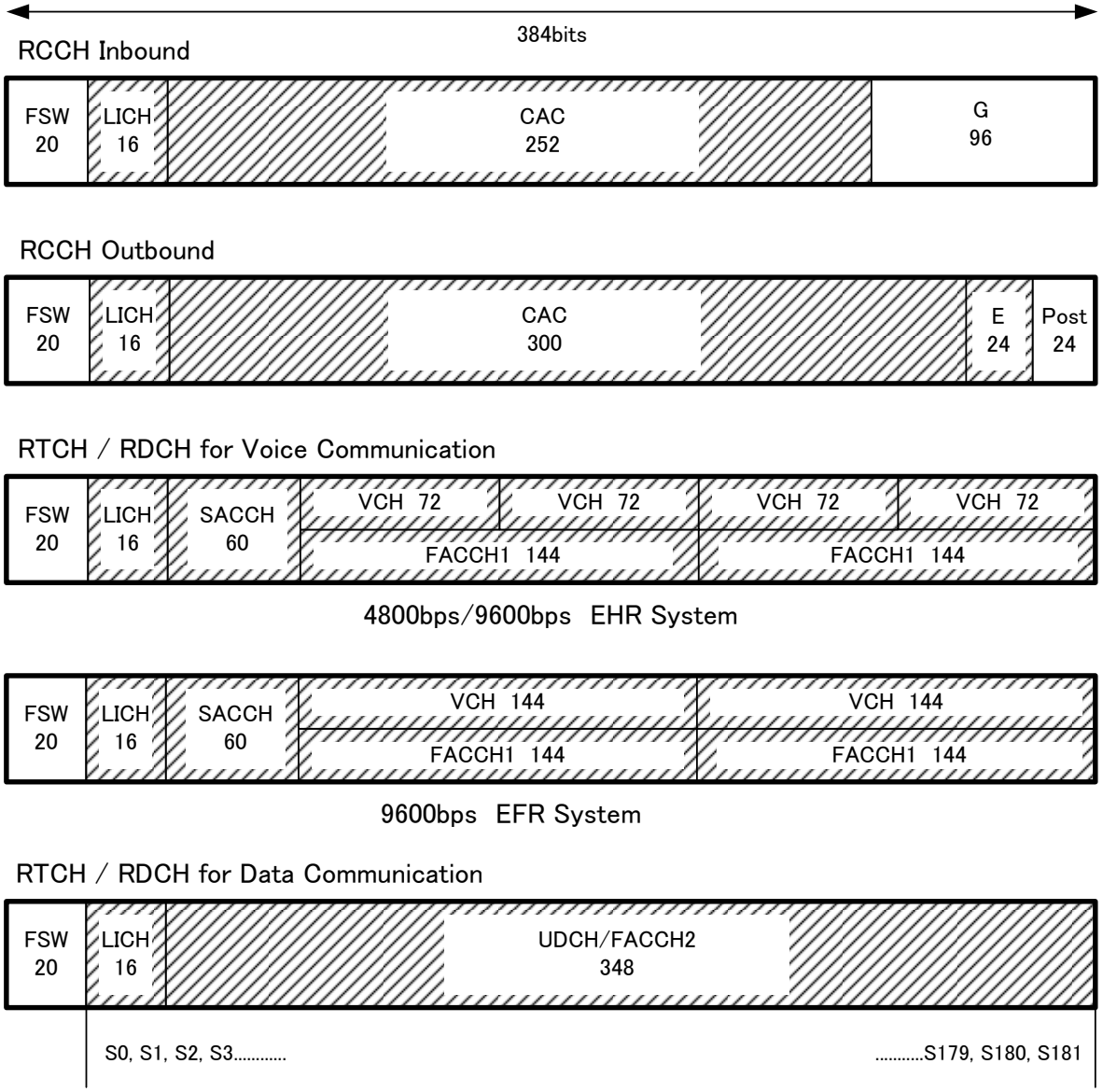


Figure 4.6-2 Scramble Range

5. Transfer Control Method (Layer-2 Standard)

5.1. Outline

This section defines the Transfer Control method (layer 2) in the radio interface in NXDN. Layer 2 specification shall define the frame and channel identification, transmission timing, random access, etc. between opposite stations.

5.2. Identification Information of LICH

LICH has information for identifying RF channels, functional channels, and frame structures related to the channels.

5.2.1. Configuration of LICH

LICH is comprised of 7 bits.

2 most significant bits are used for identification of the RF channel, the subsequent 2 bits are used for identification of the functional channel, and the following 2 bits are used for identification of the frame structure related to the functional channel. LSB specifies the direction of radio communication (inbound/outbound).

The RF channel type is also used to judge a status of frame synchronization, and channel coding is processed using information of the RF channel type.

Configuration of LICH is described in Table 5.2-1.

Transmission Order →

	MSB 6	5	4	3	2	1	LSB 0
Signal Name	RF Channel Type		Functional Channel Type		Option		Direction
RCCH	0	0	CAC Type		Data Flag		0:Inbound 1:Outbound
RTCH	0	1	USC Type		Steal Flag		
RDCH	1	0	USC Type		Steal Flag		
RTCH_C (Composite Control Channel)	1	1	USC Type		Steal Flag		

Functional Channel Type

CAC Type

4	3	CAC (Inbound)	CAC (Outbound)
0	0	Reserved	CAC
0	1	Long CAC	Reserved
1	0	Reserved	Reserved
1	1	Short CAC	Reserved

USC Type

4	3	
0	0	SACCH (Non-Superframe Structure)
0	1	UDCH
1	0	SACCH (Superframe Structure)
1	1	SACCH (Superframe Structure)/ Idle

It is not mandatory to receive from the next to SACCH.

Option

Data Flag

2	1	CAC (Inbound)	CAC (Outbound)
0	0	Spare	Normal Data
0	1	Spare	Idle Data
1	0	Spare	Common Data
1	1	Spare	Reserved

Normal Data shows the normal control data
Idle Data shows data not required to receive.
Common Data shows data to receive optionally such as additional information.

Steal Flag

2	1	USC = SACCH	USC = UDCH	USC = SACCH/Idle
1	1	No steal (VCH only)	No steal (UDCH)	Spare
1	0	2 VCHs of second half is FACCH1	Reserved	Spare
0	1	2 VCHs of first half is FACCH1	Reserved	Spare
0	0	Both are FACCH1	FACCH2	Spare

Table 5.2-1 Configuration of LICH

5.2.2. LICH Settings

Based on LICH settings defined in the Section 5.2.1, the bit setting used for the actual operation is defined in Table 5.2-2.

1) Trunked Radio System

RF Channel	TX	RX	Type of RF Channel		Type of Functional Ch.		Option		Direction	Voice (Half)	Voice (Full)*	State
			6	5	4	3	2	1	0			
RCCH	SU	TR	0	0	1	1	0	0	0			CCCH Transmission using Short CAC
	SU	TR	0	0	0	1	0	0	0			UPCH or CCCH Transmission using Long CAC
	TR	SU	0	0	0	0	0	0	1			CAC Transmission
	TR	SU	0	0	0	0	0	1	1			CAC Transmission which has not to be received
	TR	SU	0	0	0	0	1	0	1			CAC Transmission which can be received arbitrarily
RTCH	SU	TR	0	1	1	0	1	1	0	●	●	Voice Call Transmission: superframe SACCH, VCH Only
	SU	TR	0	1	1	0	1	0	0	●	●	Voice Call Transmission: superframe SACCH, first half VCH & last half FACCH1
	SU	TR	0	1	1	0	0	1	0	●	●	Voice Call Transmission: superframe SACCH, first half FACCH1 & last half VCH
	SU	TR	0	1	1	0	0	0	0	●	●	Voice Call Transmission: superframe SACCH, two FACCH1s
	SU	TR	0	1	0	0	0	0	0	●	●	Voice Call Transmission: non-superframe SACCH, two FACCH1s
	SU	TR	0	1	0	1	1	1	0			UDCH Transmission
	SU	TR	0	1	0	1	0	0	0			FACCH2 Transmission
	SU	TR	0	1	1	1	0	0	0	●		Voice Call Transmission: superframe SACCH, Idle State
	TR	SU	0	1	1	0	1	1	1	●	●	Voice Call Transmission: superframe SACCH, VCH Only
	TR	SU	0	1	1	0	1	0	1	●	●	Voice Call Transmission: superframe SACCH, first half VCH & last half FACCH1
	TR	SU	0	1	1	0	0	1	1	●	●	Voice Call Transmission: superframe SACCH, first half FACCH1 & last half VCH
	TR	SU	0	1	1	0	0	0	1	●	●	Voice Call Transmission: superframe SACCH, two FACCH1s
	TR	SU	0	1	0	0	0	0	1	●	●	Voice Call Transmission: non-superframe SACCH, two FACCH1s
	TR	SU	0	1	0	1	1	1	1			UDCH Transmission
	TR	SU	0	1	0	1	0	0	1			FACCH2 Transmission
	TR	SU	0	1	1	1	0	0	1	●		Voice Call Transmission: superframe SACCH, Idle State
RTCH_C	TR	SU	1	1	1	0	1	1	1	●	●	Voice Call Transmission: superframe SACCH, VCH Only
	TR	SU	1	1	1	0	1	0	1	●	●	Voice Call Transmission: superframe SACCH, first half VCH & last half FACCH1
	TR	SU	1	1	1	0	0	1	1	●	●	Voice Call Transmission: superframe SACCH, first half FACCH1 & last half VCH
	TR	SU	1	1	1	0	0	0	1	●	●	Voice Call Transmission: superframe SACCH, two FACCH1s
	TR	SU	1	1	0	0	0	0	1	●	●	Voice Call Transmission: non-superframe SACCH, two FACCH1s
	TR	SU	1	1	0	1	1	1	1			UDCH Transmission
	TR	SU	1	1	0	1	0	0	1			FACCH2 Transmission
	TR	SU	1	1	1	1	0	0	1	●		Voice Call Transmission: superframe SACCH, Idle State

Note:
* indicates optional supports

2) Conventional System

RF Channel	TX	RX	Type of RF Channel		Type of Functional Ch.		Option		Direction	Voice (Half)	Voice (Full)*	State
			6	5	4	3	2	1	0			
RDCH	SU	CR/SU	1	0	1	0	1	1	0	●	●	Voice Call Transmission: superframe SACCH, VCH Only
	SU	CR/SU	1	0	1	0	1	0	0	●	●	Voice Call Transmission: superframe SACCH, first half VCH & last half FACCH1
	SU	CR/SU	1	0	1	0	0	1	0	●	●	Voice Call Transmission: superframe SACCH, first half FACCH1 & last half VCH
	SU	CR/SU	1	0	1	0	0	0	0	●	●	Voice Call Transmission: superframe SACCH, two FACCH1s
	SU	CR/SU	1	0	0	0	0	0	0	●	●	Voice Call Transmission: non-superframe SACCH, two FACCH1s
	SU	CR/SU	1	0	0	1	1	1	0			UDCH Transmission
	SU	CR/SU	1	0	0	1	0	0	0			FACCH2 Transmission
	SU	CR/SU	1	0	1	1	0	0	0	●		Voice Call Transmission: superframe SACCH, Idle State
	CR	SU	1	0	1	0	1	1	1	●	●	Voice Call Transmission: superframe SACCH, VCH Only
	CR	SU	1	0	1	0	1	0	1	●	●	Voice Call Transmission: superframe SACCH, first half VCH & last half FACCH1
	CR	SU	1	0	1	0	0	1	1	●	●	Voice Call Transmission: superframe SACCH, first half FACCH1 & last half VCH
	CR	SU	1	0	1	0	0	0	1	●	●	Voice Call Transmission: superframe SACCH, two FACCH1s
	CR	SU	1	0	0	0	0	0	1	●	●	Voice Call Transmission: non-superframe SACCH, two FACCH1s
	CR	SU	1	0	0	1	1	1	1			UDCH Transmission
	CR	SU	1	0	0	1	0	0	1			FACCH2 Transmission
	CR	SU	1	0	1	1	0	0	1	●		Voice Call Transmission: superframe SACCH, Idle State

Note:
* indicates optional supports
In transmitting toward a mobile station from a console connected to the repeater in a conventional system, since a console is recognized as a mobile station, the path of the console to the repeater is considered as inbound and the path of the repeater to a mobile station is considered as outbound.

Table 5.2-2 LICH Settings

5.3. Frame Synchronization

This section defines an acquisition and loss condition regarding frame synchronization. If the RF channel type of LICH is part of the synchronization condition, it is subject to when the parity bit of LICH does not indicate errors.

5.3.1. Synchronization Conditions

5.3.1.1. Frame Synchronization in Trunked Radio System

Conditions of frame synchronization for a SU in a trunked radio system are defined as follows. Conditions for a Trunking Repeater are not specified.

5.3.1.1.1. Capture of RCCH

(1) Frame Synchronization

When a Frame Sync Word is received N_1 times continuously, or a Sync Word combined with the last 9 symbols in the post field is received N_6 times continuously, and if the frame when reception has completed under the said conditions represents RCCH as the RF channel type of LICH, frame synchronization shall be established. If the RF channel type of LICH is RTCH or RDCH, the receiver can determine to be channels other than the RCCH.

(2) Superframe Synchronization

After frame synchronization is established, superframe synchronization shall be established if the number of frame in the superframe is determined through BCCH.

5.3.1.1.2. Capture of RTCH

(1) Initial Synchronization

RTCH is normally activated only when a SU does channel switching from RCCH. Therefore, the SU shall establish synchronization when the Frame Sync Word is received N_2 times continuously under retaining the acquired frame synchronization timing on RCCH. LICH is not included in the synchronization condition.

(2) Resynchronization in Hold Time

If Hold Time is configured in a Trunking Repeater, the Trunking Repeater keeps transmitting until the Hold Time expires after a SU terminates transmission. Therefore, the SU must resynchronize after terminating the transmission. However, If the reception timing before the transmission is retained in the SU, synchronization can be established when the Frame Sync Word is received N_3 times continuously, in the range of ±2 symbols in timing.

(3) Resynchronization in the case of timing lost or desynchronization

When the initial synchronization or the resynchronization after terminating the transmission are not established under the said conditions, or when resynchronization occurs after a desynchronized status, the SU may establish synchronization when the Frame Sync Word is received N_4 times continuously.

5.3.1.2. Frame Synchronization in Conventional System

Conditions of frame synchronization for a SU via a Conventional Repeater in a conventional system are defined as follows. Conditions for the Conventional Repeater are not specified. LICH is not included in the condition of frame synchronization.

(1) Initial Synchronization

The SU shall establish synchronization when the Frame Sync Word is received N_5 times continuously. However, if a Sync Word combined with the last 9 symbols of the preamble is detected, the SU can establish synchronization when the Sync Word is received N_6 times continuously.

(2) Resynchronization in Hold Time

If Hold Time is configured in a Conventional Repeater, the Conventional Repeater keeps transmitting until the Hold Time elapses after a SU terminates transmission. Therefore, the SU must resynchronize after terminating the transmission. However, If the reception timing before the transmission is retained in the SU, synchronization can be established when the Frame Sync Word is received N_3 times continuously, in the range of ±2 symbols in timing.

(3) Resynchronization in the case of timing lost or desynchronization

When the initial synchronization or the resynchronization after terminating the transmission are not established under the said conditions, or when resynchronization occurs after a desynchronized status, the SU may establish synchronization when the Frame Sync Word is received N_4 times continuously.

5.3.1.3. Frame Synchronization in Direct Mode Operation (DMO)

Conditions of frame synchronization during direct mode in a conventional system are defined as follows.

(1) Initial Synchronization

The SU shall establish synchronization when the Frame Sync Word is received N_5 times continuously. However, if a Sync Word combined with the last 9 symbols of the preamble is detected, the SU can establish synchronization when the Sync Word is received N_6 times continuously. LICH is not included in the condition of frame synchronization.

5.3.2. Desynchronization Conditions

5.3.2.1. Desynchronization in Trunked Radio System

5.3.2.1.1. Desynchronization on RCCH

If a Frame Sync Word is undetected N_7 times continuously or if a RF channel type of LICH indicates anything other than the RCCH S_1 times or more continuously, a desynchronization shall occur. Behaviors after detecting the desynchronization are not specified.

5.3.2.1.2. Desynchronization on RTCH

If a Frame Sync Word is undetected N_7 times continuously or if a RF channel type of LICH indicates anything other than the RTCH S_1 times or more continuously, a desynchronization shall occur. Behaviors after detecting the desynchronization are not specified.

5.3.2.2. Desynchronization in Conventional System

When a Frame Sync Word is undetected N_7 times continuously or if a RF channel type of LICH indicates anything other than the RDCH S_1 times or more continuously, a desynchronization shall occur. Behaviors after detecting the desynchronization are not specified.

5.3.2.3. Desynchronization in Direct Mode Operation (DMO)

Conditions are the same as that of Section 5.3.2.2.

5.4. RF Channel Activation and deactivation

(1) RCCH

RCCH in a Trunking Repeater is always activated as a common control channel. However, a channel switch is executed in accordance with the upper layers procedure when RCCH is switched or turns into a Composite Control Channel.

In a trunked radio system, a SU activates a control channel when the SU is activated (during power-up or by a user operation), an RCCH switch occurs by Site Roaming or System Roaming, or an RTCH is terminated. The control channel is automatically deactivated when an RTCH is activated, an RCCH is switched to another RCCH, or a SU is turned off.

(2) RTCH

In a Trunking Repeater, an RTCH is activated by the RTCH activation request from layer 3, and transmission and reception are activated at the same time. Reception activation completes after analyzing a transmission signal from a SU and establishing synchronization.

In a SU, an RTCH activation is initiated by the RTCH activation request from layer 3 and completes after analyzing a transmission signal from a Trunking Repeater and establishing synchronization. Subject to activation from an RCCH, an RTCH cannot be activated unless synchronization is established on an RCCH. In a SU that transmits during the initial RTCH activation, RTCH activation completes when the transmission starts followed by reference timing on RCCH. After a SU terminates the transmission, if the Hold Time does not expire, the SU establishes synchronization with a transmission signal from a Trunking Repeater.

Deactivation is done by a disconnect request from a Trunking Repeater after the Hold Time expiration, a desynchronization or a user operation, but details are not specified.

(3) RDCH

RDCH activation completes after analyzing a transmission signal from a Conventional Repeater or another SU and establishing synchronization.

RDCH is deactivated by a disconnect request, a desynchronization or a user operation.

5.5. System Synchronization

5.5.1. Reference Timing

Figure 5.5-1 shows the transmission and reception timing in a trunked radio system and a conventional system with a Conventional Repeater.

In a trunked radio system, all transmission and reception timings shall be based on a RCCH in a TRS.

Transmission timing of a Trunking Repeater used as a RTCH shall synchronize the timing of RCCH. A SU shall transmit and receive by synchronization with the timing of the Trunking Repeater.

In a conventional system with a Conventional Repeater, a transmission frame sent from a SU at the beginning of call shall be applied as an initial timing, and then the SU transmits and receives,

synchronizing on RDCH timing transmitted by the Conventional Repeater until the Hold Time expiration.

The timing in direct mode in a conventional system is not specified.

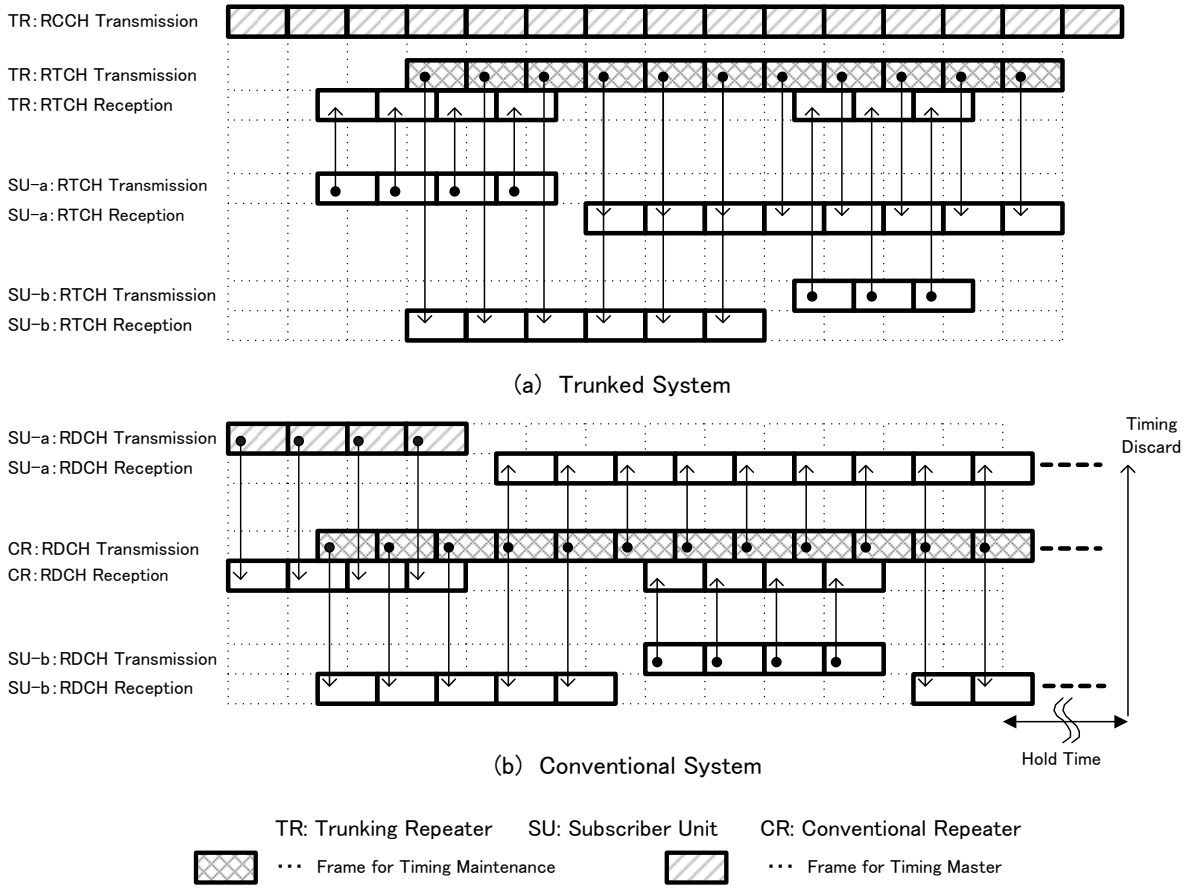


Figure 5.5-1 Timing for Transmitting and Receiving Frames (4800bps)

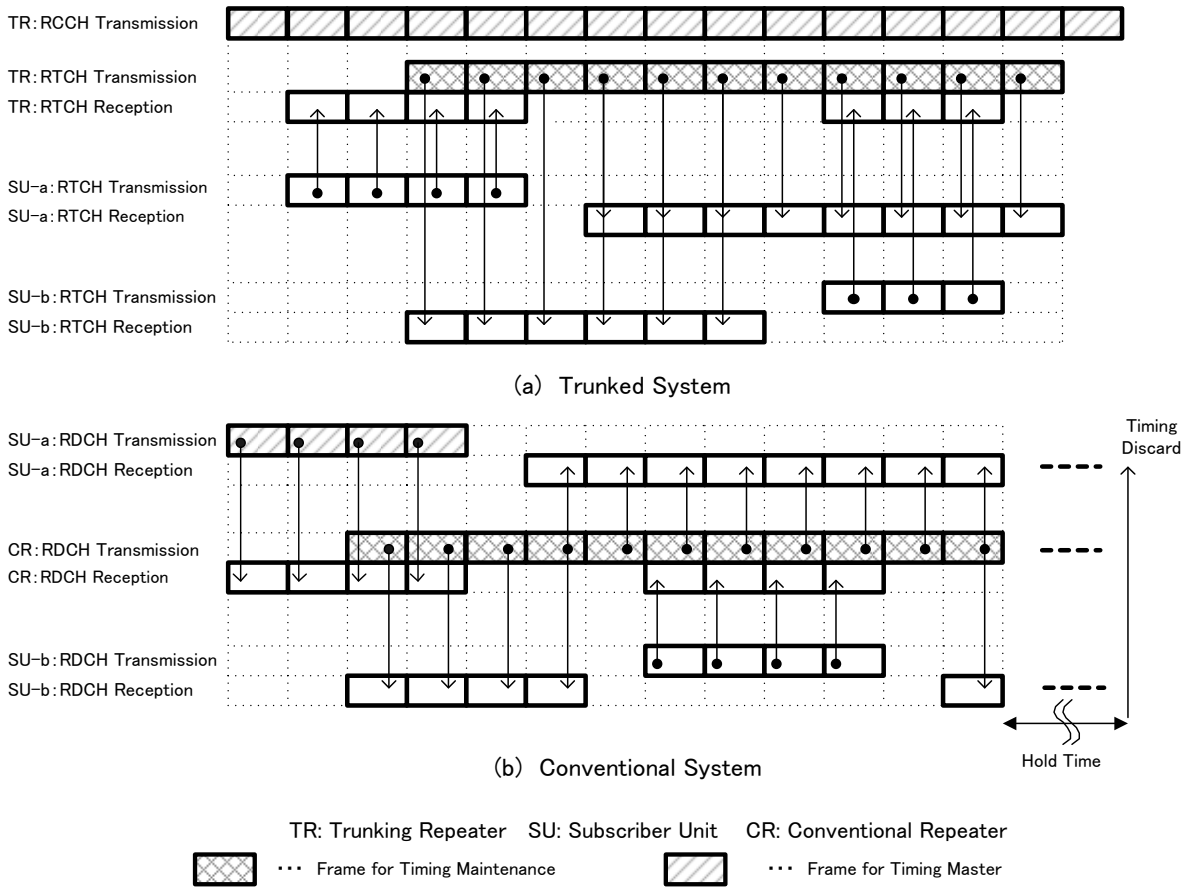


Figure 5.5-2 Timing for Transmitting and Receiving Frames (9600 bps)

5.5.2. Transmission Conditions for the Trunking Repeater

In a Trunking Repeater, the transmission start timing for the RCCH initial transmission is not defined in detail, however the same condition as for RTCH is recommended.

