Software Application Note

For only SPI Interface

(PAIOS2_AD_SAPN_OS_001)

V 1.1.3

Note: This documentation is preliminary and is subject to change. PnpNetwork Technologies, Inc. reserves the right to do any kind of modification in this application note regarding hardware or software implementations without notice.

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1. Document Introduction

1.1 Purpose of the document

The purpose of this document is to give basic understanding of world-wide radio solution firmware to the user. The content of this document is subject to change without prior notice to the user. However, change log shall inform the modification point and the reason of change.

1.2 Coverage of the document

This document covers basic firmware structure of world-wide radio solution and hardware interface configuration. Based on this information, actual communication message format shall be defined. On the later chapter, each command and its purpose shall be defined. This document has been written based on WWR device slave mode SPI interface protocol to maintain the consistency of message format as much as possible. However, some of the message format or message itself has been modified to fit into current and future world-wide radio solution. In addition, possible hardware configuration is left as open item because various interface method will be used for multi standard configuration.

1.3 Notification of symbols

In this document, binary, decimal and hexadecimal values are used. To distinguish these values, decimal values are used without any prefix, but hexadecimal and binary values have “0x” and “b’x” as a prefix accordingly. Example is shown below.

Hexadecimal value: 0x64 = Decimal value: 100
Binary value : b’1100100 = Decimal value : 100

If the value is ‘0x##’, it means the byte value shall be defined by other factors such as broadcasters or automatic assignment. This value can be any number as long as it is within the limitation. On the other hand, if the value is ‘b’xxxxxx’, it means the binary value shall be defined by other factors same as hexadecimal case.

Byte and Bit notification also used. To distinguish these, Byte notation is using capital character “B” or “byte”, and Bit notation is using lower case character “b’”.

In case of bit position, b7 means left-most bit as known as MSB, and b0 means right-most bit as known as LSB with in a byte.

2. Definitions and Abbreviations

2.1 Definition

ADSCType	Audio/Data Service Component Type
CH NUM	Channel number
CHKSUM	Check Sum
CMD ID	Command identification
DATA LEN	Data length
DPType	Dynamic Program Type
Ensemble ECC	Extended Country Code for the current ensemble
Ensemble ID	Ensemble Identification
MAGIC ID	An identification value that is used to synchronize the message and to detect the communication error
MSG NUM	Sequential message count value for every message, applies modulo 128 counter
MSG CUR	Current message counter number
MSG COUNT	Total message counter number
PKT Address	Packet address for the packet component
PPType	Primary service component type code
Prot Level	Protection level
PS Flag	Primary or secondary service flag
SC Label	Service component label
SCId	Service component identifications
SCIds	Service component identifications within the Service
Service Label	Alphanumeric characters associated with a particular service and intended for display in a receiver
SID	16-bit or 32-bit code used to identify a particular service
SPType	Static program type
SrvComp	Service component
SubChId	Sub channel identification
TMID	Transport mechanism identifier
Application Index	Virtual path of audio and data transmission

2.2 Abbreviation

AAC	Advanced Audio Coding
AGC	Automatic Gain Control
AM	Amplitude Modulation
AU	Audio Unit
BER	Bit Error Rate
BSAC	Bit Sliced Arithmetic Coding
CAS	Conditional Access System
CEI	Change Event Indication
CRC	Cyclic Redundancy Check
DAB	Digital Audio Broadcasting
DAB+	Digital Audio Broadcasting Plus
DAC	Digital to Analog Converter
DLS	Dynamic Label Segment
DMB	Digital Multimedia Broadcasting
DRC	Dynamic Range Control
EEP	Equal Error Protection
EPG	Electronic Program Guide
FIC	Fast Information Channel
FIDC	Fast Information Data Channel
FIG	Fast Information Group
FM	Frequency Modulation
GPIO	General Purpose Input Output
HLPM	High Level Protocol Module
I2C	Inter-Integrated Circuit
I2S	Integrated Inter-chip Sound
IF	Intermediate Frequency
LLHI	Low Level Host Interface
LLIM	Low Level Interface Manager
LSB	Least Significant Bit
MP2	MPEG-1 Audio Layer II
MSB	Most Significant Bit
MSC	Main Service Channel
OFDM	Orthogonal Frequency Division Multiplexing

PAD	Program Associated Data
RDS	Radio Data System
RF	Radio Frequency
RSSI	Received Signal Strength Indication
SCF	Scale Factor
SDRAM	Synchronous Dynamic Random Access Memory
SFN	Single Frequency Network
SLI	Signal Lock Indicator
SNR	Signal to Noise Ratio
SPI	Serial Peripheral Interface Bus
TBC	To Be Confirmed
TBD	To Be Determined
TII	Transmitter Identification Information
TPEG	Transport Protocol Experts Group
TS	Transport Stream
TSM	Time Scale Modification
UEP	Un-equal Error Protection
WWR	World Wide Radio