The RTCH transmission starts by receiving an RTCH activation request from layer 3, and the transmission power, as defined by the transceiver performance specification, shall be output at the beginning of the FSW in the start frame required by layer 3. End of transmission is controlled by a deactivation request from layer 3.

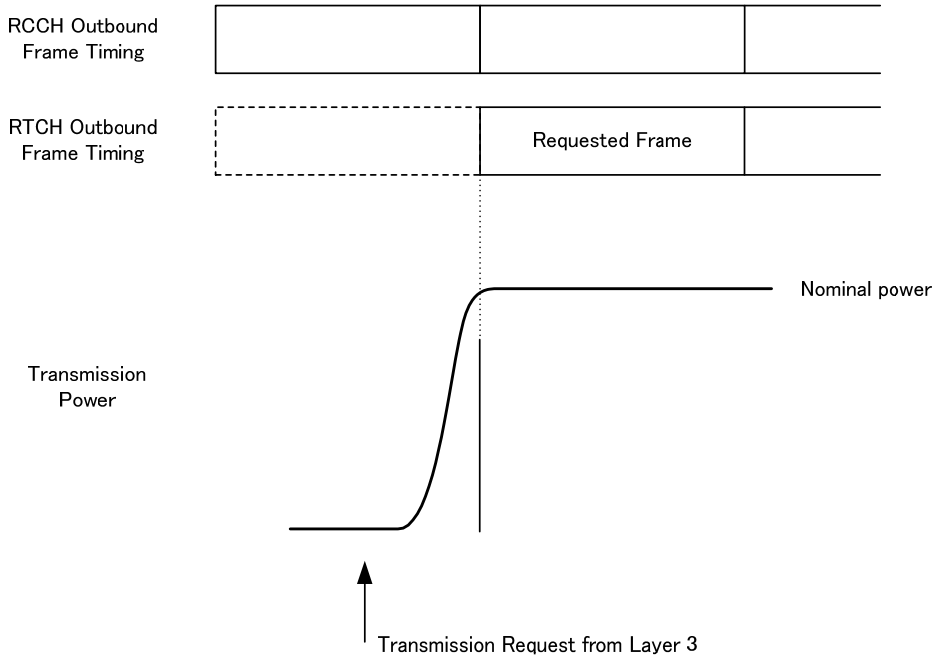


Figure 5.5-3 Transmission Power on RTCH for Trunking Repeater

5.5.3. Transmission Conditions for the SU (Trunked and Conventional System)

5.5.3.1. Standard Transmission

In a trunked radio system, the transmission condition of SUs shall be subject to establishing synchronization.

Standard Transmission timing in a trunked radio system shall be referenced to the received symbol timing. The maximum impulse response of transmitted symbols shall have the same timing as the determination timing of received symbols.

A SU starts transmission after 279 symbols (375 symbols at 9600 bps) from the time when an outbound FSW is detected.

The accuracy of the standard transmission timing shall be the following:

Accuracy: -1 to +1 symbol

The conditions for conventional systems are not specified except that SUs should apply the same condition as a trunked radio system while they synchronize the outbound signal from a Conventional Repeater

5.5.3.2. Transmission Transient Response (Ramp Timing)

(1) RCCH

In the random access transmission of SU on the RCCH, the transmitter power ramps up/down in the guard time.

The power levels for ramp-up/down within the guard time are based on the nominal transmit power specified in transceiver performance specification.

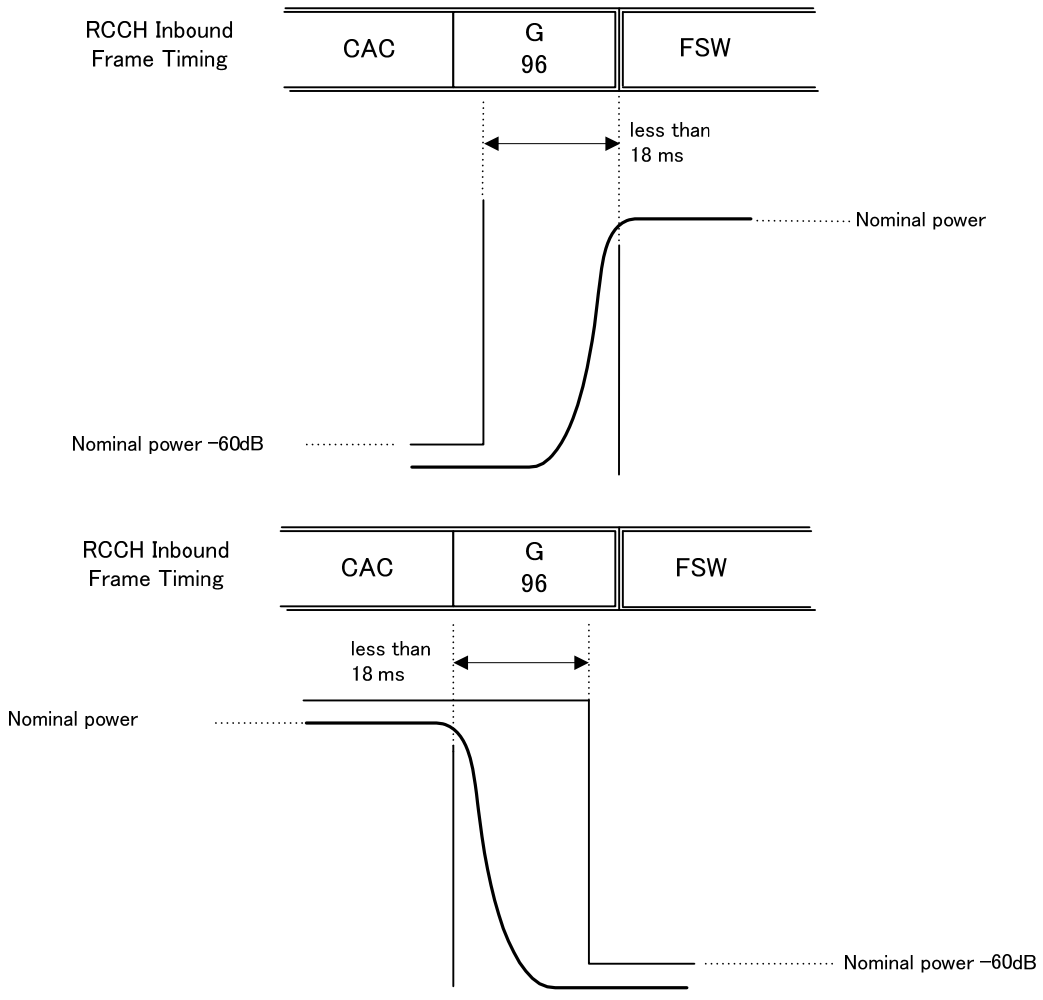


Figure 5.5-4 Transmission Transient Response on RCCH for SU (4800 bps)

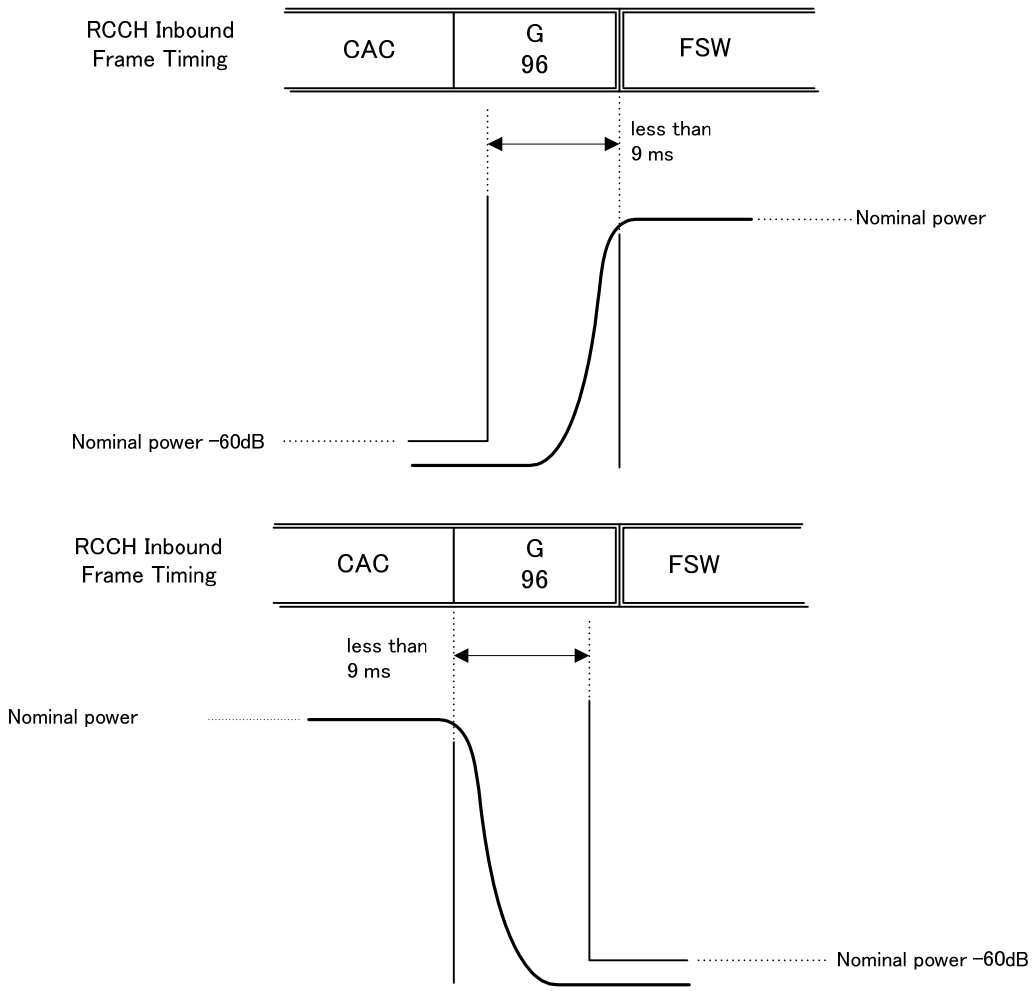


Figure 5.5-5 Transmission Transient Response on RCCH for SU (9600 bps)

(2) RTCH

The RTCH transmission starts by receiving a activation request from layer 3, and the transmitter power, as defined by the transceiver performance specification, shall be output at the beginning of the FSW in the start frame required by layer 3. End of transmission is controlled by the deactivation request from layer 3.

The timing of moving and transmitting from RCCH to RTCH is 40 ms after a Channel Assignment Message is received.

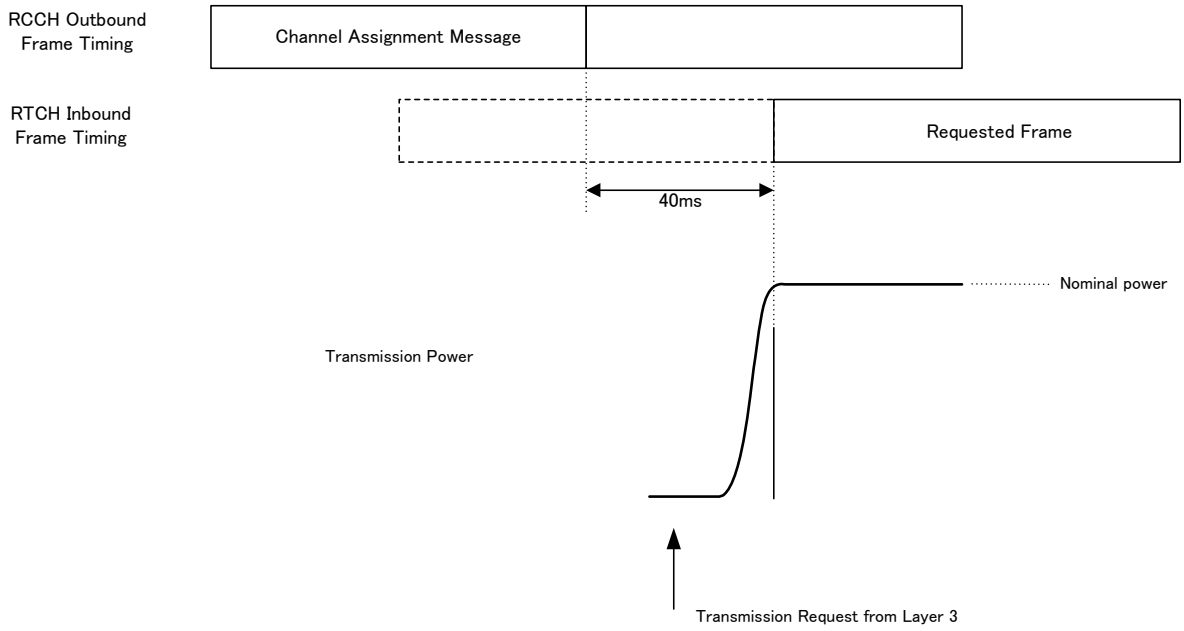


Figure 5.5-6 Transmission Power on RTCH for SU (4800 bps)

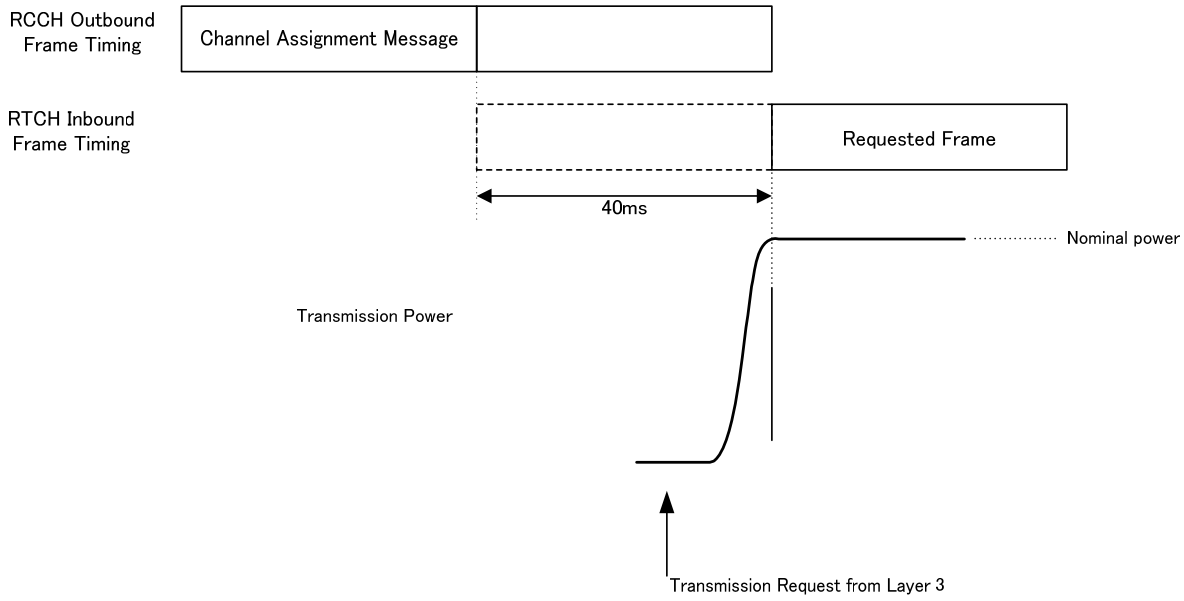


Figure 5.5-7 Transmission Power on RTCH for SUs (9600 bps)

5.6. Random Access Control

On an inbound RCCH, a SU shall transmit using random access method.

This random access transmission uses the Slotted Aloha method, and its protocol is based on the ICMA-PE (Idle-signal Casting Multiple Access with Partial Echo).

A frame normally represents a physical format and a unit represents data separation in layer 3, but here they have the same meaning (the same length of information).

5.6.1. Collision Control Field

Collision Control Field (24 bits) is used in random access, and the structure and the coding procedure shall be defined in Figure 5.6-1.

The bits of I/B, P/D, CK and R/N are converted to dibit respectively. The even parity bit (CK) is calculated from the bits of I/B and P/D. No dibit conversion is applied for PE.

A Trunking Repeater transmits the 16 bits CRC after error correction decoding of Short CAC or Long CAC as PE, and the SU receives PE within 2 bits error allowance. Details of I/B, P/D, R/N and PE are described in the next section.

I/B	P/D	CK	R/N	PE
2	2	2	2	16

Bit ←→ Dibit

Encoding

Bit	Symbol
0 → 01	+3
1 → 11	−3

Decoding

Symbol	Bit
+3	01 → 0
+1	00 → 0
−1	10 → 1
−3	11 → 1

I/B
- 1: Idle (I)
- 0: Busy (B)

P/D
- 1: Permit to transmit continuously (P)
- 0: Don't permit to transmit continuously (D)

R/N
- 1: Receive (R)
- 0: No Receive (N)

Figure 5.6-1 Collision Control Field and Coding Procedure

5.6.2. Operation Description

5.6.2.1. Trunking Repeater

In the case of random access transmission in one frame or four frames, the behavior in 4800 bps is described in Figure 5.6-2 and the behavior in 9600 bps is described in Figure 5.6-3. For description purposes, frame numbers are indicated as (#) or ($), but these frame numbers are not actually used.

The received frames from a SU are indicated by shaded frames.

(1) A transmission of a Collision Control Field is done by timing of each frame.

(2) The Collision Control Field in outbound signal sends the following information:

For instance, the information of outbound frame #3 ($4 at 9600 bps) is shown as follows:

a) I/B (Idle/Busy): shows transmit possible/impossible in the next inbound frame #3 (the same frame number as the outbound frame number, $4 at 9600 bps)

b) R/N (Receive/ Non Receive): shows receive success/fail in inbound frame #0 (the inbound frame that has a number of subtracting 3 from an outbound frame number) or inbound frame $0 (a number of subtracting 4 from an outbound frame number) at 9600 bps

c) P/D (Permit/ Don't Permit): shows continuous transmit permissible/impermissible from the next inbound frame #3 ($4 at 9600 bps)

d) PE (Partial_Echo): shows decoding results of received CRC in inbound frame #0 ($0 at 9600 bps)

(3) When the signal from a SU is received, “R” shall be configured for R/N, and the decoding result of received CRC is configured for PE.

(4) According to the information for message length of received messages, “P” is configured for P/D, and “B” is configured for I/B if continuous transmission is permitted.

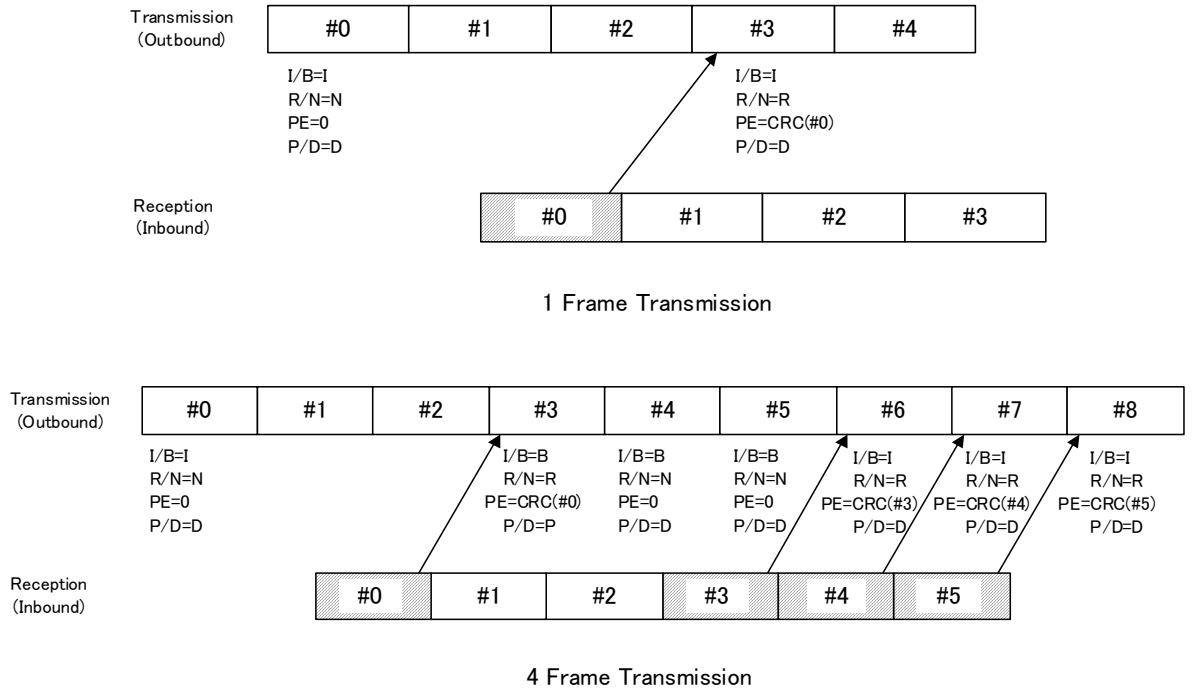


Figure 5.6-2 Trunking Repeater (4800 bps)

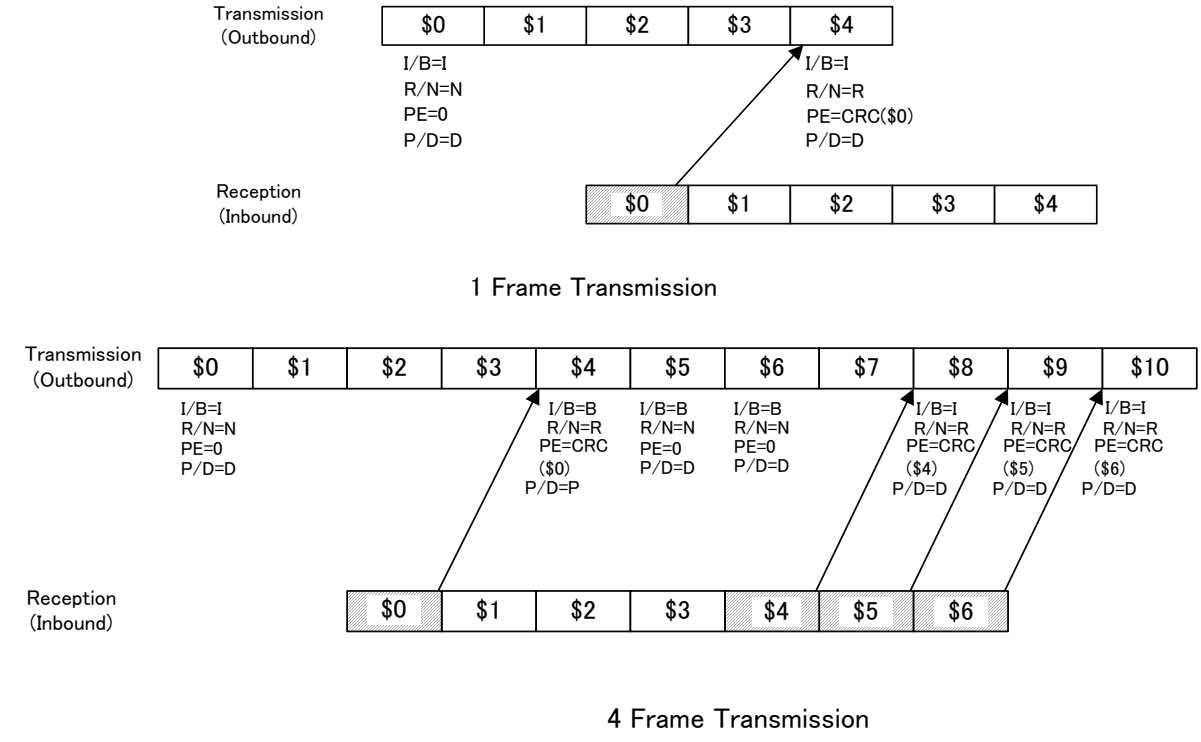


Figure 5.6-3 Trunking Repeater (9600 bps)

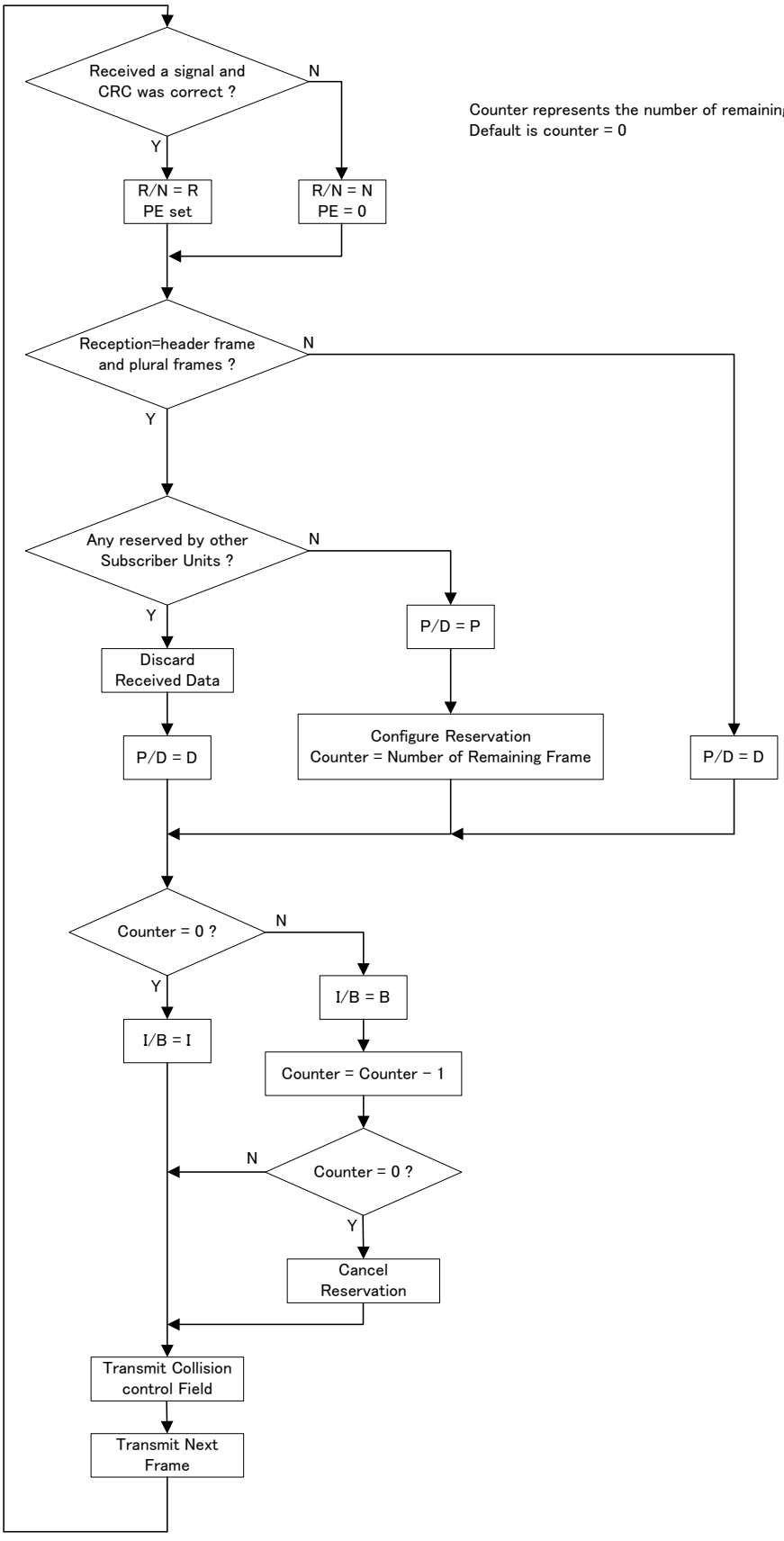


Figure 5.6-4 Operation Flow of Trunking Repeater

5.6.2.2. Subscriber Unit

(1) A random access transmission is done by timing of each frame.

(2) If any send data exists, the first frame shall be transmitted in an inbound frame (the inbound frame having the same number as received outbound frame) next to the frame representing I/B = “I”. SUs shall not transmit if an error is detected by CK.

(3) The SU return to receive mode immediately after transmitting the first frame, and read the information for the Collision Control Field of the outbound frame (the outbound frame having a number of adding 3 to an inbound frame number, or the outbound frame having a number of adding 4 to an inbound frame number at 9600 bps).

(4) The SU deems the 1st unit has been successfully transmitted when R/N = “R” and PE is 2 bits or less error compared to a CRC check bit transmitted by itself.

(5) If the transmission of the 1st unit does not satisfy the conditions as above, the 1st unit is retransmitted after the random delay within the random delay time T2. Transmission fails when the maximum retry times have been exhausted (Recycle Over).

(6) In the state of (4), if data consists of 1 unit or more, the remaining units can be transmitted continuously when P/D = “P” as well as the detection condition of (4). The SU shall not transmit the remaining units if an error is detected by CK.

(7) If a repeater does not correctly receive continuously transmitted data, a retry by upper layers may be used.

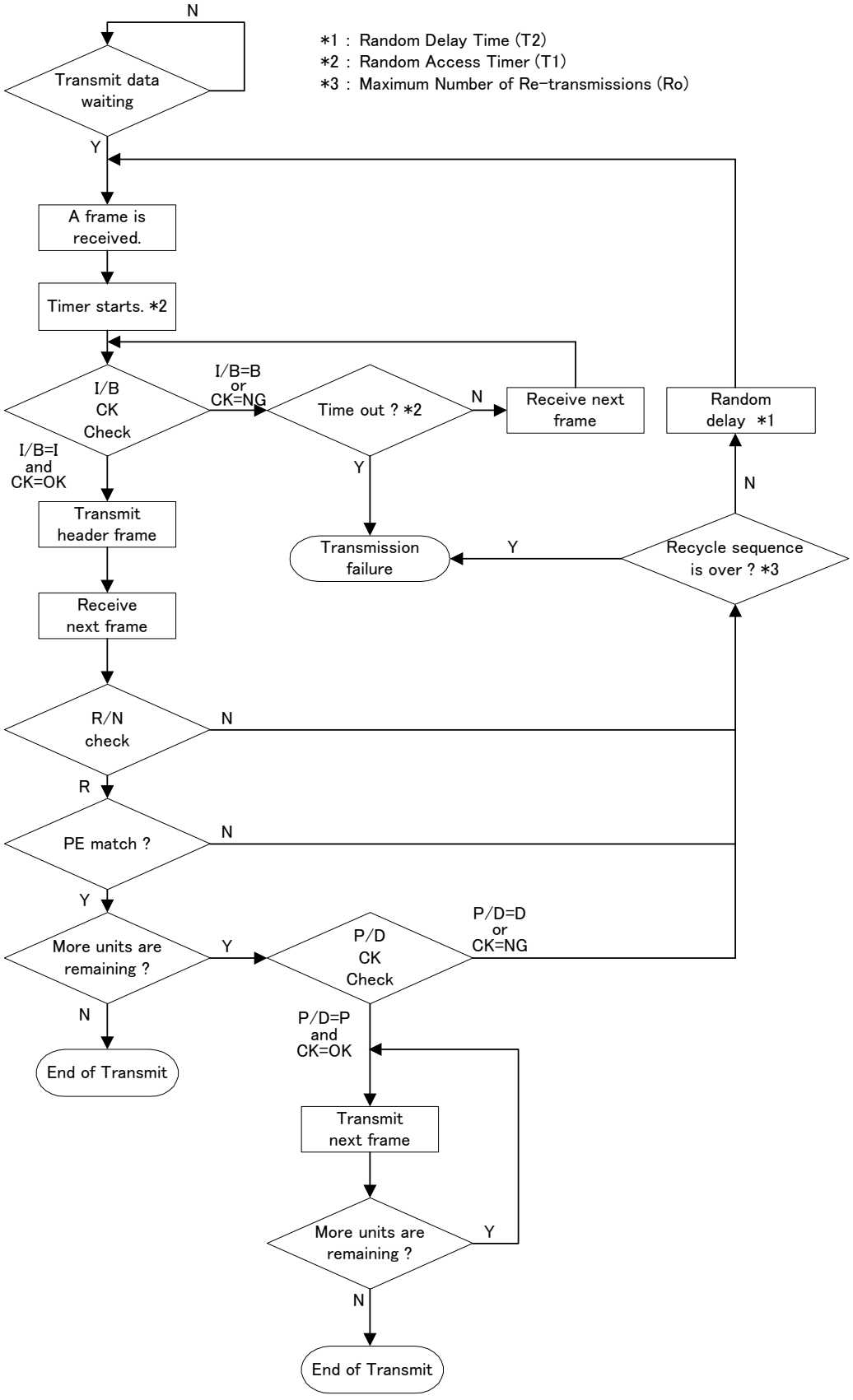
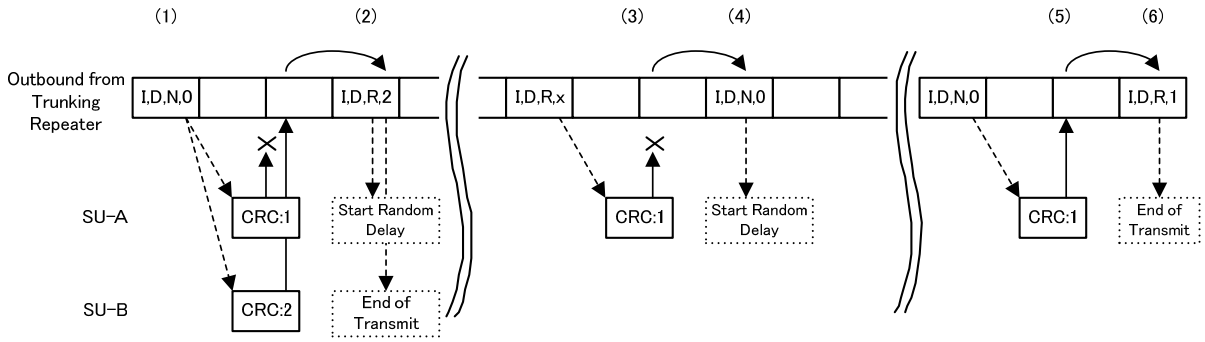
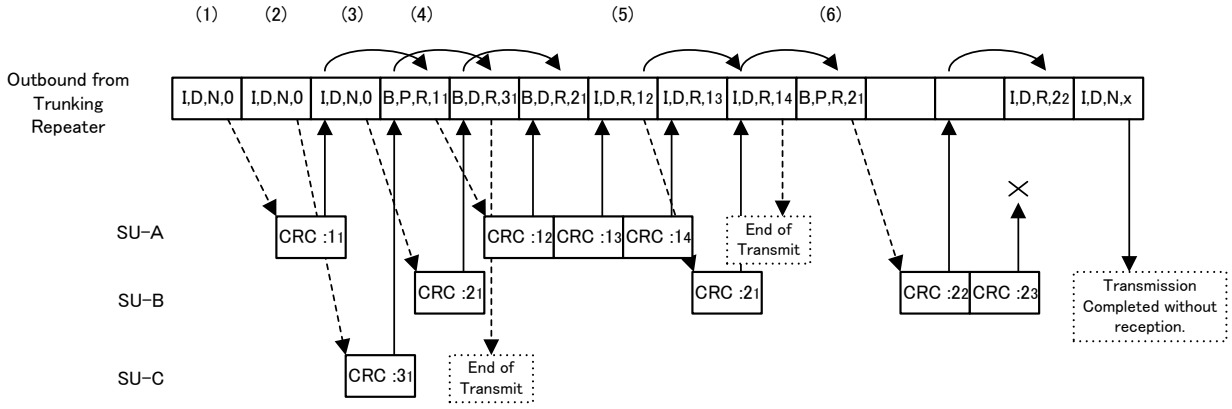


Figure 5.6-5　Operation Flow of SU



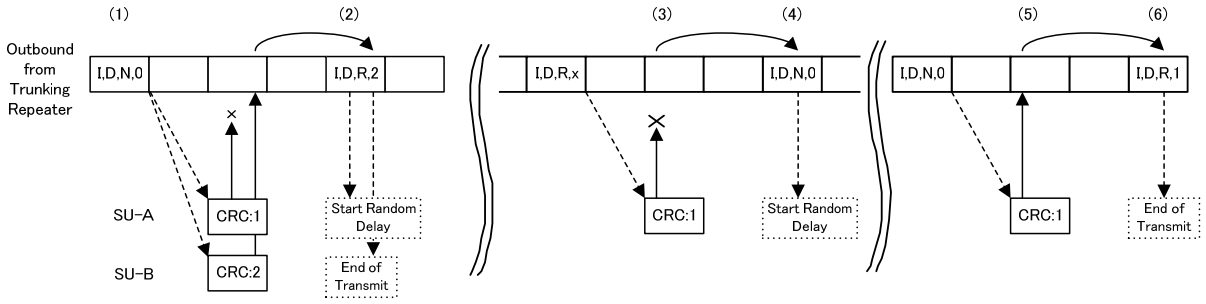
SU-A started the transmission after receiving frame (1) because the frame (1) collision control was I/B = “I”. But since SU-B started the transmission at the same time, a collision was caused and the SU-B transmission data reached the TR. At the timing of frame (2), TR notified of R/N = "R” and PE = “2” which is the same as the CRC transmitted by SU-B.
Both SU-A and SU-B received the collision control data at the timing of frame (2), and the state of SU-A went transmission failure while SU-B went transmission success.
At the timing of frame (3), SU-A retransmitted after the random delay time due to the transmission failure. But since the transmitted signal did not reach TR again because of the poor RF conditions, the TR notified of R/N = “N” and PE = “0” at frame (4).
SU-A recognized the transmission failure and retransmitted again at frame (5) after the random delay time. Since the TR notified of R/N = “R” and PE = “1” which is the same as the CRC transmitted by SU-A at frame (6), the state of SU-A went transmission success and completed the random access.

Figure 5.6-6 Collision Control for One Frame Transmission (4800 bps)



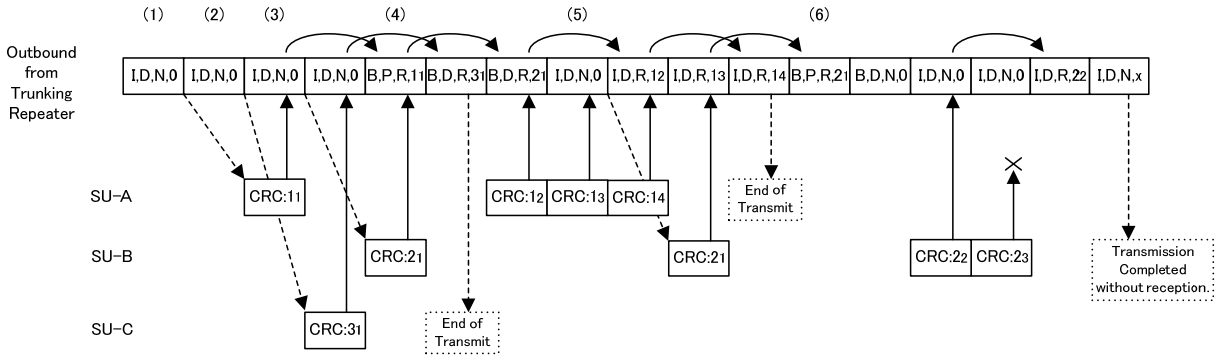
SU-A started the transmission after receiving frame (1) because of I/B = “I”. SU-A’s transmission data indicates that the number of frames is 4 frames. SU-B started the transmission after receiving frame (3) because of I/B = “I”. SU-B’s transmission data indicates that the number of frames is 3 frames. TR received data from SU-A, and configures the P/D = “P” at frame (4) and I/B = “B” in the following 2 frames because the received data indicated continuous data (more than 1 frame).
SU-A transmitted 3 frames continuously because the P/D = “P” and PE was the same as the CRC transmitted by SU-A at frame (4).
SU-B started the transmission after receiving frame (3) because of I/B = “I”, but activated the random delay timer to retransmit because of P/D = “D”.
SU-A completed the transmission after transmitting all the data. (Regardless of the data received.)
SU-B transmitted the 1st frame after the random delay time and then transmitted the following 2 frames after receiving frame (6) because the P/D = “P” and PE was the same as the CRC transmitted by SU-B. The last frame of SU-B did not reach TR. Although R/N = “N”, SU-B completed the transmission since all the data were sent.
This example is the case that SU-B could receive the I/B = “I” at frame (5). But if it could not receive the Idle (I), the reserved transmission is considered as a failure after the random access timer expires, and SU needs to try another random access sequence. If TR's response to the 1st frame was R/N = “N”, PE mismatching, or P/D = “D” for the continuous transmission request, SU can recycle the random access automatically within the maximum number of re-transmissions. In the case that a frame error occurs during the continuous transmission and all frames do not reach TR correctly, SU must wait for the retransmission request from TR and cannot carry out the recycle sequence.
Additionally SU-C transmits at frame (3) after receiving frame (2), but this does not affect SU-A or SU-B activities.

Figure 5.6-7 Collision Control for Two or More Frames Transmission (4800 bps)



SU-A started the transmission after receiving frame (1) because the frame (1) collision control was B/I = “I”. But since SU-B started the transmission at the same time, a collision was caused and the SU-B transmission data reached the TR. At the timing of frame (2), TR notified of R/N = “R” and PE = “2” which is the same as the CRC transmitted by SU-B.
Both SU-A and SU-B received the collision control data at the timing of frame (2), and the state of SU-A went transmission failure while SU-B went transmission success.
At the timing of frame (3), SU-A retransmitted after the random delay time due to the transmission failure. But since the transmitted signal did not reach TR again because of the poor RF conditions, the TR notified of R/N = “N” and P/E = “0” at frame (4).
SU-A recognized the transmission failure and retransmitted again at frame (5) after the random delay time. Since TR notified of R/N = “R” and PE = “1” which is the same as the CRC transmitted by SU-A at frame (6), the state of SU-A went transmission success and completed the random access.

Figure 5.6-8 Collision Control for One Frame Transmission (9600 bps)



SU-A started the transmission after receiving frame (1) because of I/B = “I”. SU-A’s transmission data indicates that the number of frames is 4 frames. SU-B started the transmission after receiving frame (3) because of I/B = “I”. SU-B’s transmission data indicates that the number of frames is 3 frames. TR received data from SU-A, and configures P/D = “P” at frame (4) and I/B = “B” in the following 2 frames because the received data indicated continuous data (more than 1 frame).
SU-A transmitted 3 frames continuously because the P/D = “P” and PE was the same as the CRC transmitted by SU-A at frame (4).
SU-B started the transmission after receiving frame (3) because of I/B = “I”, but activated the random delay timer to retransmit because P/D = “D”.
SU-A completed the transmission after transmitting all the data. (Regardless of the data received)
SU-B transmitted the 1st frame after a random delay time and then transmitted the following 2 frames after receiving frame (6) because the P/D = “P” and PE was the same as the CRC transmitted by SU-B. The last frame of SU-B did not reach TR. Although R/N = “N”, SU-B completed the transmission since all the data were sent.
This example is the case that SU-B could receive the I/B = “I” at frame (5). But if it could not receive the Idle (I), the reserved transmission is considered as a failure after the random access timer expires, and SU needs to try another random access sequence. If TR's response to the 1st frame was R/N = “N”, PE mismatching, or P/D = “D” for the continuous transmission request, SU can recycle the random access automatically within the maximum number of re-transmissions. In the case that a frame error occurs during continuous transmission and all frames do not reach TR correctly, SU must wait for the retransmission request from TR and cannot carry out the recycle sequence.
Additionally the activity of SU-C does not affect both SU-A and SU-B.

Figure 5.6-9 Collision Control for Two or More Frames Transmission (9600 bps)

5.7. Quality Control

5.7.1. RSSI Detection

A SU monitors the reception level at its own station and may use this level as information for open-loop power control or site roaming. The calculation method of the RSSI value (such as moving average or interval average) is not specified. The calculation method of reception level in a Trunking Repeater is not also specified.

5.7.2. BER Detection

The estimation method of bit error rate in error rate detection is not specified. However, it is recommended to calculate this value to facilitate interference detection.

5.7.3. Carrier Detection (Squelch Check)

It is recommended to use a carrier detection so that it will be possible to determine whether input signal exists or not or it will be applicable to perform fast SCAN. Noise squelch or symbol detection may be used for it.

5.8. Transmission Output Control

A SU may have 2 power control functions: a closed-loop power control that controls the transmit power by a command from a Trunking Repeater and an open-loop power control that controls its own transmit power.

5.9. Parameter for Layer 2

Values of timers and values for counters used in layer 2 are presented in Table 5.9-1 and Table 5.9-2 respectively. Values of parameters presented in Table 5.9-3 are recommended value.

(1) Timer

Notation	Name	Minimum	Maximum
T1	Random Access Timer	1 s	5 s
T2	Random Delay Timer (Number of Frames)	0	6

Table 5.9-1 Timer

(2) Counter

Notation	Name	Minimum	Maximum
Ro	Maximum Number of Retry for Random Access	1	15

Table 5.9-2 Counter

(3) Parameter

Notation	Name	Default
N_1	Synchronization Establishment Parameter (RCCH)	2 (2 bits error allowance)
N_2	Synchronization Establishment Parameter (RTCH)	1 (2 bits error allowance)
N_3	Resynchronization (while holding the timing) Parameter	1 (2 bits error allowance)
N_4	Resynchronization Parameter	2 (2 bits error allowance)
N_5	Synchronization Establishment Parameter (RDCH)	2 (2 bits error allowance)
N_6	Synchronization Establishment Parameter (Synchronization including the Preamble or the last 9 symbols of the post field)	1 (3 bits error allowance)
N_7	Synchronization Error Parameter	5 (2 bits error allowance)
S1	Synchronization Error Counter (LICH)	5

Table 5.9-3 Parameter

6. Connection Control Method (Layer 3 standard)

6.1. Overview

Layer 3 in the Common Air Interface defines the configuration, maintenance, switching and restoring methods for radio channel connections, and defines the location registration method for a SU. These transactions are applied to messages exchanged via RCCH, RTCH and RDCH used in an NXDN system, and this section intends to specify the characteristics, procedures and messages required in RF transmission management, mobility management and call control.

6.2. Message Format

This section provides the basic configuration of messages used in layer 3.

A layer 3 message basically uses a fixed length format containing a single message.