3. References

3.1 Related Document

[A1] PAIOS-V_n_PAIOS-A_BRAMD_GUI_Manual_V0 0 1 0_Pnp_2018Aug20.pdf

[A2] WWR_PAIOS2-A_DATASHEET_Preliminary_V0 12.pdf

[A3] WWR_PAIOS2-V_DATASHEET_Preliminary_V0 11.pdf

[A4] WWR_PAIOS-A_DATASHEET_Preliminary_V0 12.pdf

[A5] WWR_PAIOS-V_DATASHEET_Preliminary_V0 11.pdf

3.2 Reference Document

[R1] ETSI EN 300 401 V2.1.1 (2017-01), Radio Broadcasting Systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers

[R2] ETSI TS 102 563 V2.1.1 (2017-01) Digital Audio Broadcasting (DAB); Transport of Advanced Audio Coding (AAC) audio

[R3] ETSI TS 101 756 V2.1.1 (2017-01) Digital Audio Broadcasting (DAB); Registered Tables

[R4] ETSI TS 102 652 V1.1.1 (2007-10) Digital Audio Broadcasting (DAB); Intellitext; Application specification

[R5] EN 50248:1997 EUROPEAN STANDARD, August 2001 ; Characteristics of DAB receivers

[R6] ETSI ES 201 980 V4.1.2 (2017-02) Digital Radio Mondiale (DRM); System Specification

[R7] DRM Introduction and Implementation Guide Revision 2, September 2013, www.drm.org

[R8] ETSI EN 301 234 V2.1.1. (2006-05) Digital Audio Broadcasting (DAB); Multimedia Object Transfer (MOT) protocol

[R9] CENELEC EN 50067:1998 Specification of the radio data system (RDS) for VHF/FM sound broadcasting in the frequency range from 87.5 to 108.0 MHz

4. System Architecture

4.1 Hardware Configuration

The following diagram describes a brief WWR solution system architecture.

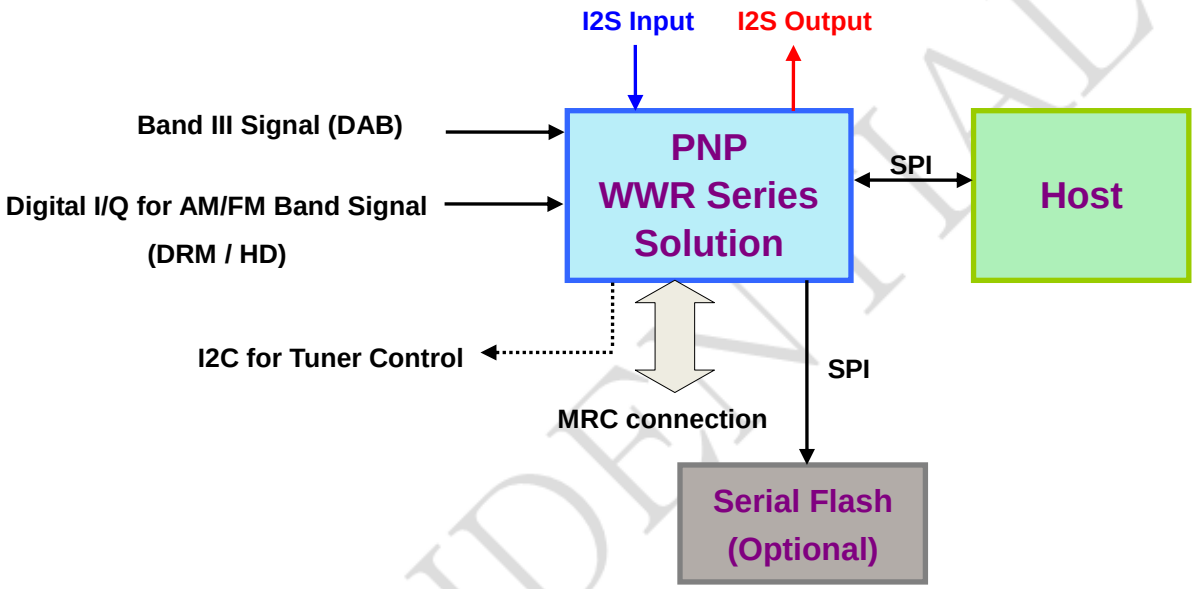

Figure 4-1 WWR solution basic system architecture

The WWR series solution has three types of products.