6.2.1. Common Notation

This section describes the notation of layer 3 message format.

Figure 6.2-1 shows the basic format. Layer 3 messages are represented in Octet, which expresses information of 8-bit length, and Bit within the octet. The first Octet 0 includes the message type. The message type determines the information elements included in Octet 1 and the subsequent Octets. Therefore, the length of Octets represented by n + 1 varies according to the message type.

The order of transmitted bit is from Bit 7 of Octet 0 to Bit 0 of Octet 0, and the same bit ordering is repeated in Octet 1 and the subsequent Octets.

Since the length of Octet varies by message, residual Octets are filled with Null if a short message does not fill all Octets by its information elements.

Octet \ Bit	7	6	5	4	3	2	1	0
0	F1	F2	Message Type					
1	Elements							
2								
. . .								
n-1								
n								

Figure 6.2-1 Layer 3 Message Format

Flag 1 (Octet 0; Bit 7)

Used as a flag for each message. Refer to each message for the usage.

Flag 2 (Octet 0; Bit 6)

Used as a flag for each message. Refer to each message for the usage.

Message Type (Octet 0; Bit 5 to Bit 0)

Indicates the type of layer 3 messages. A maximum of 64 message types can be identified for an inbound control channel, an outbound control channel and a traffic channel respectively.

Elements (Octet 1 to Octet n)

Various information elements are embedded according to message types. Refer to Section 6.5 for the details of information elements.

6.2.2. Functional Channel Format of RCCH

This section describes the layer 3 message format used in a functional channel of RCCH.

On a RCCH, a layer 3 message is embedded in the CAC. The data capacity of the CAC in outbound is 18 octets, while the CAC in inbound is 12 octets or 16 octets.

6.2.2.1. Outbound RCCH

The functional channels used on an outbound RCCH are BCCH, CCCH and UPCH.

BCCH is used to inform of various broadcast information from a TC to SUs.

CCCH is used to inform of various control information from a TC to SUs.

UPCH is used on RCCH to make short data calls. While BCCH and CCCH carry the layer 3 messages completed with single frame, UPCH uses multiple frames to send user data. As described in Section 6.4.1.9 and in Section 6.4.1.10, the layer 3 information is contained in the first UPCH and the other UPCH is mainly used to carry the user data. The first and other UPCHs have different formats for Octet 0 and the area following Octet 1.

On the outbound RCCH, two formats are defined for efficient transmission. One is to carry two layer 3 messages in one CAC, and the other is to carry one message per CAC.

Since many layer 3 messages comprise 9 octets or less, such short messages should use the Dual Message format shown in Figure 6.2-2, while a standard message of 9 octets or more shall use the Single Message format shown in Figure 6.2-3. When the Dual Message format is used, it shall always contain two layer 3 messages. There is no limitation for the combination of these two messages, except that the same message shall not be embedded.

UPCH shall use the Single Message format only.

<table>
<tr><th>Bit
Octet</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th><th>0</th></tr>
<tr><td>0</td><td>F1</td><td>F2</td><td colspan="6">1st Message Type</td></tr>
<tr><td>1</td><td colspan="8" rowspan="4">Elements for 1st Message</td></tr>
<tr><td></td></tr>
<tr><td>…</td></tr>
<tr><td></td></tr>
<tr><td>8</td></tr>
<tr><td>9</td><td>F1</td><td>F2</td><td colspan="6">2nd Message Type</td></tr>
<tr><td>10</td><td colspan="8" rowspan="4">Elements for 2nd Message</td></tr>
<tr><td></td></tr>
<tr><td>…</td></tr>
<tr><td></td></tr>
<tr><td>17</td></tr>
</table>

Figure 6.2-2 Outbound Dual Message Format

Bit / Octet	7	6	5	4	3	2	1	0
0	F1	F2	Message Type					
1	Elements							
2								
…								
16								
17								

Figure 6.2-3 Outbound Single Message Format

6.2.2.2. Inbound RCCH

The function channels used on an inbound RCCH are CCCH and UPCH.

CCCH is used to inform of control information such as request-to-call from a SU to a TC.

UPCH is used on RCCH to make short data calls. While CCCH carries the layer 3 messages completed with single frame, UPCH uses multiple frames to send user data. As described in Section 6.4.1.9 and in Section 6.4.1.10, the layer 3 information is contained in the first UPCH frame and the other UPCH is mainly used to carry the user data. The first and other UPCHs have different formats for Octet 0 and the area following Octet 1.

An inbound CAC has two formats, and most messages use the Short CAC format of 12 octets length. When a long message does not fit in the Short CAC Format, it uses the Long CAC format of 16 octets length. UPCH shall use the Long CAC format only.

Bit / Octet	7	6	5	4	3	2	1	0
0	F1	F2	Message Type					
1	Elements							
2								
…								
10								
11								

Figure 6.2-4 Inbound Short CAC Message Format

Bit / Octet	7	6	5	4	3	2	1	0
0	F1	F2	Message Type					
1	Elements							
2								
…								
14								
15								

Figure 6.2-5 Inbound Long CAC Message Format

6.2.3. Functional Channel Format of RTCH & RDCH

This section describes the layer 3 message format of the functional channels on RTCH/ RDCH.

On the RTCH/ RDCH, the layer 3 messages are embedded in the functional channels of SACCH, FACCH1, FACCH2 and UDCH, and the information capacity of each functional channel is different.

6.2.3.1. SACCH Format

The SACCH, which always associates the VCH for voice call, is mainly used to carry the control information for call such as ID information. SACCH has the capacity to carry 9 octets.

Bit / Octet	7	6	5	4	3	2	1	0
0	F1	F2	Message Type					
1	Elements							
2								
...								
7								
8								

Figure 6.2-6 SACCH Message Format

6.2.3.2. FACCH1 Format

FACCH1, which is used by replacing the VCH for voice call, is mainly used to temporarily send user data during voice call or to carry control information during voice call on RTCH. FACCH1 has the capacity to carry 10 octets.

Bit / Octet	7	6	5	4	3	2	1	0
0	F1	F2	Message Type					
1	Elements							
2								
...								
8								
9								

Figure 6.2-7 FACCH1 Message Format

6.2.3.3. UDCH Format

UDCH is used for data call on a traffic channel. UDCH has the capacity to carry 22 octets.

As described in Section 6.4.1.3 and in Section 6.4.1.4, the layer 3 information is contained in the first UDCH and the other UDCH is mainly used to carry the user data. The first and other UDCHs have different formats for Octet 0 and the area following Octet 1.

Bit / Octet	7	6	5	4	3	2	1	0
0	F1	F2	Message Type					
1	Elements and/or User Data							
2								
...								
20								
21								

Figure 6.2-8 UDCH Message Format

6.2.3.4. FACCH2 Format

FACCH2, which is used by replacing UDCH for data call or is used independently, is mainly used to carry the control information at the end of data call or to make status call on traffic channels. FACCH2 has the capacity to carry 22 octets.

Bit / Octet	7	6	5	4	3	2	1	0
0	F1	F2	Message Type					
1	Elements							
2								
...								
20								
21								

Figure 6.2-9 FACCH2 Message Format

6.3. SR Information

The 8-bit SR information contains the information to identify each channel structure and the Radio Access Number.

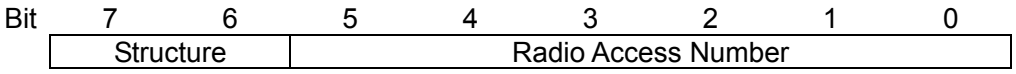


Figure 6.3-1 SR Information Format

6.3.1. Structure Field

The 2-bit Structure field indicates the structure information of radio channels and functional channels. The setting of Structure field depends on radio channels and functional channels.

Bit 1	Bit 0	Description
0		Not head of superframe
1		Head of superframe
	0	Single Message Format
	1	Dual Message Format

Table 6.3-1 Structure Field on Outbound RCCH

Bit 1	Bit 0	Description
0	0	4/4 SACCH (last) or single SACCH
0	1	3/4 SACCH
1	0	2/4 SACCH
1	1	1/4 SACCH (head)

Table 6.3-2 Structure Field on RTCH/RDCH with SACCH

Except for the above radio channels and functional channels, this field is spare.

6.3.2. Radio Access Number Field

In a conventional system, the 6-bit Radio Access Number (RAN) is used to determine a whether a signaling matches in a direct mode, or to identify the access code to a CRS. In a trunked radio system, it is used as a color code for each TRS.

Value (Hex)	Description
00	Unmute on any RAN in Receiver
01 - 3F	User definable

Table 6.3-3 RAN for Conventional Systems

Value (Hex)	Description
00 - 3F	The value obtained with calculation (Site Code) mod (64)

Table 6.3-4 RAN for Trunked Radio Systems

6.3.3. Combining SR and Message

This section describes how to combine the SR and messages.

Except for FACCH1, the SR is added to the head of each message on functional channels. For the SACCH with superframe structure, the 72-bit message is divided into four 18-bit data, and the SR is added to the head of each 18 bits. For the SACCH without superframe structure, the bit length of the message is substantively 18 bits but not 72 bits and the SR is added to the head of 18-bit message.

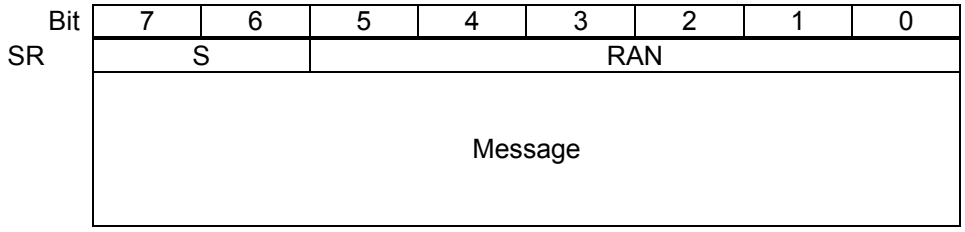


Figure 6.3-2 Combining SR and Message

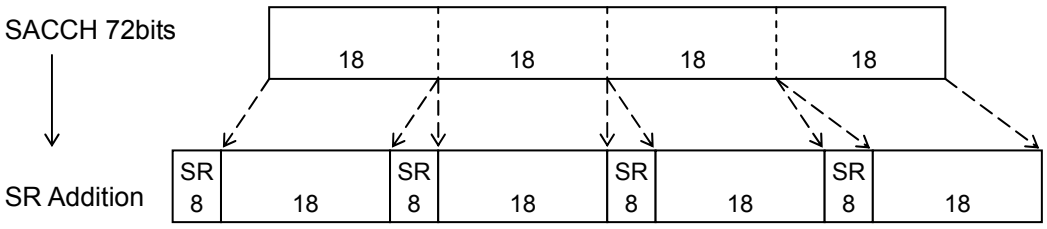


Figure 6.3-3 Procedure for Splitting SACCH and Adding SR

6.4. Message Definitions

This section describes the definition of each layer 3 message.

It is defined which functional channel each message uses and what type of control information each message sends, and the messages are grouped into the following three categories according to its purpose.

- Call Control message used during a call to control or terminate the calls.
- Mobility Management message used to register a subscriber location.
- Broadcast message used to broadcast information of a trunked radio system.

The following section describes the detailed definition such as function of each message, the functional channel used and the radio system type applied. The M/O symbol at the right of each message format indicates whether that information element is Mandatory or Optional.

6.4.1. Call Control Messages

Call Control message is used for voice call service, data call service or additional services such as status call. Call Control message can be subdivided as described in Table 6.4-1 to Table 6.4-4.

Message Name (Alias)	Description	In/Out	CH	Trunk Conv.	Message Type
Voice Call (VCALL)	It indicates during Voice Call	Both	SA FA1	Both	00 0001
Voice Call Initialization Vector (VCALL_IV)	It indicates a transmission of an initialization vector	Both	SA FA1	Both	00 0011
Data Call (Header format) (DCALL)	It indicates during Data call	Both	UD	Both	00 1001
Data Call (User Data format) (DCALL)	It indicates during Data call	Both	UD	Both	00 1011
Data Call Acknowledge (DCALL_ACK)	It indicates a response to Data Call	Both	UD	Both	00 1100
Transmission Release (TX_REL)	It indicates transmission released	Both	FA1 FA2	Both	00 1000
Transmission Release Extension (TX_REL_EX)	It indicates transmission released	Out	FA1 FA2	Trunk	00 0111
Header Delay (HEAD_DLY)	It indicates a delay time until 1st frame is sent out	Both	FA2	Both	00 1111

Table 6.4-1 Messages Used on a RTCH & RDCH

Message Name (Alias)	Description	In/Out	CH	Trunk Conv.	Message Type
Short Data Call Request (Header format) (SDCALL_REQ)	It indicates a request of Short Data Call or Simultaneous Data Call	Both	UP FA1	Both	11 1000
Short Data Call Request (User Data format) (SDCALL_REQ)	It indicates a request of Short Data Call or Simultaneous Data Call	Both	UP FA1	Both	11 1001
Short Data Call Response (SDCALL_RESP)	It indicates a response to Short Data Call or Simultaneous Data Call	Both	UP FA1	Both	11 1011
Short Data Call Initialization Vector (SDCALL_IV)	It indicates a transmission of an initialization vector in Short Data Call or Simultaneous Data Call	Both	UP FA1	Both	11 1010
Status Inquiry Request (STAT_INQ_REQ)	It indicates a request of Status Inquiry	Both	CC FA1 FA2	Both	11 0000
Status Inquiry Response (STAT_INQ_RESP)	It indicates a response to Status Inquiry	Both	CC FA1 FA2	Both	11 0001
Status Request (STAT_REQ)	It indicates a sending of Status	Both	CC FA1 FA2	Both	11 0010
Status Response (STAT_RESP)	It indicates a response to Status Request	Both	CC FA1 FA2	Both	11 0011
Remote Control Request (REM_CON_REQ)	It indicates a request of Remote Control	Both	CC FA1 FA2	Both	11 0100
Remote Control Response (REM_CON_RESP)	It indicates a response to Remote Control Request	Both	CC FA1 FA2	Both	11 0101

Table 6.4-2 Messages Used for Supplemental Service

Message Name (Alias)	Description	In/Out	CH	Trunk Conv.	Message Type
Voice Call Request (VCALL_REQ)	This indicates a request for Voice Call	In	CC	Trunk	00 0001
Voice Call Response (VCALL_RESP)	This indicates a response to Voice Call Request	Out	CC	Trunk	00 0001
Voice Call Reception Request (VCALL_REC_REQ)	This indicates a paging request for Voice Call	Out	CC SA FA1 FA2	Trunk	00 0010
Voice Call Reception Response (VCALL_REC_RESP)	This indicates a response to a paging of Voice Call	In	CC	Trunk	00 0010
Voice Call Connection Request (VCALL_CONN_REQ)	This indicates a connection request for Voice Call	In	CC	Trunk	00 0011
Voice Call Connection Response (VCALL_CONN_RESP)	This indicates a connection response for Voice Call	Out	CC	Trunk	00 0011
Voice Call Assignment (VCALL_ASSGN)	This indicates a assignment of traffic channel to Voice Call	Out	CC FA1	Trunk	00 0100
Voice Call Assignment Duplicate (VCALL_ASSGN_DUP)	This indicates a existence of assigned traffic channel to Voice Call	Out	CC SA FA1 FA2	Trunk	00 0101
Data Call Request (DCALL_REQ)	This indicates a request for Data Call	In	CC	Trunk	00 1001
Data Call Response (DCALL_RESP)	This indicates a response to Data Call Request	Out	CC	Trunk	00 1001
Data Call Reception Request (DCALL_REC_REQ)	This indicates a paging request for Data Call	Out	CC SA FA1 FA2	Trunk	00 1010
Data Call Reception Response (DCALL_REC_RESP)	This indicates a response to a paging of Data Call	In	CC	Trunk	00 1010
Data Call Assignment (DCALL_ASSGN)	This indicates a assignment of traffic channel to Data Call	Out	CC FA2	Trunk	00 1110
Data Call Assignment Duplicate (DCALL_ASSGN_DUP)	This indicates a existence of assigned traffic channel to Data Call	Out	CC SA FA1 FA2	Trunk	00 1101

Table 6.4-3 Messages Used for Calling Procedure

Message Name (Alias)	Description	In/Out	CH	Trunk Conv.	Message Type
Idle (IDLE)	This indicates a Idle status	Both	CC SA FA1 FA2	Both	01 0000
Disconnect Request (DISC_REQ)	This indicates a request for disconnecting or canceling service	In	CC FA1 FA2	Trunk	01 0001
Disconnect (DISC)	This indicates a disconnecting or canceling service	Out	CC FA1 FA2	Trunk	01 0001

Table 6.4-4 Other Messages

6.4.1.1. Voice Call (VCALL)

This message is used during voice call on a traffic channel.

Flag1: Spare
Flag2: Spare

Octet \ Bit	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Voice Call Option					
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	Cipher Type		Key ID						

Figure 6.4-1 Voice Call Format

Call Type value (Octet 6; Bits 7-5) indicates the type of call. Setting values for Octets 3 to 6 for each Call Type are presented in Table 6.4-5.

Call Type	Source ID	Destination ID
Group Call	Caller's Unit ID	Group ID
Individual Call	Caller's Unit ID	Called Unit ID
Interconnect Call (Call initiated by SU)	Subscriber Unit ID	PSTN ID
Interconnect Call (Call initiated by PSTN)	PSTN ID	Subscriber Unit ID

Table 6.4-5 Configuring ID of VCALL for each Call Type

6.4.1.2. Voice Call Initialization Vector (VCALL_IV)

This message is used to send an initialization vector in DES and AES encrypted voice call and used with VCALL message.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	Initialization Vector								M
2									
3									
4									
5									
6									
7									
8									

Figure 6.4-2 Voice Call Initialization Vector Format

6.4.1.3. Data Call (Header Format) (DCALL)

This message is used on a traffic channel for confirmed or unconfirmed types of data call. Data call uses two formats. The Header format consists of a Header part to carry layer 3 information and the User Data format consists of a User Data part to carry user data. The Header format is only used at the first UDCH, while all other UDCHs use User Data format.

By checking the header part of the Header format, the called party can identify the number of UDCH following the first UDCH, the user data information length and retry information, and reconstruct the user data correctly.

The Header format for a data call is presented in Figure 6.4-3. Initialization Vector is an optional information element specified by Cipher Type and is used in DES and AES encryption.

The setting values for Octets 3 to 6 shall conform to the Table 6.4-5.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type		Data Call Option						
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	Cipher Type		Key ID						
8	Packet Information								
9									
10									
-/11	Initialization Vector								O
...									
-/18									

Figure 6.4-3 Header Format for Data Call

6.4.1.4. Data Call (User Data Format) (DCALL)

This message is used in a data call to carry user data subsequent to the Header format as presented in Section 6.4.1.3. Except for the first UDCH, this User Data format is used for all other UDCH.

This format only contains information of the UDCH transmission sequence and data block sequence. Message CRC calculated using the entire User Data is included in User Data area of the User Data format used to send the last block.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	Packet Frame Number				Block Number				
2	User Data Area								M
...									
21									

Figure 6.4-4 User Data Format for Data Call

6.4.1.5. Data Call Acknowledge (DCALL_ACK)

This message is used as a response to the reception of confirmed data calls. The called party replies the result of a received data call, and the calling party will retry according to the response.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Data Call Option					
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
7	Response Information								
8									
9	Error Block Flag								
10									

Figure 6.4-5 Data Call Acknowledge Format

6.4.1.6. Transmission Release (TX_REL)

This message is used to terminate a transmission on a traffic channel. This message is used in the last transmission frame to notify the called party at the end of the transmission.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			spare					
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									

Figure 6.4-6 Transmission Release Format

6.4.1.7. Transmission Release Extension (TX_REL_EX)

In a trunked radio system, this message is used by a TC on a traffic channel when the traffic channel is released. This message is used on the outbound traffic channel and a SU that received this message can recognize that no SU is transmitting on the traffic channel.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	Flag 2	Message Type						M
1	CC Option								
2	Call Type			spare					
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	TX	spare							

Figure 6.4-7 Transmission Release Extension Format

This message is an extensive version of the TX_REL message, and differs only Octet 7 added to the original TX_REL message.

Transmission Flag (Octet 7, Bit 7)

Flag used for indicating the right of transmission (permit / inhibit) on a traffic channel

TX = 0 : Transmission inhibited.

TX = 1 : Transmission permitted.

6.4.1.8. Header Delay (HEAD_DLY)

This message is used to inform of a delay time until the valid first frame is transmitted when a non-voice communication such as a data call is carried out on a traffic channel.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			spare					
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	Delay Count								
8									

Figure 6.4-8 Header Delay Format

6.4.1.9. Short Data Call Request (Header format) (SDCALL_REQ)

This message is used in a short data call and simultaneous data call. The short data call uses UPCH on a control channel in a trunked radio system and the simultaneous data call uses FACCH1 on a traffic channel.

There are two formats: the Header format consists of a Header part to carry layer 3 information and the User Data format consists of a User Data part to carry user data. The Header format is only used at the first UPCH or FACCH1, while all other UPCH or FACCH1 use User Data format.

By checking the header part of the Header format, the called party can identify the number of UPCH or FACCH1 following the first UDCH or FACCH1, the user data information length and retry information, and reconstruct the user data correctly.

When using UPCH, the format represented in Figure 6.4-9 shall be applied. Location ID is an optional information element specified by CC Option.

When using FACCH1, the format represented in Figure 6.4-10 shall be applied.

Flag1: Spare
Flag2: Spare

Octet \ Bit	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type		Data Call Option						
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	Cipher Type		Key ID						
8	Packet Information								
9									
-/10	Location ID Option					← Category Bit first			O
-/11	Location ID (except for Site Code)								
-/12									

Figure 6.4-9 Header Format for Short Data Call Request (UPCH)

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Data Call Option					
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	Cipher Type		Key ID						
8	Packet Information								
9									

Figure 6.4-10 Header Format for Simultaneous Data Call Request (FACCH1)

6.4.1.10. Short Data Call Request (User Data Format) (SDCALL_REQ)

This message is used in a short data call or simultaneous data call to carry user data subsequent to the Header format as defined in Section 6.4.1.9. Except for the first UPCH or FACCH1, this User Data format is used for all other UPCH or FACCH1.

This format only contains information of the UDCH or FACCH1 transmission sequence and data block sequence. Message CRC calculated using the entire User Data is included in User Data area in the User Data format used to send the last block.

The format represented in Figure 6.4-11 is applied when using UPCH. When an outbound RCCH which is 18-octet length in UPCH is used, since this format is 16-octet length, the last 2 octets of UPCH shall be invalid and set to null.

The format represented in Figure 6.4-12 is applied when using FACCH1.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	Packet Frame Number				Block Number				
2	User Data Area								M
⋯									
15									

Figure 6.4-11 User Data Format for Short Data Call Request (UPCH)

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	Flag 2	Message Type						M
1	Packet Frame Number				Block Number				
2	User Data Area								M
⋯									
9									

Figure 6.4-12 User Data Format for Simultaneous Data Call Request (FACCH1)

6.4.1.11. Short Data Call Response (SDCALL_RESP)

This message is used as a response to the reception of confirmed short data calls or simultaneous data calls. The called party responds the result of a received data call, and the calling party will retry according to the response.

When using UPCH, the format represented in Figure 6.4-13 shall be applied. Location ID is an optional information element specified by CC Option.
When using FACCH1, the format represented in Figure 6.4-14 shall be applied.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Data Call Option					
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
7	Cause (SS)								
-/8	Location ID Option					← Category Bit first			O
-/9	Location ID (except for Site Code)								
-/10									

Figure 6.4-13 Short Data Call Response Format (UPCH)

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Data Call Option					
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
7	Cause (SS)								

Figure 6.4-14 Simultaneous Data Call Response Format (FACCH1)

6.4.1.12. Short Data Call Initialization Vector (SDCALL_IV)

This message is used to send an initialization vector in a short data call and a simultaneous data call using DES and AES encryption and used with SDCALL_REQ (Header) message.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	Initialization Vector								M
2									
3									
4									
5									
6									
7									
8									

Figure 6.4-15 Short Data Call Initialization Vector Format

6.4.1.13. Status Inquiry Request (STAT_INQ_REQ)

This message is used to inquiry a current status of other SUs. When this message is received, the SU sends back its status.