Most commonly used type is Back-end type which has base-band logics, DSP, and memory. In addition to this, Front-end type chipset can be used for dual or triple solution. This front-end type chipset contains RF tuner and base-band logics in it.

As a final one, all-in-one type is also available. This all-in-one type solution contains from RF to DSP and memory so that all necessary process can be done within a single chipset.

Below table can be referred as a summary these type definition.

Table 4-1 WWR series solution types

Type	Configuration	Description
Back-End	Base-band + DSP + Memory	Digital I/Q or Analog IF can be used for base-band signal input
Front-End	RF Tuner + Base-band	External processor is needed to control the chipset and process the data output
All-In-One	RF Tuner + Base-band + DSP + Memory	All necessary process can be done within a chipset

As shown on above diagram and table, a WWR chipset has various interface methods for input, output signals and tuner control.

As a base-band signal input interface, digital I/Q can be used for any digital radio standards and additional analog IF input can be used in case of DAB application for back-end type of products.

In case of front-end type of products, both direct-RF or digital I/Q input is needed.

In case of DAB application and for other standards, it takes digital I/Q signal from external tuner. Input of DAB signal can be either digital I/Q or analog IF format in case of WWR backend solution. For the WWR front-end solution, RF tuner is integrated and control will be done by external processor such as one of WWR back-end chipset.

In addition to RF signal input, there is an optional MRC interface connection. This is only required to use in case of diversity concept.

Other than baseband input, there are audio input and output, and the host communication interface. For the audio input, it is required for audio seamless linking. In common host interface, SPI is used for command and response, and extra data transmission accordingly.

Lastly, the F/W boot up interface is needed. In normal system configuration, a serial Flash memory can be used for storing the S/W binary image file. However, it is also possible that the host processor can be operated as serial flash so that WWR back-end chipset can read the binary image data directly from the host processor.

By using this method, serial flash can be omitted from the BOM.

4.2 Software Architecture

Following diagram describes the software architecture of WWR solution S/W architecture.

The command handler receives commands from the host S/W and sends responses as a reaction of the command operation. After receiving a command, the command handler will hand over the information to Instance manager so that the Instance manager can select appropriate instance for actual operation. This procedure is needed to control multiple instance solution. Each S/W stacks handles multiple standards and/or instances so that it can handle virtually any kind of combination of H/W configuration.

Following is logical structure of S/W stack in WWR solution.