Location ID is an optional information element specified by CC Option. When Location ID is in the message, the CCCH is the only functional channel to be used.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Status Call Option					
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
-/7	Location ID Option					Category Bit first			O
-/8	Location ID (except for Site Code)								
-/9									

Figure 6.4-16 Status Inquiry Request Format

6.4.1.14. Status Inquiry Response (STAT_INQ_RESP)

A SU uses this message to send back its current status in response to the Status Inquiry Request.

Location ID is an optional information element specified by CC Option. When Location ID is in the message, the CCCH is the only functional channel to be used.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			spare					
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
7	Cause (SS)								
8	Status								
-/9	Location ID Option					← Category Bit first			O
-/10	Location ID (except for Site Code)								
-/11									

Figure 6.4-17 Status Inquiry Response Format

6.4.1.15. Status Request (STAT_REQ)

A SU uses this message to send its current status.

Location ID is an optional information element specified by CC Option. When Location ID is in the message, the CCCH is the only functional channel to be used.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Status Call Option					
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	spare								
8	Status								
-/9	Location ID Option					Category Bit first			O
-/10	Location ID (except for Site Code)								
-/11									

Figure 6.4-18 Status Format for Status Request

6.4.1.16. Status Response (STAT_RESP)

This message is used to answer the acknowledgment to the Status Request from a SU.

Location ID is an optional information element specified by CC Option. When Location ID is in the message, the CCCH is the only functional channel to be used.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			spare					
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
7	Cause (SS)								
-/8	Location ID Option					← Category Bit first			O
-/9	Location ID (except for Site Code)								
-/10									

Figure 6.4-19 Status Response Format

6.4.1.17. Remote Control Request (REM_CON_REQ)

A SU uses this message to remotely control other SUs.

Location ID is an optional information element specified by CC Option. When Location ID is in the message, the CCCH is the only functional channel to be used.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	G/U	spare	D	Control Command					
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	Control Parameter								
8									
-/9	Location ID Option					← Category Bit first			O
-/10	Location ID (except for Site Code)								
-/11									

Figure 6.4-20 Remote Control Request Format

3 flag settings for Octet 2 are described as follows.

G/U (Group ID or Unit ID)

This represents the information element configured for Octets 5 to 6.

G/U = 0: Group ID

G/U = 1: Unit ID

D (Delivery)

This represents that this message is transacted as an unconfirmed or confirmed delivery.

D = 0: Unconfirmed type without the response from the destination

D = 1: Confirmed type requiring the response from the destination (This is used only if G/U = Unit ID.)

6.4.1.18. Remote Control Response (REM_CON_RESP)

This message is used to answer the acknowledgement when a Remote Control Request is received from other SU, TRS, or CRS.

Location ID is an optional information element specified by CC Option. When Location ID is in the message, the CCCH is the only functional channel to be used.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	G/U	spare	spare	Control Command					
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
7	spare								
8	Cause (SS)								
-/9	Location ID Option					← Category Bit first			O
-/10	Location ID (except for Site Code)								
-/11									

Figure 6.4-21 Remote Control Response Format

6.4.1.19. Voice Call Request (VCALL_REQ)

In a trunked radio system, a SU uses this message on a control channel to request a traffic channel for a voice call. When this message is received, a TC assigns a traffic channel according to the content in the information elements.

Location ID is used in individual call only and is an optional information element specified by CC Option.

VCALL_REQ has three formats depending on the Call Type.

When the Call Type is Group Call or Individual Call, the format defined in Figure 6.4-22 is used. For Group Call, Octets 5 to 6 are set to the called Group ID, and for Individual Call, Octets 5 to 6 are set to the Unit ID of the called SU.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type		Voice Call Option						
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
-/7	Location ID Option					← Category Bit first			O
-/8	Location ID (of Destination Unit ID) (except for Site Code)								
-/9									

Figure 6.4-22 Voice Call Request Format for Group & Individual Call

If Call Type is Speed Dial Call, the format defined in Figure 6.4-23 is used. In this case, Octets 5 to 6 are set to the Unit ID representing the PSTN, and Octet 7 is configured for the destination speed dial predefined for a dial number.

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type		Voice Call Option						
3	Source Unit ID								
4									
5	TRS PSTN ID								
6									
7	Speed Dial								

Figure 6.4-23 Voice Call Request Format for Speed Dial

If Call Type is Dialing Call, the format defined in Figure 6.4-24 is used and sent in inbound Long CAC. In this case, Octets 5 to 6 are set to the Unit ID representing the PSTN, and Octets 7 to 22 are configured for the destination dial number. Digit 1 is set to the first digit of the dial number and a maximum of an 18-digit number can be sent If the number of digits in the dial number is less than 18, the remaining Digits shall be filled with Filler.

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						
1	CC Option								
2	Call Type				Voice Call Option				M
3	Source Unit ID								
4									
5	TRS PSTN ID								
6									
7	Digit 1				Digit 2				
8	Digit 3				Digit 4				
…	…				…				
15	Digit 17				Digit 18				

Figure 6.4-24 Voice Call Request Format for Interconnect

6.4.1.20. Voice Call Response (VCALL_RESP)

In a trunked radio system, a TC uses this message on a control channel to send back the processing result of the TC or the condition of a called SU to a voice call request.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						
1	CC Option								
2	Call Type				Voice Call Option				M
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
7	Cause (VD)								

Figure 6.4-25 Voice Call Response Format

6.4.1.21. Voice Call Reception Request (VCALL_REC_REQ)

In a trunked radio system, a TC uses this message on a control or a traffic channel to check whether the called SU is ready for a voice call. When the SU receives this message, the SU responds whether it can accept the voice call.

Location ID is an optional information element specified by CC Option. When this message has a Location ID, using this message in SACCH is prohibited for the capacity restriction of functional channel.

VCALL_REC_REQ has two formats depending on the Call Type.

If the Call Type is Individual Call, the format defined in Figure 6.4-26 is used. In this format, Octets 3 to 4 are configured for the Unit ID of the calling SU and Octets 5 to 6 are configured for the Unit ID of the called SU.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type		Voice Call Option						
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
-/7	Location ID Option					← Category Bit first			O
-/8	Location ID (of Source Unit ID) (except for Site Code)								
-/9									

Figure 6.4-26 Voice Call Reception Request Format for Individual

If the Call Type is Interconnect Call, the format defined in Figure 6.4-27 is used. In this format, Octets 3 to 4 are set for the Unit ID representing the PSTN, and Octets 5 to 6 are configured for the Unit ID of the called SU. As an option, Octets 7 to 17 may be configured for the originating dial number. If the dial number is less than 22 digits, the remaining Digits shall be filled with Filler.

The outbound CCCH shall use the Single Message format. For SACCH or FACCH1, only Octets 0 to 6 are sent and the Digits after Octet 7 are not used.

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type				Voice Call Option				
3	TRS PSTN ID								
4									
5	Destination Unit ID								
6									
7	Digit 1				Digit 2				
8	Digit 3				Digit 4				
…	…				…				
17	Digit 21				Digit 22				

Figure 6.4-27 Voice Call Reception Request Format for Interconnect

6.4.1.22. Voice Call Reception Response (VCALL_REC_RESP)

In a trunked radio system, a called SU uses this message on a control channel to respond its condition for a voice call. When a TC receives this message, it executes the necessary operation according to the response.

Location ID is an optional information element specified by CC Option.

In this format, Octets 3 to 4 are configured for the Unit ID of the called SU and Octets 5 to 6 are configured for the Unit ID of the calling SU.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Voice Call Option					
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
7	Cause (VD)								
-/8	Location ID Option					← Category Bit first			O
-/9	Location ID (of Destination Unit ID) (except for Site Code)								
-/10									

Figure 6.4-28 Voice Call Reception Response Format

6.4.1.23. Voice Call Connection Request (VCALL_CONN_REQ)

In a trunked radio system, a called SU uses this message on a control channel to send a connection request for a voice call. When this message is received, a TC assigns a traffic channel according to the contents of the message.

Location ID is an optional information element specified by CC Option.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Voice Call Option					
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
-/7	Location ID Option					← Category Bit first			O
-/8	Location ID (of Destination Unit ID) (except for Site Code)								
-/9									

Figure 6.4-29 Voice Call Connection Request Format

6.4.1.24. Voice Call Connection Response (VCALL_CONN_RESP)

In a trunked radio system, a TC uses this message on a control channel to send back the processing result of the TC for a connection request from a called SU for a voice call.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Voice Call Option					
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
7	Cause (VD)								

Figure 6.4-30 Voice Call Connection Response Format

6.4.1.25. Voice Call Assignment (VCALL_ASSGN)

In a trunked radio system, a TC uses this message on a control channel to assign a traffic channel to a voice call request. When SUs receive this message, they move to the assigned traffic channel.

Location ID and Temporary Unit ID are used in individual call only and are optional information elements specified by CC Option.

Only if a control channel communication operation, a TC can use this message on a traffic channel. In this case, an inter-system call shall not be permitted and the optional information elements shall not be included.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Voice Call Option					
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	Call Timer								
8	Channel								
-/9	Location ID Option					← Category Bit first			O
-/10	Location ID (except for Site Code)								
-/11									
-/12	Temporary Unit ID								
-/13									

Figure 6.4-31 Voice Call Assignment Format

The setting values of Octets 3 to 6 for each Call Type are defined in Table 6.4-6.

Call Type	Source ID	Destination ID
Group Call	Unit ID	Group ID
Individual Call	Calling Unit ID	Called Unit ID
Interconnect Call	Calling Unit ID or PSTN ID	PSTN ID or Called Unit ID

Table 6.4-6 Configuring ID of VCALL_ASSGN for each Call Type

6.4.1.26. Voice Call Assignment Duplicate (VCALL_ASSGN_DUP)

In a trunked radio system, a TC uses this message on a control or traffic channel to periodically inform of the availability of traffic channels assigned for a voice call.

When SUs receive this message on the control channel, they move to the specified traffic channel and are able to join the ongoing voice call. If SUs receive this message on the traffic channel, they can join the ongoing voice call of other groups.

On a control channel, the format defined in Figure 6.4-32 is used. Location ID and Temporary Unit ID are used in a individual call only and are optional information elements specified by CC Option.

On a traffic channel, the format defined in Figure 6.4-33 is used. This message is used for a group call only on a traffic channel.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type		Voice Call Option						
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	Call Timer								
8	Channel								
-/9	Location ID Option					← Category Bit first			O
-/10	Location ID (except for Site Code)								
-/11									
-/12	Temporary Unit ID								
-/13									

Figure 6.4-32 Voice Call Assignment Duplicate Format for RCCH

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type		Voice Call Option						
3	Source Unit ID								
4									
5	Group ID								
6									
7	Call Timer								
8	Channel								

Figure 6.4-33 Voice Call Assignment Duplicate Format for RTCH

The setting values of Octets 3 to 6 for each Call Type are defined in Table 6.4-7.

Call Type	Source ID	Destination ID
Group Call	Unit ID	Group ID
Individual Call	Calling Unit ID	Called Unit ID
Interconnect Call	Calling Unit ID or PSTN ID	PSTN ID or Called Unit ID

Table 6.4-7 Configuring ID of VCALL_ASSGN_DUP for each Call Type

6.4.1.27. Data Call Request (DCALL_REQ)

In a trunked radio system, a SU uses this message on a control channel to request a traffic channel for a data call. When this message is received, a TC assigns a traffic channel according to the content in the information elements.

Location ID is used in individual call only and is an optional information element specified by CC Option.

Octets 5 to 6 are set to the called Group ID when the Call Type is Group Call and are set to the Unit ID of the called SU when the Call Type is Individual Call.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Data Call Option					
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
-/7	Location ID Option					← Category Bit first			O
-/8	Location ID (of Destination Unit ID) (except for Site Code)								
-/9									

Figure 6.4-34 Data Call Request Format

6.4.1.28. Data Call Response (DCALL_RESP)

In a trunked radio system, a TC uses this message on a control channel to send back the processing result of the TC or the condition of a called SU to a data call request.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Data Call Option					
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
7	Cause (VD)								

Figure 6.4-35 Data Call Response Format

6.4.1.29. Data Call Reception Request (DCALL_REC_REQ)

In a trunked radio system, a TC uses this message on a control or traffic channel to check whether the called SU is ready for a data call. When the SU receives this message, the SU responds whether it can accept the data call.

Location ID is an optional information element specified by CC Option. When this message has a Location ID, using this message in SACCH is prohibited for the capacity restriction of functional channel.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Data Call Option					
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
-/7	Location ID Option					← Category Bit first			O
-/8	Location ID (of Source Unit ID) (except for Site Code)								
-/9									

Figure 6.4-36 Data Call Reception Request Format

6.4.1.30. Data Call Reception Response (DCALL_REC_RESP)

In a trunked radio system, a called SU uses this message on a control channel to respond its condition for a data call. When a TC receives this message, it executes the necessary operation according to the response.

Location ID is an optional information element specified by CC Option.

In this format, Octets 3 to 4 are configured for the Unit ID of the called SU and Octets 5 to 6 are configured for the Unit ID of the calling SU.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						
1	CC Option								
2	Call Type			Data Call Option					M
3	Source Unit ID								
4									
5	Destination Unit ID								
6									
7	Cause (VD)								
-/8	Location ID Option					← Category Bit first			
-/9	Location ID (of Destination Unit ID) (except for Site Code)								O
-/10									

Figure 6.4-37 Data Call Reception Response Format

6.4.1.31. Data Call Assignment (DCALL_ASSGN)

In a trunked radio system, a TC uses this message on a control channel to assign a traffic channel to a data call request. When SUs receive this message, they move to the assigned traffic channel.

Location ID and Temporary Unit ID are used in individual call only and are optional information elements specified by CC Option.

Only if a control channel communication operation, a TC can use this message on a traffic channel. In this case, an inter-system call shall not be permitted and the optional information elements shall not be included.

The setting values of Octets 3 to 6 shall be conform to Table 6.4-6.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			Data Call Option					
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	Call Timer								
8	Channel								
-/9	Location ID Option					← Category Bit first			O
-/10	Location ID (except for Site Code)								
-/11									
-/12	Temporary Unit ID								
-/13									

Figure 6.4-38 Data Call Assignment Format

6.4.1.32. Data Call Assignment Duplicate (DCALL_ASSGN_DUP)

In a trunked radio system, a TC uses this message on a control or traffic channel to periodically inform of the availability of traffic channels assigned for a data call.

When SUs receive this message on the control channel, they move to the specified traffic channel and are able to join the ongoing data call. If SUs receive this message on the traffic channel, they can join the ongoing data call of other group.

On a control channel, the format defined in Figure 6.4-39 is used. Location ID and Temporary Unit ID are used in individual call only and are optional information elements specified by CC Option.

On a traffic channel, the format defined in Figure 6.4-40 is used. This message is used for a group call only on a traffic channel.

The setting values of Octets 3 to 6 shall be conform to Table 6.4-7.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type		Data Call Option						
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	Call Timer								
8	Channel								
-/9	Location ID Option					← Category Bit first			O
-/10	Location ID (except for Site Code)								
-/11									
-/12	Temporary Unit ID								
-/13									

Figure 6.4-39 Data Call Assignment Duplicate Format for RCCH

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type		Data Call Option						
3	Source Unit ID								
4									
5	Group ID								
6									
7	Call Timer								
8	Channel								

Figure 6.4-40 Data Call Assignment Duplicate Format for RTCH

6.4.1.33. Idle (IDLE)

This message is used when there is no specific information to deliver such as idle transmission on a traffic channel of a Trunking Repeater or on a Conventional Repeater.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M

Figure 6.4-41 Idle Format

6.4.1.34. Disconnect Request (DISC_REQ)

A SU uses this message to request a call disconnect on a traffic channel or to cancel a service. Location ID is an optional information element specified by CC Option and can be configured only on CCCH.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type		spare						
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	Cause (DREQ)								
-/8	Location ID Option					← Category Bit first			O
-/9	Location ID (except for Site Code)								
-/10									

Figure 6.4-42 Disconnect Request Format

6.4.1.35. Disconnect (DISC)

This message is used to release the traffic channel of a Trunking Repeater or to abort a service. Location ID is an optional information element specified by CC Option and can be configured only on CCCH.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	CC Option								
2	Call Type			spare					
3	Source Unit ID								
4									
5	Destination Group or Unit ID								
6									
7	Cause (DISC)								
-/8	Location ID Option					← Category Bit first			O
-/9	Location ID (except for Site Code)								
-/10									

Figure 6.4-43 Disconnect Format

The setting values of Octets 3 to 6 for each Call Type are defined in Table 6.4-8.

Call Type	CH	Source ID	Destination ID
Group Call	RCCH	TC ID	Unit ID
	RTCH	Unit ID	Group ID
Individual Call	RCCH	Calling or Called Unit ID	Called or Calling Unit ID
	RTCH	Calling Unit ID	Called Unit ID
Interconnect Call	RCCH	PSTN ID	Calling or Called Unit ID
	RTCH	Calling Unit ID or PSTN ID	PSTN ID or Called Unit ID

Table 6.4-8 Configuring ID of DISC for each Call Type

6.4.2. Mobility Management Messages

Mobility Management Messages are used for subscriber unit's location registration, authentication and group affiliation.

Message Name (Alias)	Description	In/Out	CH	Trunk Conv.	Message Type
Registration Request (REG_REQ)	This indicates a request of registration	In	CC	Trunk	10 0000
Registration Response (REG_RESP)	This indicates a response to Registration Request	Out	CC	Trunk	10 0000
Registration Clear Request (REG_C_REQ)	This indicates a request to clear registration	In	CC	Trunk	10 0010
Registration Clear Response (REG_RESP)	This indicates a response to Registration Clear Request	Out	CC	Trunk	10 0010
Registration Command (REG_COMM)	This indicates a command of registration	Out	CC	Trunk	10 0011
Group Registration Request (GRP_REG_REQ)	This indicates a request to register group	In	CC	Trunk	10 0100
Group Registration Response (GRP_REG_RESP)	This indicates a response to Group Registration Request	Out	CC	Trunk	10 0100
Authentication Inquiry Request (AUTH_INQ_REQ)	This indicates a request to inquire for authentication	Out	CC	Trunk	10 1000
		Both	FA2	Conv.	
Authentication Inquiry Response (AUTH_INQ_RESP)	This indicates a response to Authentication Inquiry Request	In	CC	Trunk	10 1001
		Both	FA2	Conv.	

Table 6.4-9 Messages for Mobility Management

6.4.2.1. Registration Request (REG_REQ)

In a trunked radio system, a SU uses this message on a control channel to register its information.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	Registration Option					← Category Bit first			
2	(Subscriber Home) Location ID (except for Site Code)								
3									
4	Source Unit ID								
5									
6	Group ID								
7									
8	Subscriber Type								
9									
10	Version Number								

Figure 6.4-44 Registration Request Format

6.4.2.2. Registration Response (REG_RESP)

In a trunked radio system, a TC uses this message on a control channel to respond to a SU registration request.
Visitor Unit ID and Visitor Group ID are optional information elements specified by Registration Option.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	Registration Option					← Category Bit first			
2	(Subscriber Home) Location ID (except for Site Code)								
3									
4	Destination Unit ID								
5									
6	Group ID								
7									
8	Cause (MM)								
-/9	Visitor Unit ID								O
-/10									
-/11	Visitor Group ID								
-/12									

Figure 6.4-45 Registration Response Format

6.4.2.3. Registration Clear Request (REG_C_REQ)

In a trunked radio system, a SU used this message on a control channel to clear the registration information of the SU.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	Registration Option					← Category Bit first			
2	(Subscriber Home) Location ID (except for Site Code)								
3									
4	Source Unit ID								
5									

Figure 6.4-46 Registration Clear Request Format

6.4.2.4. Registration Clear Response (REG_C_RESP)

In a trunked radio system, a TC used this message on a control channel to respond to a request to clear the registration information from the SU.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	Registration Option					← Category Bit first			
2	(Subscriber Home) Location ID (except for Site Code)								
3									
4	Destination Unit ID								
5									
6	Cause (MM)								

Figure 6.4-47 Registration Clear Response Format

6.4.2.5. Registration Command (REG_COMM)

In a trunked radio system, a TC uses this message on a control channel to command a SU to perform its registration.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	Registration Option					← Category Bit first			
2	(Subscriber Home) Location ID (except for Site Code)								
3									
4	Destination Unit ID								
5									

Figure 6.4-48 Registration Command Format

6.4.2.6. Group Registration Request (GRP_REG_REQ)

In a trunked radio system, a SU uses this message on a control channel to register its affiliate group.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	Group Registration Option								
2	Source Unit ID								
3									
4	Group ID								
5									

Figure 6.4-49 Group Registration Request Format

6.4.2.7. Group Registration Response (GRP_REG_RESP)

In a trunked radio system, a TC uses this message on a control channel to respond to a group registration request from a SU.
Visitor Group ID is an optional information element specified by Group Registration Option.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	Group Registration Option								
2	Destination Unit ID								
3									
4	Group ID								
5									
6	Cause (MM)								
-/7	Visitor Group ID								O
-/8									

Figure 6.4-50 Group Registration Response Format

6.4.2.8. Authentication Inquiry Request (AUTH_INQ_REQ)

This message is used to inquiry authentication information to confirm the validity of a SU. Location ID is an optional information element specified by Authentication Option.

Flag1: Spare
Flag2: Spare

Octet \ Bit	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	Authentication Option								
2	Source Unit ID								
3									
4	Destination Unit ID								
5									
6	Authentication Parameter								
7									
-/8	Location ID Option					← Category Bit first			O
-/9	Location ID (except for Site Code)								
-/10									

Figure 6.4-51 Authentication Inquiry Request Format

6.4.2.9. Authentication Inquiry Response (AUTH_INQ_RESP)

This message is used to inform of authentication information to confirm the validity of a SU. Location ID is an optional information element specified by Authentication Option.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0	M/O
0	F1	F2	Message Type						M
1	Authentication Option								
2	Source Unit ID								
3									
4	Destination Unit ID								
5									
6	Authentication Value								
7									
8									
9									
10									
11									
12									
-/13	Location ID Option					← Category Bit first			O
-/14	Location ID (except for Site Code)								
-/15									

Figure 6.4-52 Authentication Inquiry Response Format

6.4.3. Broadcast Messages

Broadcast Messages are used to inform of system and control channel information for a trunked radio system to a SU.

Message Name (Alias)	Description	In/Out	CH	Trunk Conv.	Message Type
Site Information (SITE_INFO)	This broadcasts site configuration information	Out	BC	Trunk	01 1000
Service Information (SRV_INFO)	This broadcasts service information which site provides	Out	BC CC FA1 FA2	Trunk	01 1001
Control Channel Information (CCH_INFO)	This broadcasts information of site's control channel	Out	BC CC FA1 FA2	Trunk	01 1010
Adjacent Site Information (ADJ_SITE_INFO)	This broadcasts information of control channel for adjacent site	Out	BC CC FA1 FA2	Trunk	01 1011
Failure Status Information (FAIL_STAT_INFO)	This notifies that the site is in failure.	Out	FA1 FA2	Trunk	01 1100

Table 6.4-10 Broadcast Messages

6.4.3.1. Site Information (SITE_INFO)

In a trunked radio system, a TC uses this message on a control channel to inform SUs of various kinds of site configuration information.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0
0	F1	F2	Message Type					
1	Location ID (for current site)							
2								
3								
4	Channel Structure Information							
5								
6	Service Information							
7								
8	Restriction Information							
9								
10								
11	Channel Access Information							
12								
13								
14	Version Number							
15	Adjacent Site Allocation							
16	1st Control Channel							
17	2nd Control Channel							

Figure 6.4-53 Site Information Format

6.4.3.2. Service Information (SRV_INFO)

In a trunked radio system, a TC uses this message on a control channel to inform SUs of service information which the site provides.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0
0	F1	F2	Message Type					
1	Location ID (for current site)							
2								
3								
4	Service Information							
5								
6	Restriction Information							
7								
8								

Figure 6.4-54 Service Information Format

6.4.3.3. Control Channel Information (CCH_INFO)

In a trunked radio system, a TC used this message on a control channel or a traffic channel to inform SUs of information about the control channel in this site or about change of the control channel in a specific site.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0
0	F1	F2	Message Type					
1	Location ID (for certain site)							
2								
3								
4	Curr	New	Add	Del	spare	spare		
5	Control Channel 1							
6	spare	spare	spare	spare	spare	spare		
7	Control Channel 2							

Figure 6.4-55 Control Channel Information Format

This message can notify the following different information:

(1) Notifying of the channel number of the first and the second control channels used in the site

(2) Notifying of the channel number of the new control channel when changing the control channel in this site

(3) Notifying of the channel number of a radio channel added in a specific site that can be a candidate for control channel

(4) Notifying of the channel number of a radio channel deleted in a specific site that is one of candidate for control channels

Each information is specified by 4 different flags. At least one flag shall be asserted and multiple flags shall not be asserted at a time.

Current (Octet 4, Bit 7)

This flag represents notifying of the control channel currently used in this site. If this flag is asserted, both fields for Control Channel 1 and Control Channel 2 are valid.

Curr = 0: Invalid.

Curr = 1: The current control channel is being notified

New (Octet 4, Bit 6)

This flag represents notifying of a new control channel in this site. This flag is used when a control channel is changed. If this flag is asserted, only Control Channel 1 field is valid.

New = 0: Invalid.

New = 1: The new control channel is being notified

Add (Octet 4, Bit 5)

This flag represents that a candidate for control channel has been added to the site specified by the Location ID. If this flag is asserted, only Control Channel 1 field is valid.

Add = 0: Invalid.

Add = 1: Addition of the corresponding Channel number is being notified

Delete (Octet 4, Bit 4)

This flag represents that a candidate for control channel has been deleted from the site specified by the Location ID. If this flag is asserted, only Control Channel 1 field is valid.

Del = 0: Invalid.

Del = 1: Deletion of the corresponding Channel number is being notified

6.4.3.4. Adjacent Site Information (ADJ_SITE_INFO)

In a trunked radio system, a TC uses this message on a control channel or a traffic channel to notify of the control channel information for an adjacent site to a SU.

One adjacent site information can be sent in CCCH (Dual Message format) or FACCH1. A maximum of 3 adjacent sites information can be sent in CCCH (Single Message format) and a maximum of 4 adjacent sites information can be sent in FACCH2. If the number of adjacent sites to be broadcasted does not reach a maximum number, Location ID and Channel field are set to null to fill the unused fields.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0
0	F1	F2	Message Type					
1	Adjacent Site Location ID (1)							
2								
3								
4	Adjacent Site Option (1)							
5	Adjacent Site Control Channel (1)							
6	Adjacent Site Location ID (2)							
7								
8								
9	Adjacent Site Option (2)							
10	Adjacent Site Control Channel (2)							
…	…							
16	Adjacent Site Location ID (4)							
17								
18								
19	Adjacent Site Option (4)							
20	Adjacent Site Control Channel (4)							

Figure 6.4-56 Adjacent Site Information Format

6.4.3.5. Failure Status Information (FAIL_STAT_INFO)

In a trunked radio system, a TC uses this message on a control channel or a traffic channel to notify a SU that the site has been out of service.

The information about failure and its relevant information are indicated in Failure Condition Information.

Flag1: Spare

Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0
0	F1	F2	Message Type					
1	Location ID (for current site)							
2								
3								
4	Failure Condition Information							
5								
6								
7								
8								

Figure 6.4-57 Failure Status Information Format

Fail-soft Mode

4	1	0	0	0	0	0	0	0
5	Call Timer							
6	spare							
7								
8								

Figure 6.4-58 Failure Condition Information

6.4.4. Non-Standard Messages

Non-Standard Messages are messages without definition for usage of the information elements.

Message Name (Alias)	Description	In/Out	CH	Trunk Conv.	Message Type
Proprietary Form (PROP_FORM)	Manufacturer-defined messages	Both	Any	Both	11 1111

Table 6.4-11 Non-standard Messages

6.4.4.1. Proprietary Form (PROP_FORM)

When a manufacturer wishes to add its proprietary functions, this message can be defined freely with any information elements. The Manufacturer Number field is set to the manufacturer number used in the ESN. Octet 2 and following can be defined freely, and the octet length “n” depends on the functional channel used.

Flag1: Spare
Flag2: Spare

Bit / Octet	7	6	5	4	3	2	1	0
0	F1	Flag 2	Message Type					
1	Manufacturer Number							
2	Manufacturer definable							
…								
n-1								
n								

Figure 6.4-59 Proprietary Form Format

6.4.5. List of Message Type

This section describes the list of message types and layer 3 messages.

Type	RCCH		RTCH/ RDCH	
	Outbound	Inbound	Outbound	Inbound
00 0000				
00 0001	(VCALL_RESP)	VCALL_REQ	VCALL	←
00 0010	VCALL_REC_REQ	VCALL_REC_RESP	VCALL_REC_REQ	
00 0011	VCALL_CONN_RESP	VCALL_CONN_REQ	VCALL_IV	←
00 0100	VCALL_ASSGN		VCALL_ASSGN	
00 0101	VCALL_ASSGN_DUP		VCALL_ASSGN_DUP	
00 0110				
00 0111			TX_REL_EX	
00 1000			TX_REL	←
00 1001	DCALL_RESP	DCALL_REQ	DCALL (Header)	←
00 1010	DCALL_REC_REQ	DCALL_REC_RESP	DCALL_REC_REQ	
00 1011			DCALL (User Data)	←
00 1100			DCALL_ACK	←
00 1101	DCALL_ASSGN_DUP		DCALL_ASSGN_DUP	
00 1110	DCALL_ASSGN		DCALL_ASSGN	
00 1111			HEAD_DLY	←
01 0000	IDLE		IDLE	←
01 0001	DISC	DISC_REQ	DISC	DISC_REQ
01 0010				
01 0011				
01 0100				
01 0101				
01 0110				
01 0111				
01 1000	SITE_INFO			
01 1001	SRV_INFO		SRV_INFO	
01 1010	CCH_INFO		CCH_INFO	
01 1011	ADJ_SITE_INFO		ADJ_SITE_INFO	
01 1100			FAIL_STAT_INFO	
01 1101				
01 1110				
01 1111				

Type	RCCH		RTCH/ RDCH	
	Outbound	Inbound	Outbound	Inbound
10 0000	REG_RESP	REG_REQ		
10 0001				
10 0010	REG_C_RESP	REG_C_REQ		
10 0011	REG_COMM			
10 0100	GRP_REG_RESP	GRP_REG_REQ		
10 0101				
10 0110				
10 0111				
10 1000	AUTH_INQ_REQ		AUTH_INQ_REQ	←
10 1001		AUTH_INQ_RESP	AUTH_INQ_RESP	←
10 1010				
10 1011				
10 1100				
10 1101				
10 1110				
10 1111				
11 0000	STAT_INQ_REQ	←	←	←
11 0001	STAT_INQ_RESP	←	←	←
11 0010	STAT_REQ	←	←	←
11 0011	STAT_RESP	←	←	←
11 0100	REM_CON_REQ	←	←	←
11 0101	REM_CON_RESP	←	←	←
11 0110				
11 0111				
11 1000	(SDCALL_REQ) (Header)	←	←	←
11 1001	(SDCALL_REQ) (User Data)	←	←	←
11 1010	SDCALL_IV	←	←	←
11 1011	SDCALL_RESP	←	←	←
11 1100				
11 1101				
11 1110				
11 1111	PROP_FORM	←	←	←

Table 6.4-12 List of Layer 3 Messages

6.5. Element Definitions

This section describes the definitions of various information elements embedded in layer 3 messages.

6.5.1. Message Type

6-bit Message Type indicates the type of layer 3 messages.

6.5.2. Location ID

24-bit Location ID is composed of Category Bit, System Code and Site Code to identify the category and location of a trunked radio system.

The values of Category Bit and System Code are collectively managed by a management organization, and proper values are assigned to respective trunked radio systems by the management organization. A system operator can define the value for Site Code within a valid range of the specified Category.

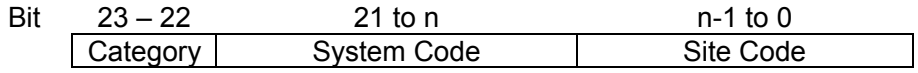


Figure 6.5-1 Location ID Format

Category	Category Bit	System Code	Site Code
Global	00	1 to 1022 (10 bits)	1 to 4094 (12 bits)
Regional	10	1 to 16382 (14 bits)	1 to 254 (8 bits)
Local	01	1 to 131070 (17 bits)	1 to 30 (5 bits)
reserved	11		

Table 6.5-1 Location ID Values

6.5.2.1. Category Bit

2-bit Category Bit indicates the scale or location of a trunked radio system. This value determines the number of systems and sites to be configured.

6.5.2.2. System Code

System Code is a value uniquely assigned to each trunked radio system to identify trunked radio systems.

Category = Global System Code has 10-bit length.
Category = Regional System Code has 14-bit length.
Category = Local System Code has 17-bit length.

The values of System Code set to all "0" or all "1" are reserved.

6.5.2.3. Site Code

Site Code is a value uniquely assigned to each site of trunked radio system to identify sites within a trunked radio system.

Category = Global Site Code has 12-bit length.
Category = Regional Site Code has 8-bit length.
Category = Local Site Code has 5-bit length.

The values of Site Code set to all "0" or all "1" are reserved.

6.5.3. Unit ID

16-bit Unit ID is a value uniquely assigned to each Unit in a system to identify units within a trunked radio system.

Value (Hex)	Definition	Description
0000	Null Unit ID	Used as Filler without specifying unit
0001 to FFEF	Standard Unit ID	Unit ID that can be defined uniquely within a system, including Visitor Unit ID and Temporary Unit ID
FFF0	TRS TC ID	Special ID to indicate a TC in a TRS
FFF1	TRS PSTN ID	Special ID to indicate PSTN connection in a TRS
FFF2 to FFF4	Special IDs	Reserved as special ID
FFF5	CR PSTN ID	Special ID to indicate PSTN in CR
FFF6 to FFFE	Special IDs	Reserved as special ID
FFFF	All Unit	Special ID to indicate all Units

Table 6.5-2 Unit ID Values

6.5.3.1. Visitor Unit ID

Visitor Unit ID is a Unit ID which a TRS temporarily assigns to a roaming SU when the SU roaming from another system does a location registration. As long as the SU belongs to the system, it uses this Visitor Unit ID for call. The assigned Visitor Unit ID is released when the SU leaves the system.

Each system shall define the assignable range for Visitor Unit IDs from the range of Standard Unit IDs.

6.5.3.2. Temporary Unit ID

Temporary Unit ID is a Unit ID which a TRS assigns to each SU when SUs located in other systems make an Individual call. SUs make the Individual call using these Temporary Unit IDs on RTCH, and the assigned Temporary Unit IDs are released when the call is over.

Each system shall define the assignable range for Temporary Unit IDs from the range of Standard Unit IDs.

6.5.3.3. Source Unit ID

Source Unit ID used in layer 3 messages indicates the Unit ID of the SU which is the sender of the message.

6.5.3.4. Destination Unit ID

Destination Unit ID used in layer 3 messages indicates the Unit ID of the SU which is the recipient of the message.

6.5.4. Group ID

16-bit Group ID is a value uniquely assigned to each group in a system to identify groups within a trunked radio system.

Value (Hex)	Definition	Description
0000	Null Group ID	Used as Filler without specifying group
0001 FFEF	Standard Group ID	Group ID which can be defined uniquely within System, including Visitor Group ID
FFF0	reserved	Reserved to avoid confusion with TRS TC ID
FFF1 FFFE	Special IDs	Reserved as special ID
FFFF	All Group	Special ID to indicate all groups

Table 6.5-3 Group ID Values

6.5.4.1. Visitor Group ID

Visitor Group ID is a Group ID which a TRS temporarily assigns to a roaming SU when the SU roaming from another system does a location registration. As long as the SU belongs to the system, it uses this Visitor Group ID for call. The assigned Visitor Group ID is released when the SU leaves the system.

Each system shall define the assignable range for Visitor Group IDs from the range of Standard Group IDs.

6.5.5. Electronic Serial Number

Electronic Serial Number (ESN) is a unique 48-bit number written into each unit by its manufacturer.

6.5.6. Authentication Parameter

16-bit Authentication Parameter is a variable used for the authentication process.

6.5.7. Authentication Value

56-bit Authentication Value is a authentication value used for authentication process.

6.5.8. Registration Option

5-bit Registration Option indicates additional information for location registration messages.

Bit	4	3	2	1	0
Octet 0	Em	H/V	spare	spare	spare

Figure 6.5-2 Registration Option Format

Field	Description and Value
Emergency	Indicates if the message is for an Emergency. 0: Non-Emergency message (Normal) 1: Emergency message
Home/ Visitor	Indicates if Visitor ID is included in the message. 0: No (Registered at Home or in Single System) 1: Yes (Registered as visitor in Multi-system)

Table 6.5-4 Registration Option Values

6.5.9. Group Registration Option

8-bit Group Registration Option indicates a supplementary information for group registration.

Bit	7	6	5	4	3	2	1	0
Octet 0	Em	H/V	←			spare		→

Figure 6.5-3 Group Registration Option Format

Field	Description and Value
Emergency	Indicates if the message is for an Emergency. 0: Non-Emergency message (Normal) 1: Emergency message
Home/ Visitor	Indicates if Visitor ID is included in the message. This is valid for GRP_REG_RESP only. 0: No (Registered at Home or in Single System) 1: Yes (Registered as visitor in Multi-system

Table 6.5-5 Group Registration Option Values

6.5.10. Authentication Option

8-bit Authentication Option indicates additional information for authentication.

Bit	7	6	5	4	3	2	1	0
Octet 0	Em	LID	←		spare			→

Figure 6.5-4 Authentication Option Format

Field	Description and Value
Emergency	Indicates if the message is for an Emergency. 0: Non-Emergency message (Normal) 1: Emergency message
Location ID	Indicates if Location ID is included in the message. 0: No (Authentication inquiry at Home or in Single System, or Conventional System) 1: Yes (Authentication inquiry during registration or for visitor in Multi-System)

Table 6.5-6 Authentication Option Values

6.5.11. CC Option

8-bit CC Option indicates additional information for Call Control messages.

Bit	7	6	5	4	3	2	1	0
	Em	I/I	Priority	←		spare		→

Figure 6.5-5 CC Option Format

Field	Description and Value
Emergency	Indicates if the message is for an Emergency. 0: Non-Emergency message (Normal) 1: Emergency message
Intra/ Inter	Indicates whether a originating or incoming call are between different systems. Location ID is included in messages for Inter-system. 0: Intra-system (or Single System) 1: Inter-system
Priority	Indicates priority of a paging 0: Normal paging 1: Priority paging

Table 6.5-7 CC Option Values

6.5.12. Call Type

3-bit Call Type is a value to identify the call type for paging.

Value (Bit)	Definition	Description
000	Broadcast Call	Unidirectional group call This value is used only in a trunked radio system.
001	Conference Call	Bidirectional group call
010	Unspecified Call	Call type is not specified. This value is used only in a TX_REL message.
011	reserved	
100	Individual Call	Indicates an individual call
101	reserved	
110	Interconnect Call	Indicates PSTN call
111	Speed Dial Call	Indicates PSTN call with speed dial

Table 6.5-8 Call Type Values

6.5.13. Voice Call Option

5-bit Voice Call Option indicates additional information for a voice call.

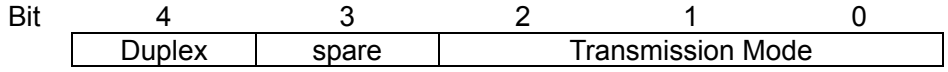


Figure 6.5-6 Voice Call Option Format

Field	Description and Value
Duplex	Indicates access method 0: Half Duplex (SU is in Simplex) 1: Duplex
Transmission Mode	Indicates communication parameters including bit rate, Vocoder 000: 4800 bps/EHR 010: 9600 bps/EHR 011: 9600 bps/EFR Others: reserved

Table 6.5-9 Voice Call Option Values

6.5.14. Data Call Option

5-bit Data Call Option indicates additional information for a data call.

Bit	4	3	2	1	0
	Duplex	spare	Transmission Mode		

Figure 6.5-7 Data Call Option Format

Field	Description and Value
Duplex	Indicates access method 0: Half-duplex (SU is in Simplex) 1: Duplex
Transmission Mode	Indicates communication parameters including bit rate 000: 4800 bps 010: 9600 bps Others: reserved

Table 6.5-10 Data Call Option Values

6.5.15. Status Call Option

5-bit Status Call Option indicates additional information for a status call.

Bit	4	3	2	1	0
	spare	Delivery	spare	Format Indication	

Figure 6.5-8 Status Call Option Format

Field	Description and Value
Delivery	Indicates confirmed or unconfirmed delivery 0: Unconfirmed type without a response from destination 1: Confirmed type with a response from destination
Format Indication	Indicates the content of Status messages 00: Status Others: reserved

Table 6.5-11 Status Call Option Values

The values for Status Call Option in each message shall be set as follows.

STAT_INQ_REQ	Status Call Option = 01000
STAT_REQ in confirmed type	Status Call Option = 01000
STAT_REQ in unconfirmed type	Status Call Option = 00000

6.5.16. Location ID Option

5-bit Location ID Option indicates additional information on the Location ID included in messages for Multi-system.

Bit	4	3	2	1	0
	Related Unit ID		spare	spare	spare

Figure 6.5-9 Location ID Option Format

Field	Description and Value
Related Unit ID	Indicates whether Location ID is related to Source Unit ID or to Destination Unit ID. If the related Unit ID is specified in each message, the Location ID shall be set in accordance with the designation. 10: Location ID of Source Unit ID 01: Location ID of Destination Unit ID Others: reserved

Table 6.5-12 Location ID Option Values

6.5.17. Digit

4-bit Digit is a value to represent digit of dial number and DTMF codes.

A value for Extended DTMF Code is used as a Digit sent subsequent to the extension of DTMF Code.

Value (Bit)	DTMF Code	Extended DTMF Code
0000	Filler	reserved
0001	“1”	“A“
0010	“2”	“B”
0011	“3”	“C”
0100	“4”	“D”
0101	“5”	reserved
0110	“6”	reserved
0111	“7”	reserved
1000	“8”	reserved
1001	“9”	reserved
1010	“0”	reserved
1011	“*”	reserved
1100	“#”	reserved
1101	reserved	reserved
1110	reserved	reserved
1111	extension	not used

Table 6.5-13 Digit Values

6.5.18. Speed Dial

8-bit Speed Dial is a value to represent the speed dial number.

Value (Hex)	Definition	Description
00	Null Dial	Used as Filler without specifying a particular speed dial.
01 to FF	System definable	System definable speed dial

Table 6.5-14 Speed Dial Values

6.5.19. Packet Information

24-bit Packet Information indicates the configuration of transmission packet in a data call. In SDCALL_REQ, only Octet 0 and Octet 1 are used and TX Fragment Count is not used.

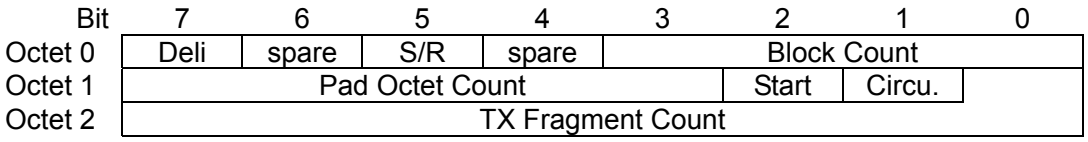


Figure 6.5-10 Packet Information Format

Field	Description and Value
Delivery Flag (Octet 0; Bit 7)	Indicates confirmed or unconfirmed delivery 0: Unconfirmed type without a response from destination 1: Confirmed type with a response from destination
Spare (Octet 0; Bit 6)	
Selective Retry Flag (Octet 0; Bit 5)	Indicates if selective retry transmission packet. 0: Normal transmission packet (Fixed to 0 in SDCALL_REQ) 1: Selective retry transmission packet
Spare (Octet 0; Bit 4)	
Block Count (Octet 0; Bits 3-0)	Indicates the number of User Data blocks in the transmission packet. Valid range is 1 to16 blocks (0000 to 1111)
Pad Octet Count (Octet 1; Bits 7-3)	Indicates the number of Null octets of the last block in the transmission packet Valid range is 0 to 20 Octets (00000 to 10100) in UDCH Valid range is 0 to 14 Octets (00000 to 01110) in UPCH Valid range is 0 to 8 Octets (00000 to 01000) in FACCH1
Start Fragment Flag (Octet 1; Bit 2)	Indicates the first fragment 0: Not first 1: First (Fixed to 1 in SDCALL_REQ)
Circular Fragment Flag (Octet 1; Bit 1)	Indicates if the TX Fragment Count circulates 0: Not circulate (Fixed to 0 in SDCALL_REQ) 1: Circulate
TX Fragment Count (Octet 1; Bit 0 to Octet 2; Bit 0)	Indicates the number and sequence of fragments If Circular Fragment Flag = 0: In the first fragment, it is set to (The Number of Fragments - 1) and in the last fragment it is set to 0 If Circular Fragment Flag = 1: In the first fragment, it is set to the max value (all bits set to 1), then in each fragment it is decremented using mod 9 calculation

Table 6.5-15 Packet Information Values

6.5.20. Block Number

4-bit Block Number indicates the block sequence when fragments are divided into multiple blocks.

Value (Bit)	Definition	Description
1111	Block No. 15	Represents a Block No. 15
1110 to 0001	Block No. 14 to No. 1	Represents Block No. 14 to No. 1
0000	Block No. 0	Represents a Block No. 0 (last)

Table 6.5-16 Block Number Values

For selective retry, the Block Number corresponding to the block to which retransmission is required is reused as the Block Number of the User Data format in the selective retry packet.

6.5.21. Packet Frame Number

4-bit Packet Frame Number indicates the frame transmission sequence of a User Data format included in the transmission packet.

Value (Bit)	Definition	Description
1111	Frame No. 15	Represents a Frame No. 15
1110 to 0001	Frame No. 14 to No. 1	Represents Frame No. 14 to No. 1
0000	Frame No. 0	Represents Frame No. 0 (last)

Table 6.5-17 Packet Frame Number Values

A transmission packet includes a maximum of 16 User Data formats. In that maximum case, the first Header format is deemed as Frame No. 16, and No.15 to No. 0 values are sequentially used in Packet Frame Numbers of the following User Data formats.

6.5.22. Response Information

16-bit Response Information indicates the configuration of response packet in data call. Unused value is reserved in Class and Type.

Bit	7	6	5	4	3	2	1	0
Octet 0	spare	spare	Class			Type		
Octet 1	RX Fragment Count							

Figure 6.5-11 Response Information Format

Class	Type	Description
00	001	ACK (Reception Successful)
01	001	ACK_S (Request for Selective Retry)
11	001	NACK (Request for Full Retry)
	010	NACK (Memory Full)
	011	NACK (abort)

Table 6.5-18 Class and Type Values

Field	Description and Value
spare (Octet 0: Bit 7)	Spare
spare (Octet 0: Bit 6)	Spare
RX Fragment Count (Octet 0: Bit 0 to Octet 1: Bit 0)	Indicates received TX Fragment Count

Table 6.5-19 Response Information Values

6.5.23. Error Block Flag

16-bit Error Block Flag used in a response message for data calls indicates the blocks required to be retransmitted by reception failure.

Bit	7	6	5	4	3	2	1	0
Octet 0	F15	F14	F13	F12	F11	F10	F9	F8
Octet 1	F7	F6	F5	F4	F3	F2	F1	F0

Figure 6.5-12 Error Block Flag Format

Field	Description and Value
Fx	Successful reception for each Block Number 15 to 0 is presented. 0: Reception success or unused block 1: Reception failure

Table 6.5-20 Error Block Flag Values

6.5.24. Status

8-bit Status indicates the status of a user or a SU. The Status is comprised of user or system definable Status (1 to 207) and Status predefined in this document (208 to 255).