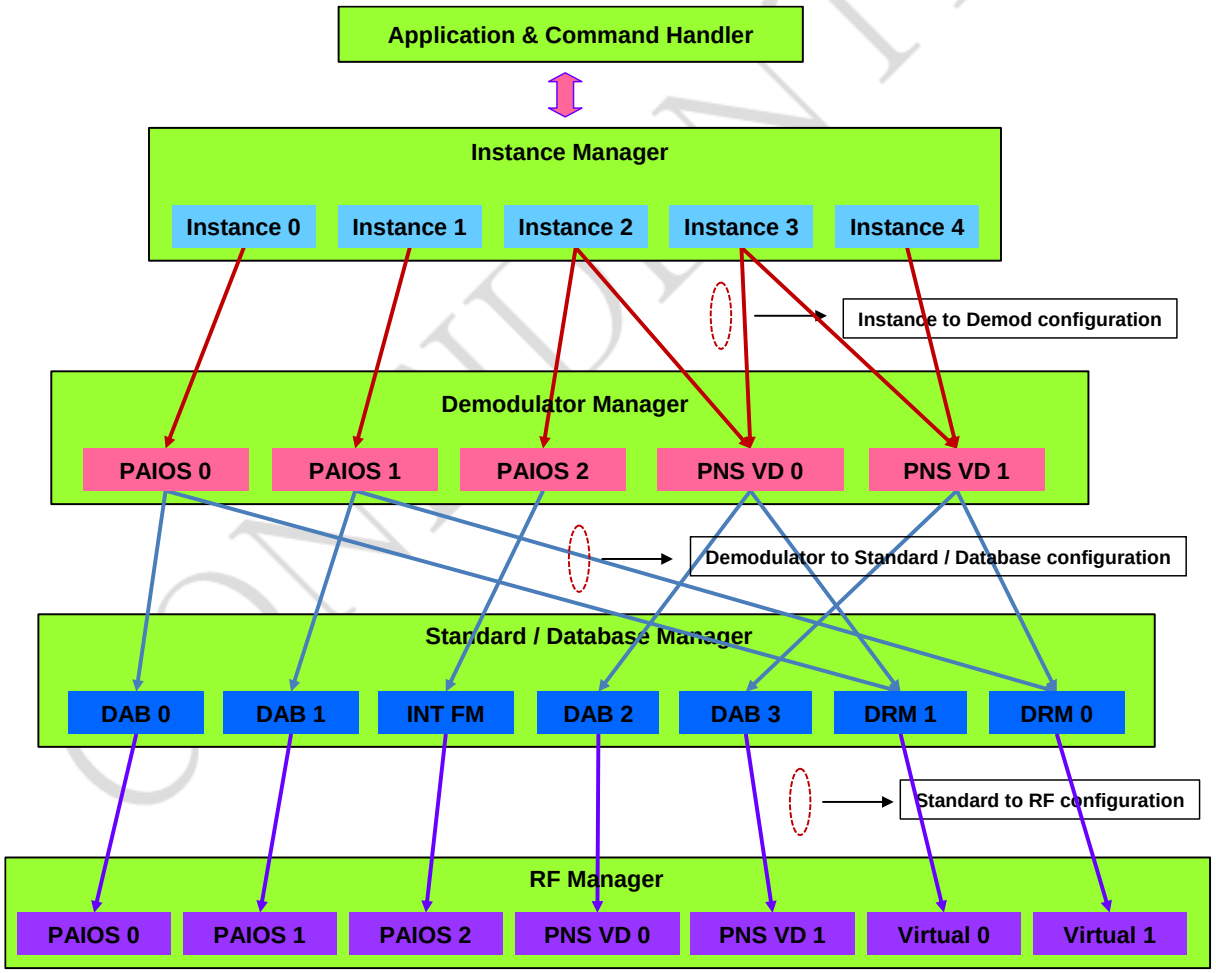

Figure 4-2 WWR solution software architecture

Instance manager and audio manager can be connected in a variety of ways.

In general, Instance 0 is connected to audio channel 0 and Instance 1 is connected to audio channel 1.

Below is a diagram of the connection between the Instance manager and the audio manager.

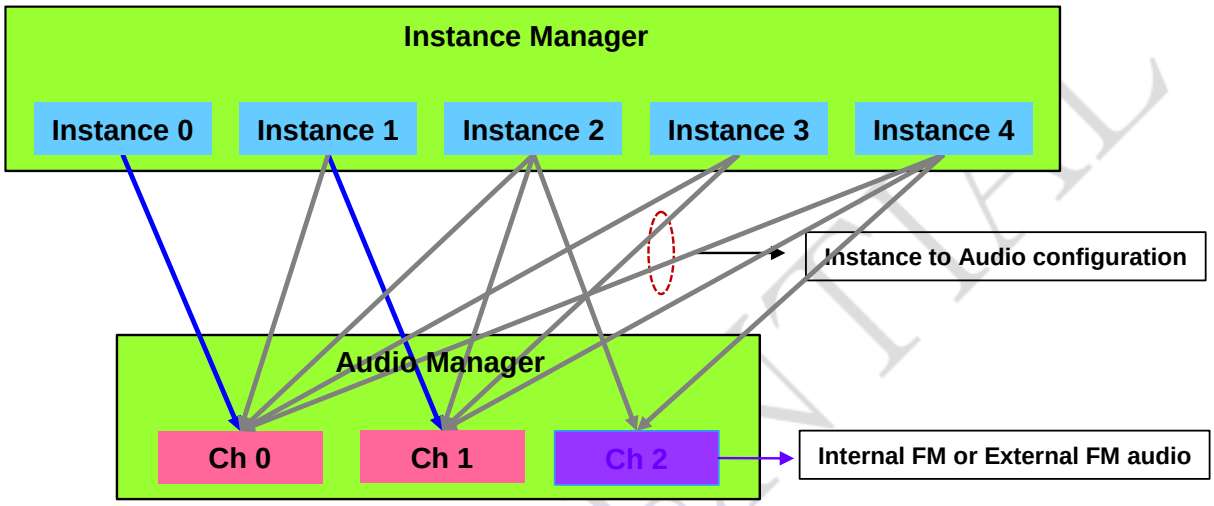

Figure 4-3 WWR solution audio manage architecture

5. Communication Interface

5.1 SPI Interface Flow

5.1.1 SPI Slave

WWR solution could SPI Slave interface to communicate with the Host. WWR device have independent 2 SPI Slave channel port.

Following is SPI Slave interface configuration between WWR device and the host processor.

- WWR device : SPI Slave
- Host Processor : SPI Master

The messages between WWR device and the host processor can be categorized as command, response and the details will be explained from next chapter.

This SPI Slave communication protocol architecture is shown in the following figure.

Below is a picture of the SPI Slave interface connected between WWR device and Host.