Value (Hex)	Definition	Description
00	Null Status	Used as Filler without specifying a Status
01 to CF	User definable	User definable Status
D0	Paging Status	Paging
D1 to DF	reserved	Reserved for predefined Status
E0	Emergency Status	Emergency
E1	Emergency Status	Emergency by Man-down
E2	Emergency Status	Emergency Termination
E3	Emergency Status	Emergency by Stationary Detection
E4	Emergency Status	Emergency by Motion Detection
E5	Emergency Status	Emergency by Lone Worker
E6 to FF	Reserved	Reserved for predefined Status

Table 6.5-21 Status Values

6.5.25. Control Command

5-bit Control Command indicates a remote control command used in REM_CON_REQ/RESP. ID Type (Group ID or Unit ID) that can be used for REM_CON_REQ is limited depending on Control Command value.

Value (Bit)	Definition	ID type	Description
00000	Stun	Both	Makes a SU to be in the Stun state.
00001	Revival	Both	Makes a SU to be released from the Stun state.
00010	Kill	Both	Makes a SU to be in the Kill state.
00011	Reserved		Reserved
00100	Remote Monitor	Unit ID	Makes a SU to automatically transmit.
Other values	reserved		Reserved

Table 6.5-22 Control Command Values

6.5.26. Control Parameter

2-bit Control Parameter indicates a control parameter corresponding Control Command information element.

Bit	7	6	5	4	3	2	1	0
Octet 0	Parameter 1							
Octet 1	Parameter 2							

Figure 6.5-13 Control Parameter Format

Command	Definition of Parameter 1	Definition of Parameter 2
Stun	Bit 7: Mode 0: Tx Inhibition 1: Tx & Rx Inhibition Bit 6 to 0: spare	Bit 7 to 0: spare
Revival	Bit 7 to 0: spare	Bit 7 to 0: spare
Kill	Bit 7 to 0: spare	Bit 7 to 0: spare
Remote Monitor	Bit 7: Mode 0: Normal Mode 1: Silence Mode Bit 6 to 0: spare	Bit 7 to 0: Transmission Duration 00h : reserved 01 to FFh: 1 second to 255 seconds

Table 6.5-23 Control Parameter Values

6.5.27. Cipher Type

2-bit Cipher Type indicates the encryption method.

Value (Bit)	Definition
00	Non-ciphered Mode
01	Scramble Mode
10	DES Mode
11	AES Mode

Table 6.5-24 Cipher Type Values

6.5.28. Key ID

6-bit Key ID indicates the encryption key used in encryption.

Value (Hex)	Definition
00	Non-ciphered Mode Default or Unspecified Key ID (Ver.1.2 or before) Non-ciphered Mode Default or User definable (Ver.1.3 or later)
01 to 3F	User definable

Table 6.5-25 Key ID Values

6.5.29. Delay Count

16-bit Delay Count indicates the number of remaining frames before a valid frame being sent out.

Value (Hex)	Definition
0000	The number of remaining frames = 0 (last)
0001	The No. of remaining frames = 1
0002	The No. of remaining frames = 2
•••	•••
03FE	The No. of remaining frames = 1022
03FF	The No. of remaining frames = 1023
Others	reserved

Table 6.5-26 Delay Count Values

6.5.30. Cause

8-bit Cause has the following 5 formats for different message types.
Although all 5 formats can be used in a trunked radio system, some formats are required for a conventional system.

Cause (MM) is the information element in the response message for mobility management. It is used to inform of a reception result for request messages including the location registration request message.
Cause (VD) is the information element in the response message for call control in voice or data call. It is used to inform of a reception result or status for request messages.
Cause (SS) is the information element in the response message for call control in status call or short data call, simultaneous data call and remote control. It is used to inform of a reception result for request messages.
Cause (DREQ) is the information element in the disconnect request message (DISC_REQ). It is used to inform of a reason of disconnect when a SU disconnects.
Cause (DISC) is the information element in the disconnect message (DISC). It is used to inform of a reason of disconnect when a TC disconnects.

Values that are not used for Type and Indications are reserved.

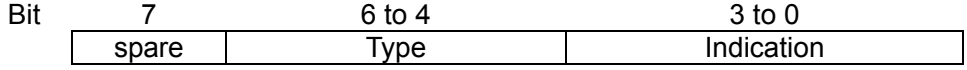


Figure 6.5-14 Cause Format

Type	Indication	Definition
000 Normal	0001	Registration is accepted.
	0100	Location is accepted, but Group is failed.
	0101	Location is accepted, but Group is refused.
	0110	Registration is failed.
	1000	Registration is refused.
101 Resource Unavailable	0001	Network failure
	0010	Temporary failure
	0011	Equipment congestion
	1111	Other class for resource unavailable
110 Service Unavailable	0000	Request for unavailable service
	1111	Other class for service unavailable or unsupported
111 Procedure error	0000	Lack of mandatory information elements
	0001	Undefined information element or Invalid contents
	1111	Other class for procedure error

Table 6.5-27 Cause (MM) Values

Type	Indication	Definition
001 Normal 1	0000	Accepted normal
	0001	Called group is not permitted for the service
	0010	Calling SU is not permitted for the service
	0011	Called SU is not permitted for the service
	0100	Called SU has not done the registration yet
	0101	No response from the called SU
	0110	Incoming call rejection for a called SU
	1000	Called SU is in busy
	1001	Called group is in busy
	1010	Calling SU is in busy
	1100	SU has not been registered yet
	1101	Group has not been registered yet
	1110	Queuing interruption
010 Normal 2	0000	Calling SU is not permitted for use
	0001	Called SU is not permitted for use
	0010	Group is not permitted for use
011 Normal (Queue)	0000	All channel resources are in use
	0001	All phone line resources are in use
	0010	Called unit is being alerted
	0011	Phone line is being alerted
	1000	Called SU is in busy
	1001	Called group is in busy
	1111	Other queue without a specific reason
101 Resource Unavailable	0000	Channel unavailable
	0001	Network failure
	0010	Temporary failure
	0011	Equipment congestion
	1111	Other class for resource unavailable
110 Service Unavailable	0000	Request for unavailable service
	0001	Request for unsupported service
	1111	Other class for service unavailable or unsupported
111 Procedure error	0000	Lack of mandatory information elements
	0001	Undefined information element or Invalid contents
	1111	Other class for procedure error

Table 6.5-28 Cause (VD) Values

Type	Indication	Definition
000 Normal (data response)	0001	ACK (Receive success)　[1]
	0010	ACK (Send success)
	1000	NACK (Request for full retry)　[1]
	1001	NACK (Memory Full)　[1]
	1010	NACK (Abort)　[1]
001 Normal 1	0000	Accepted normal
	0001	Called group is not permitted for the service
	0010	Calling SU is not permitted for the service
	0011	Called SU is not permitted for the service
	0100	Called SU has not done the registration yet
	0101	No response from the called SU
	0110	Incoming call rejection for a called SU
	1000	Called SU is in busy
	1001	Called group is in busy
	1010	Calling SU is in busy
	1100	SU has not been registered yet
	1101	Group has not been registered yet
010 Normal 2	0000	Calling SU is not permitted for use
	0001	Called SU is not permitted for use
	0010	Group is not permitted for use
101 Resource Unavailable	0000	Channel unavailable
	0001	Network failure
	0010	Temporary failure
	0011	Equipment congestion
	1111	Other class for resource unavailable
110 Service Unavailable	0000	Request for unavailable service
	0001	Request for unsupported service
	1111	Other class for service unavailable or unsupported
111 Procedure error	0000	Lack of mandatory information elements
	0001	Undefined information element or Invalid contents
	1111	Other class for procedure error

[1]: Only these Causes are required in a conventional system.

Table 6.5-29　Cause (SS) Values

Type	Indication	Definition
001 Normal	0000	Disconnected by a user
	0100	Disconnected by timer
	1111	Other disconnect request

Table 6.5-30 Cause (DREQ) Values

Type	Indication	Definition
001 Normal (SU)	0000	Disconnected by a user
	0001	Disconnected by PSTN
	0100	Disconnected by timer
	1111	Other disconnect from SU
010 Normal (TC)	0000	Disconnected by timer of TC
	1111	Other disconnect from TC
101 Resource Unavailable	0000	Channel unavailable
	0001	Network failure
	0010	Temporary failure
	0011	Equipment congestion
	1111	Other class for resource unavailable
110 Service Unavailable	0000	Request for unavailable service
	0001	Request for unsupported service
	1111	Other class for service unavailable or unsupported
111 Procedure error	0000	Lack of mandatory information elements
	0001	Undefined information element or Invalid contents
	1111	Other class for procedure error

Table 6.5-31 Cause (DISC) Values

6.5.31. Channel

10-bit Channel is a value to determine the carrier frequency used for control channels or traffic channels of a TRS.

Value (Hex)	Definition
000	Null
001	Channel No. 1
•••	•••
3FF	Channel No. 1023

Table 6.5-32 Channel Values

6.5.32. Call Timer

6-bit Call Timer indicates the transmission duration that allows a SU to continuously transmit on a traffic channel in a trunked radio system.

Value (Bit)	Definition
00 0000	Unspecified (SU dependent)
00 0001	15 seconds
00 0010	30 seconds
•••	In steps of 15 seconds
00 1100	180 seconds
00 1101	210 seconds
•••	In steps of 30 seconds
01 1010	600 seconds
01 1011	Reserved
•••	•••
11 1110	Reserved
11 1111	Reserved

Table 6.5-33 Call Timer Values

6.5.33. Service Information

16-bit Service Information indicates the services supported by a TRS.

The service is indicated by 16 flags where the available service is indicated with the flag set to "1".

Bit	7	6	5	4	3	2	1	0
Octet 0	SIF1	SIF2	SIF3	SIF4	SIF5	SIF6	SIF7	SIF8
Octet 1	SIF9	SIF10	SIF11	SIF12	SIF13	SIF14	SIF15	SIF16

Figure 6.5-15 Service Information Format

SI Flag	Description
SIF1	Multi-site Service
SIF2	Multi-system Service
SIF3	Location Registration Service
SIF4	Group Registration Service
SIF5	Authentication Service
SIF6	Composite Control Channel Service
SIF7	Voice Call Service
SIF8	Data Call Service
SIF9	Short Data Call Service
SIF10	Status Call & Remote Control Service
SIF11	PSTN Network Connection Service
SIF12	IP Network Connection Service
SIF13	spare
SIF14	spare
SIF15	spare
SIF16	spare

Table 6.5-34 Service Information Flags

6.5.34. Restriction Information

24-bit Restriction Information indicates restriction of functions and a restricted SU in a TRS.

Bit	7	6	5	4	3	2	1	0
Octet 0	Mobile station operation information				Access cycle interval			
Octet 1	Restriction group				Restriction Information			
Octet 2	←	spare					→	ISO

Figure 6.5-16 Restriction Information Format

Mobile station operation information (Octet 0, Bits 7 to 4)				
Bit 7	Bit 6	Bit 5	Bit 4	Setting Description
0				No access restriction
1				Access restriction
	0			No restriction for maintenance
	1			Restriction for maintenance
		spa	spa	Bit 5 and Bit 4 are spares.

Access cycle interval (Octet 0, Bits 3 to 0)				
Bit 3	Bit 2	Bit 1	Bit 0	Setting Description
0	0	0	0	No restriction
0	0	0	1	20 frames
				…
1	1	1	1	300 frames

Restriction group specification (Octet 1, Bits 7 to 4)				
Bit 7	Bit 6	Bit 5	Bit 4	Setting Description
0				No Group 4 restriction
1				Group 4 restriction
	0			No Group 3 restriction
	1			Group 3 restriction
		0		No Group 2 restriction
		1		Group 2 restriction
			0	No Group 1 restriction
			1	Group 1 restriction

Restriction Information (Octet 1, Bits 3-0)				
Bit 3	Bit 2	Bit 1	Bit 0	Setting Description
0				General mobile station; No location registration restriction
1				General mobile station; Location registration restriction
	0			General mobile station; No call restriction
	1			General mobile station; Call restriction
		spa	spa	Bit 1 and Bit 0 are spares.

Field	Description and Value
Temporarily Isolated Site (Octet 2, Bit 0)	Indicates the site is temporarily isolated from the network due to trouble such as failure in a Multi Site Service system. This is valid only if the SIF 1 of Service Information is set to “1”. 0: Normal Condition 1: Isolated Condition

Table 6.5-35 Restriction Information Values

6.5.35. Channel Structure Information

16-bit Channel Structure Information indicates the RCCH structure of a TRS and the frames to page a SU.

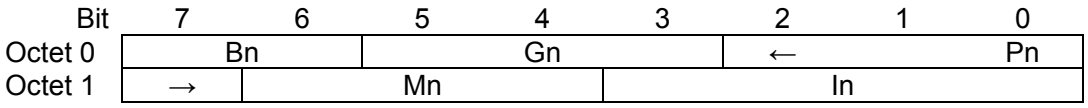


Figure 6.5-17 Channel Structure Information Format

Field	Description and Value
Bn	Number of BCCH Specifies the number of BCCH frames per superframe 00: Reserved 01 to 11: 1 frame to 3 frames
Gn	Number of Grouping Specifies the number of groups per RCCH 000: Reserved 001 to 111: Group 1 to Group 7
Pn	Number of Paging Frames Specifies the number of CCCH/ UPCH frames for paging 0000: Reserved 0001 to 1111: 1 frame to 15 frames
Mn	Number of Multipurpose Frames Specifies the number of multipurpose CCCH/ UPCH frames following the paging frame 000 to 111: 0 frame to 7 frames
In	Number of Iteration Specifies the number of iterations of groups within one superframe 0000: Reserved 0001 to 1111: 1 to 15

Table 6.5-36 Channel Structure Information Values

6.5.36. Channel Access Information

24-bit Channel Access Information indicates the access method of SUs to RCCH of a TRS or acquisition condition to the control channel.

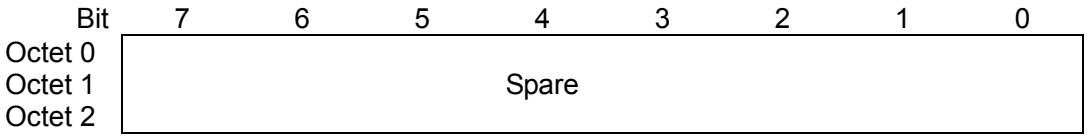


Figure 6.5-18 Channel Access Information Format

6.5.37. Adjacent Site Allocation

4-bit Adjacent Site Allocation indicates the number of adjacent TRSs.

Value (Hex)	Definition
0	0 site for Single Site
1 to F	1 site to 15 sites for Multi-Site

Table 6.5-37 Adjacent Site Allocation Values

6.5.38. Adjacent Site Option

6-bit Adjacent Site Option indicates additional information on adjacent TRSs.

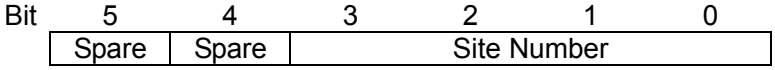


Figure 6.5-19 Adjacent Site Option Format

Field	Description and Value
Site Number	No. of adjacent sites. 0000: reserved 0001 to 1111: Site No.1 to Site No.15

Table 6.5-38 Adjacent Site Option Values

6.5.39. Subscriber Type

16-bit Subscriber Type identifies the type and maximum transmission power of a SU.

Bit	7	6	5	4	3	2	1	0
Octet 0	Classification		Tx Power			Access		
Octet 1	Bit Rate			Codec		spare		

Figure 6.5-20 Subscriber Type Format

Field	Description and Value
Classification	Type of SU 00: Mobile station 01: Fixed station 10 to 11: reserved
Tx Power	Maximum transmission power of SU 000: Not specified 001 to 111: reserved
Access	Access method which a SU uses 000: FDMA Simplex 001: FDMA Duplex Reserved for others
Bit Rate	Bit rate which a SU uses 001: 4800 bps 010: 9600 bps 011: 4800 bps & 9600 bps Reserved for others
Codec	Vocoder which a SU uses 01: AMBE+2 EHR 11: AMBE+2 EHR & EFR Reserved for others

Table 6.5-39 Subscriber Type Values

6.5.40. Version Number

8-bit Version Number indicates the NXDN version or software version for a TC and a SU.

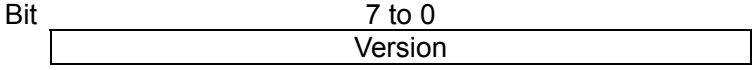


Figure 6.5-21 Version Number Format

Field	Description and Value
Version	Version of an NXDN system or software is presented. However, the notation is not specified.

Table 6.5-40 Version Number Values

6.5.41. Initialization Vector

64-bit Initialization Vector is an information element used to initialize DES and AES encryption. The value of all "0" shall not be used.

7. Voice Coding Method

7.1. Outline

The voice coding method used in NXDN is AMBE+2, which is an improved and an advanced Multi-band excitation (MBE) method, developed by Digital Voice System, Inc. in the USA. Voice-coding rates are EHR (3600 bps) and EFR (7200 bps).

In EHR, the voice coding is processed at 2450 bps by generating 49-bit voice-coding data at 20 ms intervals. This 49-bit data is converted to 72-bit VCH data by adding 23-bit redundancy bit through error correction.

In EFR, the voice coding is processed at 4400 bps by generating 88-bit voice-coding data at 20 ms intervals. This 88-bit data is converted to 144-bit VCH data by adding 56-bit redundancy bit through error correction.

A diagram of encoder for Vocoder is represented in Figure 7.1-1 and a diagram of decoder for Vocoder is represented in Figure 7.1-2.

Refer to the AMBE+2 technical documents supplied by DVSI for detailed specifications, and the following sections define the test patterns used in various tests.

Data sequences provided shall be written in hexadecimal number (hex) and the transmission order is sent from the left side of the data sequence, and is sent the right side finally.

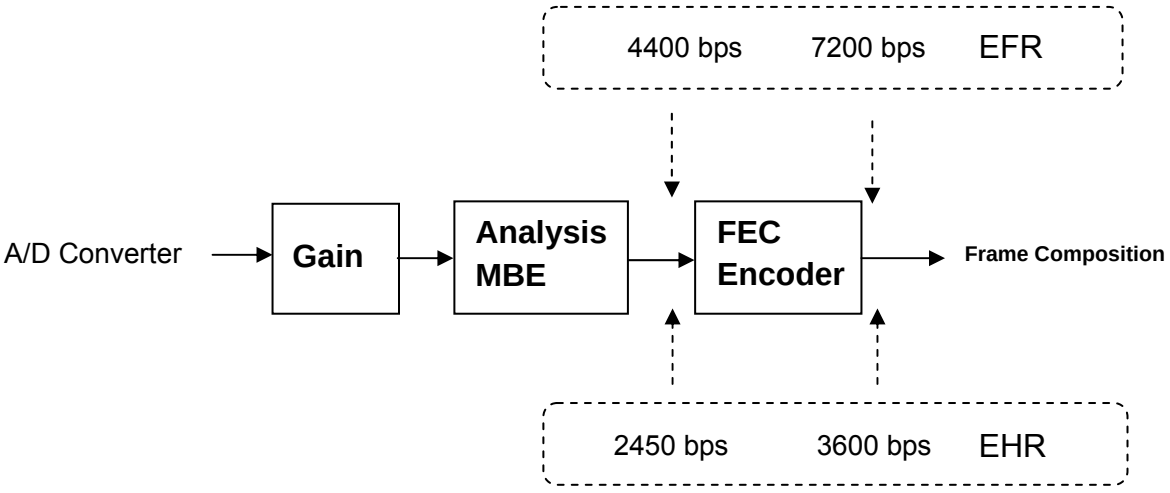


Figure 7.1-1 Diagram of Vocoder (Encoder)

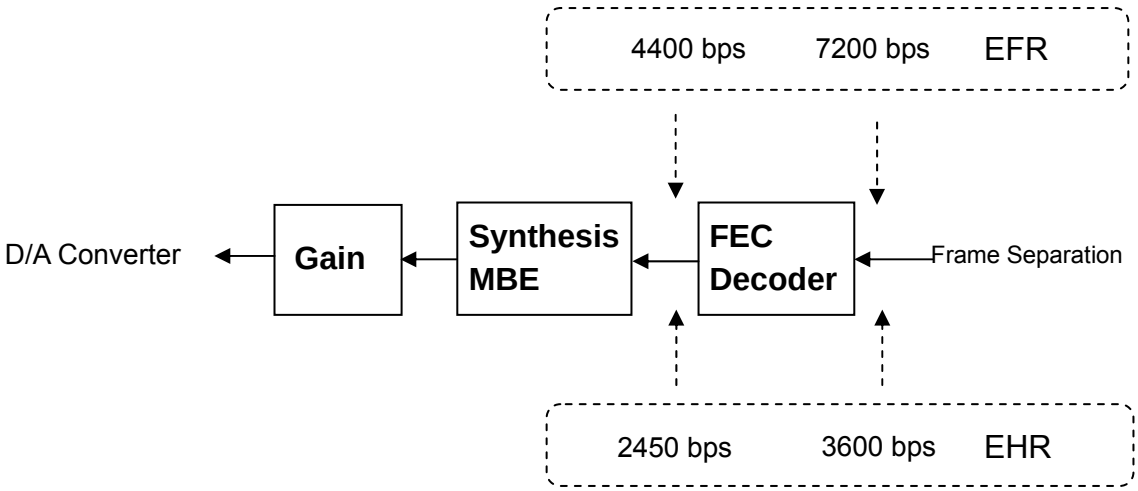


Figure 7.1-2 Diagram of Vocoder (Decoder)

7.2. Vocoder Test Signals

7.2.1. EHR Vocoder

7.2.1.1. Tone Test Pattern

Tone Test Pattern is a 1031 Hz single tone with -22 dBm0.

Following are 49-bit data sequence generated by the voice coding and 72-bit data sequence after the FEC processing.

Voice coding data (49 bits)	FEE2 1212 1210 0 (first 49 bit are valid.)
Voice coding data with FEC (72 bits)	CEA8 FE83 ACC4 5820 0A

7.2.1.2. Silence Test Pattern

Silence Test Pattern is a signal having a level of less than the -90 dBm0 in the audio frequency bandwidth.

Following are 49-bit data sequence generated by the voice coding and 72-bit data sequence after the FEC processing.

Voice coding data (49 bits)	F801A99F8CE08 (first 49 bits are valid.)
Voice coding data with FEC (72 bits)	B9E8 8152 6173 002A 6B

7.2.2. EFR Vocoder

7.2.2.1. Tone Test Pattern

Tone Test Pattern is a 1011 Hz single tone with -22 dBm0.

Following are 88-bit data sequence generated by the voice coding and 144-bit data sequence after the FEC processing. Each data sequence shall be alternately sent in the order of #1 and #2.

Voice coding data (88 bits) #1	09B0 880C C621 F680 A826 00
Voice coding data (88 bits) #2	09B0 880C C621 F680 A826 00
Voice coding data with FEC (144 bits) #1	3892 8490 D433 C0BE 1B91 844F F058 A589 D839
Voice coding data with FEC (144 bits) #2	3892 8490 D433 C0BE 1B91 844F F058 A589 D83B

7.2.2.2. Silence Test Pattern

Silence Test Pattern is a signal having a level of less than -90 dBm0 in the audio frequency bandwidth.

Following are 2 voice-coding data sequence generated. Each data sequence shall be alternately sent in the order of #1 and #2.

Voice coding data (88 bits) #1	040CFD7BFB7DF27B3D9E44
Voice coding data (88 bits) #2	040CFD7BFB7DF27B3D9E45
Voice coding data with FEC (144 bits) #1	6C42 E85D E2E8 2693 63D9 81F9 BE23 B18A E004
Voice coding data with FEC (144 bits) #2	6C42 E85D E2E8 2693 63D9 81F9 BE23 B18A E006

8. Glossaries

Broadcast Control Channel (BCCH)
: A functional channel to broadcast various configuration information of the trunked radio system on RCCH.

Broadcast Data Call
: One-to-many data communication.

Broadcast Short Data Call
: One-to-many data communication with limited size of data on the control channel.

Broadcast Status Call
: One-to-many communication for simplified and preconfigured message transmission.

Common Access Channel (CAC)
: This is one of category of functional channels and includes the functional channels used on RCCH. CAC is used on outbound RCCH, and two types of CAC, which are Long CAC and Short CAC, are used on inbound RCCH. Sendable information length and channel coding procedure differ among 3 CAC.

Common Air Interface (CAI)
: The specification of the radio communication interface at a reference point, Um.

Common Control Channel (CCCH)
: A functional channel to transfer the control information required for mobility management and call controls on RCCH.

Console
: An equipment used for controlling the system or sending the communication control commands.

Control Channel
: A general name for the bidirectional channel to transfer the control information required for mobility management and call control.

Conventional Repeater (CR)
: An equipment, which is comprised of repeater unit, that uses 2 radio channels to relay a signal and to extend the communication range among SUs.

Conventional Repeater Site (CRS)
: A facility that is comprised of multiple conventional repeaters. Each repeater works independently to relay a signal.

Conventional System
: An LMR system that does not have any functions to allocate a channel automatically and the user must select a channel manually for communication. There are 2 operating modes: Direct mode and Repeater mode.

Data Call
: One-to-one data communication.

Dibit
Information data unit processed 2 bits at a time.

Direct Mode Operation (DMO)
An operating mode to directly communicate between SUs. This operating mode includes the Talk Around function for the SUs.

Dispatcher
An operator or facility to control the tasks of the fleet in the field.

Duplex
A communication mode in which transmission and reception occur simultaneously.

Electronic Serial Number (ESN)
ESN is a unique number written into each Subscriber Unit by its manufacturer.

Enhanced Full Rate (EFR)
An operating mode of AMBE+2 Vocoder that has 7200 bps voice coding rate (including error corrections).

Enhanced Half Rate (EHR)
An operating mode of AMBE+2 Vocoder that has 3600 bps voice coding rate (including error corrections).

Fast Associated Control Channel 1 (FACCH1)
A functional channel to transfer the control information at high speed by interrupting the voice data on RTCH/RDCH.

Fast Associated Control Channel 2 (FACCH2)
A functional channel to transfer the control data together with packet data or independently on RTCH/RDCH.

Fixed Station (FS)
A SU installed and operated at a fixed location without any movement.

Frame
A minimum unit of data transmission to distinguish a block for a radio carrier.

Frame Sync Word (FSW)
A fixed bit pattern used to synchronize frames.

Frequency Division Multiple Access (FDMA)
Access method to divide a channel on frequency domain in order to share the channel by multiple users.

Group Call
One-to-many (Point to multi-point) voice communication. There are 2 modes: Broadcast Call in unidirectional and Conference Call in bidirectional.

Hold Time
Duration to hold the repeater's transmission when the inbound signal is lost.

Inbound Signal
A direction or signal that is transmitted toward a Repeater from a SU.

Inbound Message
Layer 3 message that is transferred toward a Repeater from a SU.

Individual Call
One-to-one (point-to-point) voice communication

Interconnect Call
One-to-one or one-to-many voice communication using a telephone line.

IP Network
Network using the Internet Protocol.

Layer 1 (L1)
Basic interface
This layer deals with the basic structural layer of radio channels and provides the channel definition and format.

Layer 2 (L2)
Transmission control
This layer specializes in the transmission control between stations, and provides the channel identification and timing.

Layer 3 (L3)
Connection control
This layer deals with data transmission between end systems and provides the method of call control, mobility management and RF transmission management.

Link Information Channel (LICH)
A functional channel to transfer control information to identify the radio channel or functional channel.

Mobile Station (MS)
A vehicle or portable type transceiver, which is a kind of Subscriber Unit, used in mainly mobile environment.

Nyquist 4-Level FSK (4LFSK)
FSK modulation method that has levels of 4 symbol and uses a Nyquist filter as the baseband filter.

Nyquist Response
A filter to limit the frequency bandwidth without generating intersymbol interference. This filter has an odd symmetry characteristic as the attenuation curve.

Octet
Unit of information consisting of 8 bits.

Outbound Signal
A direction or signal that is transmitted toward a SU from a Repeater.

Outbound Message
Layer 3 message that is transferred toward a SU from a Repeater.

Partial Echo (PE)
Signal to notify a SU that the transmission has succeeded by sending back a part of inbound signal received successfully by Trunking Repeater as outbound signal in random access control on RCCH.

Preamble
Fixed bit pattern to be sent prior to a frame transmission in order to establish the bit synchronization.

Private Branch Exchange (PBX)
Telephone exchange facility installed in an office building for the purpose of business communication within the office or with the external lines.

Public Switched Telephone Network (PSTN)
The public circuit-switched telephone network.

Radio Access Number (RAN)
ID information equivalent to CTCSS/CDCSS of analog FM in conventional system. This information is used as color code to detect the co-channel interference in a trunked radio system.

Repeater Unit (RU)
Transmitter/receiver equipment that can relay a radio signal.

RF Control Channel (RCCH)
RF carrier to transfer the control information in a Trunking Repeater Site. At least one carrier of Trunking Repeater is used for this channel within a site.

RF Direct Traffic Channel (RDCH)
RF carrier to transfer the communication information of the user in a conventional system.

RF Traffic Channel (RTCH)
RF carrier to transfer the communication information of the user in a Trunking Repeater Site. At least one carrier of Trunking Repeater is used for this channel within the site.

Roll Off Factor
This is expressed as a letter of “α” and represents the characteristics of a Nyquist filter.
The smaller the value is, the narrower the output spectrum becomes. However, the transmission degradation to an error of timing increases.

Root Nyquist Response
Square root of the Nyquist characteristics.

Semi-duplex
A communication mode in which one of the stations is in simplex mode and the other station is in duplex mode.

Short Data Call
One-to-one data communication with limited size data on the control channel.

Simplex
A communication mode in which either transmission or reception occurs separately, not simultaneously.

Simultaneous Data Call
Slow data communication processed simultaneously with voice communication.

Single Channel Per Carrier (SCPC)
A communication method allocating 1 carrier to a channel for transferring information.

Site Roaming
A SU moves to another site in a trunked radio system comprised of multiple sites.

Slow Associated Control Channel (SACCH)
A functional channel to transfer control information at slow speed along with voice data on RTCH/RDCH.

Status Call
One-to-one communication for simplified and preconfigured message transmission.

Subscriber Unit (SU)
A generic name to indicate all types of transceivers including portable, vehicle and fixed stations.

Superframe
A collection of frames consisting of multiple frames.

Symbol
Unit of signal used in the modulation process. In 4-level FSK, the signal consists of 2-bit data.

Symbol Rate
A rate of change of the state of a carrier modulated by a baseband signal, or modulation speed.

System Roaming
A SU moves to another system in a trunked radio system comprised of multiple systems.

Traffic Channel
A general name to indicate a bidirectional channel used for information transfer regarding voice or data communication.

Trunked Radio System
An LMR system that has a facility to automatically allocate RF channels to effectively utilize the spectrum.

Trunking Controller (TC)
A control equipment for a radio line control.

Trunking Repeater (TR)
Equipment that processes a line control or relay operation by using 2 radio channels, and comprises a Repeater Unit and Trunking Controller.

Trunking Repeater Site (TRS)
A facility that provides a minimum unit of service area in a trunked radio system, and comprises multiple Trunking Repeaters.

Type-C Trunked System
A trunked radio system which uses a centralized control method with dedicated control channel.

Type-D Trunked System
A trunked radio system which uses a distributed control method without dedicated control channel.

User Data Channel (UDCH)
A functional channel to transfer packet data on RTCH/RDCH.

User Packet Channel (UPCH)
A functional channel to transfer packet data on RCCH.

User Specific Channel (USC)
This is one of category of functional channels and includes the functional channels used on RTCH/RDCH.

Vocoder
Voice coding processing
An encoder converts analog voice signals into compressed digital data. A decoder converts digital voice signals back into analog voice signals.

Voice Channel (VCH)
A functional channel to transfer voice data on RTCH/RDCH.

9. Appendix

9.1. Dealing with Spare Field and Reserve Field

This section describes the definitions of bit patterns shown as Spare or Reserved in this document.

Spare or Reserved area is reserved field or value for future use and shall be treated as follows:

Area	Transmission	Reception
Spare area	Uses Null pattern unless otherwise specified	Ignored
Reserved area	Prohibited to use this reserved bit pattern	Processed as invalid field or message

Table 9.1-1 Dealing with Spare Field and Reserve Field

9.2. Emission Designator

This section shall define the Necessary Bandwidth used for emission type in an NXDN system.

Since an NXDN system uses 4-level FSK, Necessary Bandwidth B_n shall be represented using the formula of Multilevel Frequency Shift Keying as defined in CFR Title 47 2.202. $B_n = (R/\log_2 S) + 2DK$

R = bit rate

S = number of signaling states

D = peak frequency deviation

K = numerical factor

For 4800 bps, Necessary Bandwidth is calculated in the following manner:

$B_{n\_4800} = (4800 / \log_2 4) + 2 \times 1471 \times 0.516 = 3918 \approx 4000$ Hz i.e. 4K00

For 9600 bps, Necessary Bandwidth is calculated in the following manner:

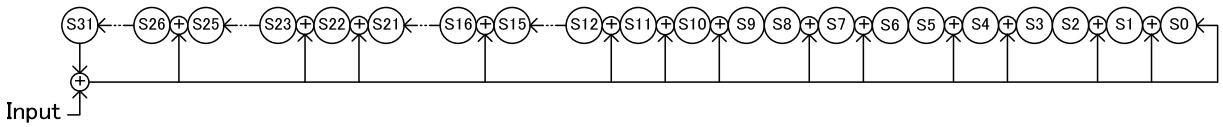
$B_{n\_9600} = (9600 / \log_2 4) + 2 \times 3361 \times 0.516 = 8269 \approx 8300$ Hz i.e. 8K30

9.3. Message CRC Calculation

In data calls, CRC is used as a method to verify that a packet data has been received properly. Message CRC is a 32-bit CRC and it can be obtained by calculating the User Data included in one packet data.

Calculation method of Message CRC is described using Figure 9.3-1. The shift register is sequentially entered from the first bit of User Data consisting of N bit, and then the value of shift register at the time when the last bit is entered shall be a generated value of 32-bit CRC. One packet data is constructed by adding this 32-bit CRC to bits followed by the last bit of User Data. The default value of shift register is set to 1.

Generator Polynomial: $X^{32}+X^{26}+X^{23}+X^{22}+X^{16}+X^{12}+X^{11}+X^{10}+X^{8}+X^{7}+X^{5}+X^{4}+X^{2}+X^{1}+1$



Example

User Data (N bits)	CRC 32bit
bN−1,bN−2,bN−3 ..... b1,b0	S31,S30....S1,S0

Figure 9.3-1 Message CRC Coder

9.4. Conditions for Receiving a Message

If the received message contains undefined Message Type, the message shall be ignored.

If the length of the received message is longer than the expected message length, unnecessary information elements shall be ignored and the message shall be processed using information elements in the expected message length.

If the received message does not contain even a part of necessary information element, the message is ignored.

If the received message does not contain even a part of optional information element, the message shall be ignored.

If necessary information element in the received message is invalid, the message shall be ignored.

If optional information element in the received message is invalid, the message shall be ignored.

9.5. Definition of Cause

This section provides the minimum definition of 5 different Causes.

9.5.1. Causes for Mobility Management Messages

Type = Normal

Indication	Definition
0001	Registration is accepted. This represents that the location registration request or group registration request is succeeded.
0100	Location is accepted, but Group is failed. This represents that the location registration request is succeeded, but the group registration request is failed.
0101	Location is accepted, but Group is refused. This represents that the location registration request is succeeded, but the group registration request is refused.
0110	Registration is failed. This represents that the location registration request or group registration request is failed.
1000	Registration is refused. This represents that the location registration request or group registration request is refused.

9.5.2. Causes for Call Control Messages in Voice and Data Calls

Type = Normal 1

Indication	Definition
0000	Accepted normal This represents that the request is accepted.
0001	Called group is not permitted for the service This represents that service requested by the calling SU is not permitted to the called group.
0010	Calling SU is not permitted for the service This represents that the service requested by the calling SU cannot be permitted. For example this is used if the requested service is not entitled to the calling SU.
0011	Called SU is not permitted for the service This represents that the service requested by the calling SU is not permitted to the called SU. For example this is used if the requested service is entitled to the called SU.
0100	Called SU has not done the registration yet This represents that no location registration information of the called SU is available and it is out of a system.
0101	No response from the called SU This represents that there is no response from the called SU to the reception request.
0110	Incoming call rejection for a called SU This represents that the called SU rejects the incoming call request.
1000	Called SU is in busy This represents that the called SU is in busy. For example this is used if the called SU is engaging in other calls when the Individual Call request is placed.
1001	Called group is in busy This represents that the called group is in busy. For example this is used if the Group ID is in use for other calls when the Group Call request is placed.
1010	Calling SU is in busy This represents that the Unit ID of the calling SU is in use. For example this is used when a call to own Unit ID is made.
1100	SU has not been registered yet This represents that no registration information of the Unit ID is available. A SU that received this cause activates processing the Registration.
1101	Group has not been registered yet This represents that no registration information of the Group ID is available. The SU that received this cause activates processing the Group Registration.
1110	Queuing interruption This represents that the queue state is paused and the call processing is terminated by the timer of the TRS or disconnect request from a SU during the queue state by Channel Busy (Cause = 011 0000, etc.).

Type = Normal 2

Indication	Definition
0000	Calling SU is not permitted for use This represents that the Unit ID of the calling SU is prohibited from accessing to the system. For example, this is used when a SU sends a service request that contains a Unit ID that has been erased from a system or has been changed to an access prohibition. Since this cause has the same meaning as the refusal of Cause (MM) in location registration, a SU that received this cause initiates a control channel hunt.
0001	Called SU is not permitted for use This represents that the Unit ID of the called SU is prohibited from accessing to the system. For example, this is used when a SU sends a service request that contains a Unit ID that has been erased from a system or has been changed to an access prohibition.
0010	Group is not permitted for use This represents that the Group ID is prohibited from accessing to the system. For example, this is used when a SU sends a service request that contains a Group ID that has been erased from a system or has been changed to an access prohibition. Since this cause has the same meaning as the refusal of Cause (MM) in group registration, a SU that received this cause initiates a control channel hunt.

Type = Normal (Queue)

Indication	Definition
0000	All channel resources are in use This represents that all RTCHs are in use. The SU that received this cause becomes in the queued state.
0001	All phone line resources are in use This represents that all PSTN lines are in use. The SU that received this cause becomes in the queued state.
0010	Called unit is being alerted This represents that the called SU is being called. The SU that received this cause becomes in the queued state.
0011	Phone line is being alerted This represents that the PSTN line is being called. The SU that received this cause becomes in the queued state.
1000	Called SU is in busy This represents that the called SU is in busy. For example this is used if the called SU is engaging in other calls when the Individual Call request is placed. The SU that received this cause becomes in the queued state.
1001	Called group is in busy This represents that the called group is in busy. For example this is used if the Group ID is in use for other calls when the Group Call request is placed. The SU that received this cause becomes in the queued state.
1111	Other queue without a specific reason This is a common cause for queued status and it does not specify the reason. The SU that received this cause becomes in the queued state.

9.5.3. Causes for Call Control Messages in Status and Short Data Calls

Type = Normal (data response)

Indication	Definition
0000	ACK (Receive Success) This represents that reception in Destination Unit ID is properly completed.
0010	ACK (Send Success) This represents that reception is properly completed in the TRS. In the unconfirmed type, this is treated in the same manner as Indication = 0000 and represents that the procedure is completed, and in the confirmed type, this represents that the procedure is in the process. This value is used by SDCALL_RESP.
1000	NACK (Request for full retry) This represents that reception in Destination Unit ID is failed.
1001	NACK (Memory Full) This represents that no free memory space in Destination Unit ID is available.
1010	NACK (Abort) This represents that a unit with Destination Unit ID aborts a reception operation.

Type = Normal 1

Indication	Definition
0000	Accepted normal This represents that the request is accepted.
0001	Called group is not permitted for the service This represents that service requested by the calling SU is not permitted to the called group.
0010	Calling SU is not permitted for the service This represents that the service requested by the calling SU cannot be permitted. For example this is used if the requested service is not entitled to the calling SU.
0011	Called SU is not permitted for the service This represents that the service requested by the calling SU is not permitted to the called SU. For example this is used if the requested service is entitled to the called SU.
0100	Called SU has not done the registration yet This represents that no location registration information of the called SU is available and it is out of a system.
0101	No response from the called SU This represents that there is no response from the called SU to the reception request.
0110	Incoming call rejection for a called SU This represents that the called SU rejects the incoming call request.
1000	Called SU is in busy This represents that the called SU is in busy. For example this is used if the called SU is engaging in other calls when the Individual Call request is placed.
1001	Called group is in busy This represents that the called group is in busy. For example this is used if the Group ID is in use for other calls when the Group Call request is placed.
1010	Calling SU is in busy This presents that the Unit ID of the calling SU is in use. For example this is used when a call to own Unit ID is made.
1100	SU has not been registered yet This represents that no registration information of the Unit ID is available. The SU that received this cause activates processing the Registration.
1101	Group has not been registered yet This represents that no registration information of the Group ID is available. The SU that received this cause activates processing the Group Registration.

Type = Normal 2

Indication	Definition
0000	Calling SU is not permitted for use This represents that the Unit ID of the calling SU is prohibited from accessing to the system. For example, this is used when a SU sends a service request that contains a Unit ID that has been erased from a system or has been changed to an access prohibition. This cause has the same meaning as the refusal of Cause (MM) in location registration.
0001	Called SU is not permitted for use This represents that the Unit ID of the called SU is prohibited from accessing to the system. For example, this is used when a SU sends a service request that contains a Unit ID that has been erased from a system or has been changed to an access prohibition.
0010	Group is not permitted for use This represents that the Group ID is prohibited from accessing to the system. For example, this is used when a SU sends a service request that contains a Group ID that has been erased from a system or has been changed to an access prohibition. This cause has the same meaning as the refusal of Cause (MM) in group registration.

9.5.4. Causes for Disconnect Request Messages

Type = Normal

Indication	Definition
0000	Disconnected by a user This represents that termination process is activated by a user of a SU disconnecting.
0100	Disconnected by timer This represents that termination process is activated by the timer in a SU.
1111	Other disconnect request This is a common cause for a disconnect request and it does not specify the reason.

9.5.5. Causes for Disconnect Messages

Type = Normal (SU)

Indication	Definition
0000	Disconnected by a user This represents that termination process is activated by a user of a SU disconnecting.
0001	Disconnected by PSTN This represents that termination process is activated by PSTN end.
0100	Disconnected by timer This represents that termination process is activated by the timer in a SU.
1111	Other disconnect from SU This is a common cause that is used when a SU starts the disconnect process and it does not specify the reason.

Type = Normal (TC)

Indication	Definition
0000	Disconnected by timer of TC This represents that disconnecting process is activated by the timer of a TC.
1111	Other disconnect from TC This is a common cause that is used when a TC starts the disconnect process and it does not specify the reason.

9.5.6. Common Causes

This section describes commonly used Type for 5 different Causes. However, the Type and Indication to be applied vary depending on Cause, hence refer to Section 6.5.30 for details.

Type = Resource Unavailable

Indication	Definition
0000	Channel unavailable This represents that a channel cannot be processed due to restricted state, etc.
0001	Network failure This represents that processes cannot be properly executed since the network is functionally failed.
0010	Temporary failure This represents that processes cannot be properly executed since temporary failure occurred on the connection to the network.
0011	Equipment congestion This represents that processes cannot be properly executed since equipment on the network are congesting due to heavy traffic.
1111	Other class for resource unavailable This is a common cause for resource unavailable status and it does not specify the reason.

Type = Service Unavailable

Indication	Definition
0000	Request for unavailable service This represents that the requested service is unavailable.
0001	Request for unsupported service This represents that the requested service is unsupported.
1111	Other class for service unavailable or unsupported This is a common cause for service unavailable or unsupported status and it does not specify the reason.

Type = Procedure error

Indication	Definition
0000	Lack of ,mandatory information elements This represents shortage of necessary information element in the received message.
0001	Undefined information element or Invalid contents This represents that contents of information element of the received message are undefined or invalid value.
1111	Other class of procedure error This is a common cause for procedure error and it does not specify the reason.

9.6. Detailed Classification of Services and Selectivity of Operation

This section provides detailed service classification for functions provided by CAI defined in Section 2.2, and corresponding level for each system is also clarified.

Services			Trunked	Conventional
Voice Services	Vocoder	Half Rate	M (4800 bps)	M (4800 bps)
			M (9600 bps)	M (9600 bps)
		Full Rate	SO (9600 bps)	SO (9600 bps)
	Unaddressed Voice Call		N/A	M
	Group Call	Broadcast	M	N/A
		Conference	M	SO
	Individual Call		M	SO
	Interconnect Call	Speed Dialing	SO	N/A
		Dialing	SO	SO
	All Call		M	SO
Data Services	Short Data Call	Broadcast	SO	N/A
		Individual	SO	N/A
	Long Data Call	Broadcast	SO	SO
		Individual	SO	SO
	Simultaneous Data	Broadcast	SO	SO
		Individual	SO	SO
Supplementary Services	Status Message		SO	SO
	Status Inquiry		SO	SO
	Remote Control Function		SO	SO
	Paging		SO	SO
	Emergency		SO	SO
	Encryption		SO	SO
	Late Entry	On Traffic Channel	N/A	M
		On Control Channel	M	N/A
	ESN Validation		N/A	SO
System Services	Mobility Management	Registration	M	N/A
		Registration Clear	SO	N/A
		Registration Command	SO	N/A
		Group Registration	SO	N/A
	Authentication		SO	N/A
	Multi-System Operation	System Roaming	SO	N/A
	Multi-Site Operation	Site Roaming	M	N/A
	Restriction control		SO	N/A
	Call relevant function	Priority Monitor	SO	N/A
		Time Out Timer	M	N/A
		Call Queuing	SO	N/A
		Transmission Trunking	M	N/A
		Message Trunking	SO	N/A
	Others	Cont. CH Communication	SO	N/A
		Intermittent operation	SO	N/A
		Control CH ADD/DEL	SO	N/A
		Switching the Control CH	SO	N/A
		1st and 2nd Control CHs	SO	N/A
		Fail Soft	SO	N/A
		Color Code	M	N/A
Other Service	Proprietary Format		OP	OP

Table 9.6-1 List of Service Availability

M (Mandatory) represents that the service is mandatory in all systems. SO (Standard Option) represents that the service is optionally supported in each system. OP (Option) represents that the service is optionally supported in each system and its specifications are definable for each system.

10. Revision History

Version	Date	Revised Contents
1.0	Oct 26 2007	Version 1.0 release
1.1	Feb 12 2008	Section 3 and 5: incorrect descriptions revised. Section 6: the association between message and function channel changed, 4 messages modified (STAT_INQ_RESP, STAT_RESP, IDLE, ADJ_SITE_INFO), the abbreviation of FAIL_STAT_INFO added, some information elements added “reserved” value, 4 information elements modified (Call Type, Status Call Option, Call Option, Service Information). Section 8: some terms revised.
1.2	Jul 7 2008	Copyright added Section 6: the association between ASSGN messages and functional channels changed, DCALL_ASSGN message modified, HEAD_DLY message added, 3 information elements modified (Location ID, Response Info, Cause), Delay Count element added Section 9: some Causes added.
1.3	Nov 11 2011	Section 1.1: Add description about Type-C and Type-D. Section 2.2: Correct mismatch against Section 9.6. Section 5.2.2: Modify contents of RCCH in LICH setting. Section 6: Add VCALL_IV, SDCALL_IV, Initialization Vector element and some setting values in Status and Cipher Type. Modify DCALL(Header) format, SDCALL_RESP format, S/R Flag in Packet Info, the description about Error Block Flag and the definition of Key ID. Delete ACK_S in Cause(SS). Section 8: Add descriptions about Type-C, Type-D and ESN. Section 9.6: Modify contents of Service Availability. Various errors in writing are corrected.