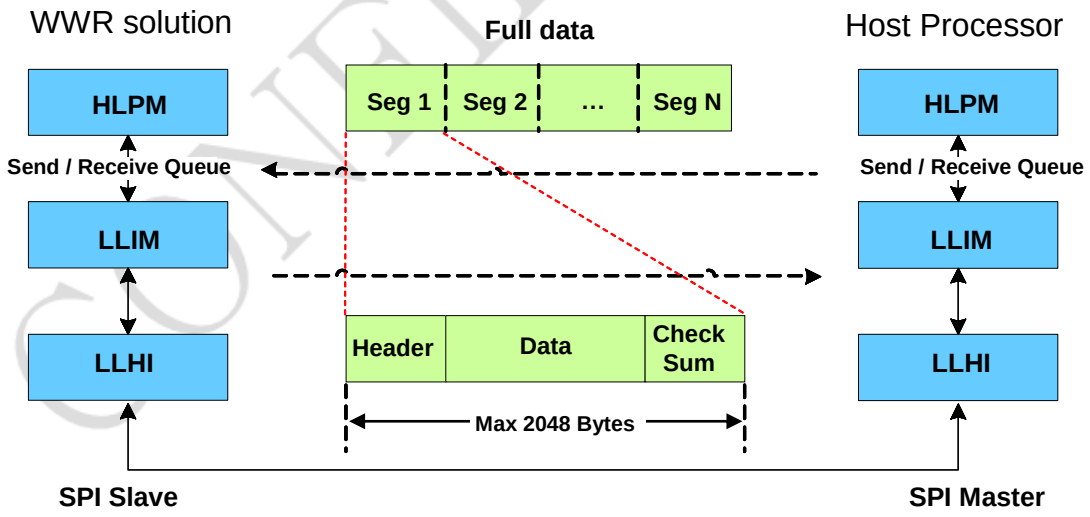

Figure 5-1 SPI Slave communication protocol architecture

The PAIOS chip set supports two types of SPI-compatible interface. One is the normalized SPI described in Chapter 5.1.2. and the other is the Motorola SPI-compatible interface described in Chapter 5.1.3.

The default SPI format is the Motorola SPI-compatible interface.

5.1.2 Normal SPI Slave

The figure below shows the waveform when HOST(Master) transmit and receives data from WWR device via SPI slave.

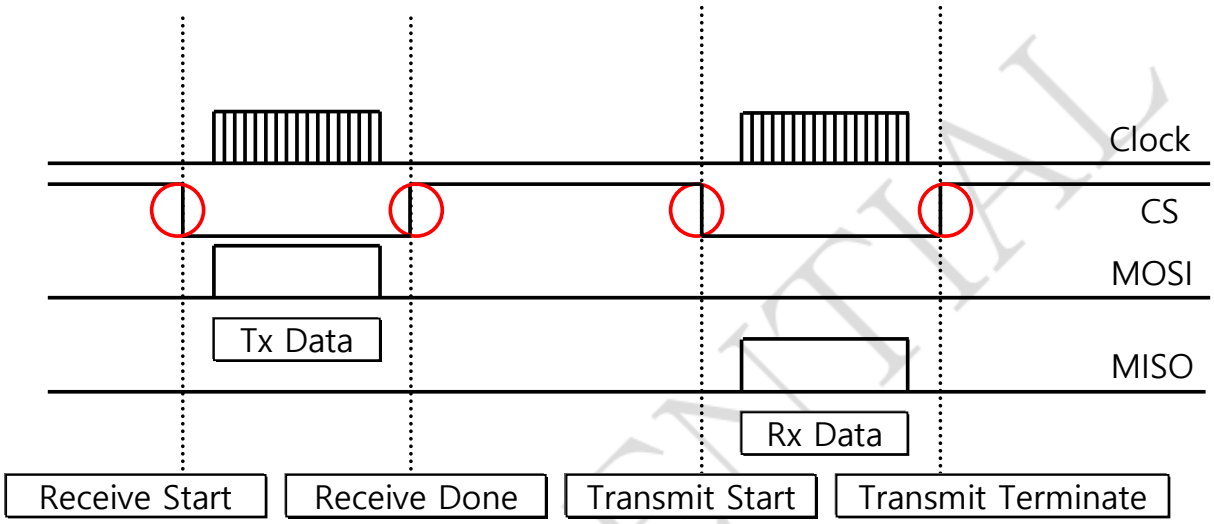

Figure 5-2 SPI Slave communication (Normal) flow

The order of transmit and receiving data is as follows.

1. Host (Master) generates Clock, CS and starts transmission.
2. When the transmission of the master is completed, operate CS low to high.
3. The CS is detected in WWR device and the receiving operation is completed.
4. Wait for the waiting time.
5. Host (Master) generates clock and CS to receive data.
6. When the Host (Master) completes the reception, CS changes from low to high.
7. CS is detected by WWR device and the transfer operation is completed.

Notice : If the host do not know how much size the host should read when reading Rx data, the host can first read the 12 bytes header, get the data length in the DATA LEN field of header, and then read the data length + 4 (checksum).

In this way, the host can fetch Rx data.

5.1.3 Motorola SPI Slave

5.1.3.1 Introduction

NSPI is an AMBA slave block that connects to the APB. NSPI is an AMBA compliant System-on-Chip (SoC) peripheral.

NSPI is a master or slave interface that enables synchronous serial communication with slave or master peripherals having one of following:

1. a Motorola SPI-compatible interface
2. a Texas Instruments synchronous serial interface
3. a National Semiconductor Microwire interface

In both master and slave configurations, the NSPI performs:

1. parallel-to-serial conversion on data written to an internal 16-bit wide, 128-location deep transmit FIFO
2. serial-to-parallel conversion on received data, buffering it in a similar 16-bit wide, 128-location deep receive FIFO

Interrupts are generated to:

1. request servicing of the transmit and receive FIFO and controlled FIFO level
2. inform the system that a receive FIFO over-run has occurred
3. inform the system that data is present in the receive FIFO after an idle period has expired

5.1.3.2 Features

NSPI has the following features:

1. Master or slave operation
2. Programmable clock bit rate and prescale
3. Separate transmit and receive first-in, first-out memory buffers, 16 bits wide, 128 location deep
4. Programmable choice of interface operation, SPI, Microwire or TI Synchronous serial
5. Programmable data frame size from 4 to 16 bits

6. Independent masking of transmit FIFO, receive FIFO, and receive overrun interrupts
7. internal loopback test mode available
8. Support for Direct Memory Access (DMA) interface
9. Support for FIFO-level interrupt

5.1.3.3 Programmable parameters

The following parameters are programmable:

1. master or slave mode
2. enabling of operation
3. frame format
4. communication baud rate
5. clock phase and polarity
6. data widths from 4 to 16 bits wide
7. interrupt masking
8. FIFO-level interrupt count

5.1.3.4 SPI features

The features of the Motorola SPI-compatible interfaces are

1. full duplex, four-wire synchronous transfers
2. programmable clock polarity and phase

5.1.3.5 Frame format

Each data frame is between 4 and 16bits long depending on the size of data programmed, and is transmitted starting with the MSB. There are three basic frame types that can be selected:

1. Motorola SPI
2. Texas Instruments synchronous serial
3. National Semiconductor Microwire

5.1.3.6 Motorola SPI frame format

The Motorola SPI interface is a four-wire interface where **NSPIFSSOUT** signal behaves as a slave select. The main features of the Motorola SPI format is that the inactive state and phase of the **NSPICLKOUT** signal are programmable through the SPO and SPH bits within the NSPISCR0 control register.

SPO, Clock polarity

When the SPO clock polarity control bit is LOW, it produces a steady state low value on the **NSPICLKOUT** pin. If the SPO clock polarity control bit is HIGH, a steady state high value is placed on the **NSPICLKOUT** pin when data is not being transferred.

SPH, clock phase

The SPH control bit selects the clock edge that captures data and allows it to change state. It has the most impact on the first bit transmitted by either allowing or not allowing a clock transition before the first data capture edge.

When the SPH phase control bit is LOW, data is captured on the first clock edge transition. If the SPH clock phase control bit is HIGH, data is captured on the second clock edge transition.

Motorola SPI Format with SPO=0, SPH=0

Single and continuous transmission signal sequences for Motorola SPI format with SPO=0, SPH=0 are shown in below figure.

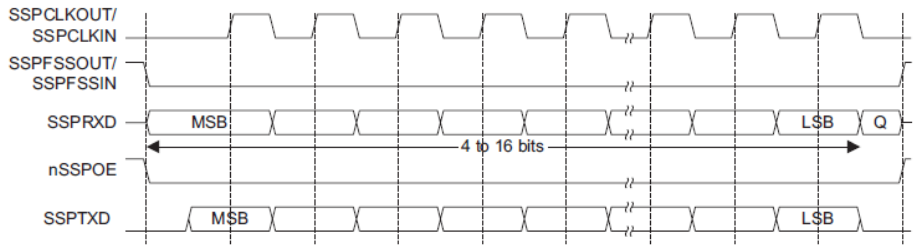

Figure 5-3 SPI frame format (single transfer) with SPO=0 and SPH=0

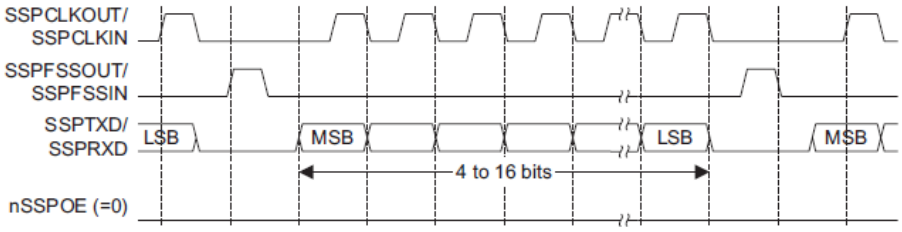

Figure 5-4 SPI frame format (continuous transfer) with SPO=0 and SPH=0

Motorola SPI Format with SPO=0, SPH=1

Single and continuous transmission signal sequences for Motorola SPI format with SPO=0, SPH=1 are shown in below figure.

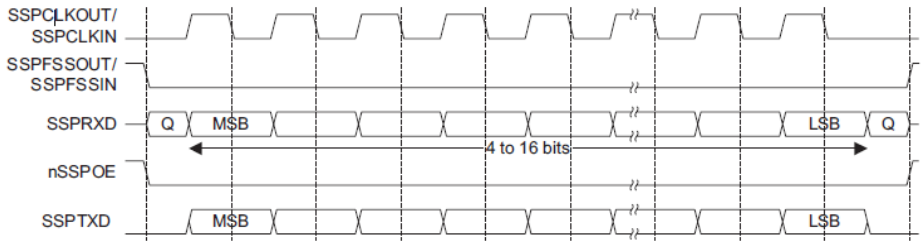

Figure 5-5 SPI frame format with SPO=0 and SPH=1

Motorola SPI Format with SPO=1, SPH=0

Single and continuous transmission signal sequences for Motorola SPI format with SPO=1, SPH=0 are shown in below figure.

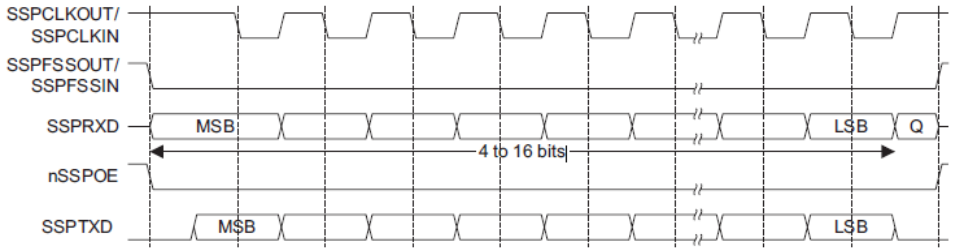

Figure 5-6 SPI frame format with SPO=1 and SPH=0

Motorola SPI Format with SPO=1, SPH=1

Single and continuous transmission signal sequences for Motorola SPI format with SPO=1, SPH=1 are shown in below figure.

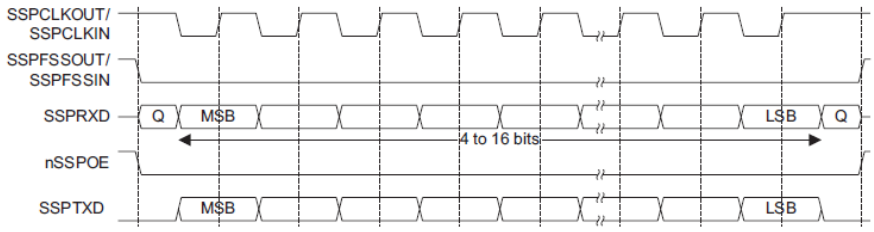

Figure 5-7 SPI frame format with SPO=1 and SPH=1

6. Message Format

6.1 Message Format Rule

In this chapter, the packet format for command / response will be described.

Prior to the detailed explanation for the format, the endian format shall be mentioned for better understanding.

For the internally generated message contents, little-endian is used same as Intel series CPUs.

For example, if you use the PN_CMD_DAB_TUNE command to tune the 181936Khz frequency in the DAB, you should write the Byte# 1~4 [Frequency in 'KHz'] part of the data area of the PN_CMD_DAB_TUNE command as follows.

181936 → 0x0002C6B0

0x0002C6B0 → B[1] : 0xB0, B[2] : 0xC6, B[3] : 0x02, B[4] : 0x00

6.2 Command / Response Message Format

In WWR software, the size of a command / response message is currently not fixed.

However, In case of the actual data cannot be transferred within a single message, it can be segmented into several messages. The maximum transferable message size is 65024 (2032 * 32) bytes.

The following is the configuration of a message.

Table 6-1 Command / Response Message configuration

MAGIC ID	MSG NUM	CMD ID	DEV STD	MSG CUR	MSG COUNT	DATA LEN	RSP STATUS	DATA IDX	DATA	CHKSUM
3 bytes	1 byte	1 byte	1 byte	1 byte	1 byte	2 bytes	1 byte	1 byte	Max 2032 bytes	4 bytes

Each data field description is given below.

Table 6-2 Command / Response Message field description

Item	Size	Description	Values
MAGIC ID	3 bytes	Used to synchronize the message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count value which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	b7	0 : command, 1 : response	b'0 or b'1
	b6 ~ b0	Command ID.	b'xxxxxxx
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the specific standard to be engaged to the message.	b'xxxx
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into	0x00~0x1F

		multiple messages.		
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01~0x20
DATA LEN	2 bytes	Length of Data part (maximum number is 2032)		0~2032
RSP STATUS	1 byte	Response status for command message. (Used only response message)	Command Accepted	0x00
			Unsupported Command Error	0xA0
			Checksum Error	0xA1
			Unsupported Standard Error	0xA2
			Invalid Instance Number Error	0xA3
			Invalid Segment Number Error	0xA4
			Invalid Parameter Error	0xA5
			Invalid Response Error	0xA6
			Other Error	0xFF
DATA IDX	1 byte	Data Index information of GET_DATA response. (Used only GET_DATA response message)		0x##
DATA	Integer bytes	Each response message has its unique data section with specified fields. Therefore, the length of this data section is depends on each one.		~
CHKSUM	4 bytes	Check Sum value of message		0x########

When WWR device responses to a command, the host processor can identify the response belongs to which command by referring 7 bit CMD ID field of the response message.

7. System Operation Protocol

WWR solution has two major S/W layers to work with. First layer is system configuration and operation layer. Second layer is for radio standards such as DAB, DRM, FMRDS.

This layer operates system level configuration such as standard selection, system health monitoring, and so on. In this chapter, all system level command sets and responses messages will be explained in terms of purpose and meaning of the parameters. Regardless of the purpose of a system message, all message names will have common indicator of "_SYS_" which can be easily distinguishable from other layer messages. Other layer of the S/W will be described in following chapters.

7.1 Command Sets / Responses

In this sub chapter, each command and the response will be described in detail. First, the functionality and purpose of the command, then actual message configuration and parameter values will be explained. Lastly, the meaning of each parameter and its value range will be given.

For a response message, there shall be various types of status indication at the header section eleventh byte of the response message. One is “Command Accepted”, and the others are “Error Detected”. From the data section, there can be additional information for some command. This will be described on each command and response message description.

These command and response messages shall be delivered via SPI interface.

Notice 1: Once a response message is received on the host MCU, the host MCU must check the response message indicator before performing any further action on the digital radio solution.

Notice 2: As a consequence, consecutive command shall not be sent out at the host MCU side before receiving and checking the previous command’s response message.

7.1.1 PN_CMD_SYS_SET_CONFIG (0x02) / RSP (0x82)

Because of the nature of the functionality of this command, it cannot be used during the radio operation except after system reset. Once a digital radio function is activated, this command will not be accepted by the S/W.

For the contents of subsequent data, see below sub chapter description. The subsequent data is separated by the DEV STD value.

The default values of this command are already in F/W, so users rarely use this command.

Following is the message configuration of PN_CMD_SYS_SET_CONFIG.

Table 7-1 PN_CMD_SYS_SET_CONFIG message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message	0x02
DEV STD	1 byte	System level message has predefined value for this field.	0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x####
RSP STATUS	1 byte	Response status for command message.	0x00
DATA IDX	1 byte	Not Used.	0x00
DATA	Byte #0 ~	Subsequent Data	~
CHKSUM	4 bytes	Check Sum value	0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

The response message is PN_CMD_SYS_SET_CONFIG_RSP and its configuration is shown on

following table.

Table 7-2 PN_CMD_SYS_SET_CONFIG_RSP message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message	0x82
DEV STD	1 byte	System level message has predefined value for this field.	0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a response message, data length is pre-defined.	0x00
RSP STATUS	1 byte	Response status for command message	0x##
DATA IDX	1 byte	Not Used.	0x00
CHKSUM	4 bytes	Check Sum value	0x########

7.1.1.1 System Configuration

This configuration is used for defining the system solution.

In this case, the DEV STD value is 0.

The first parameter is for each instance's information. This parameter contains standard supporting information for maximum of 5 instances. By checking on this parameter, the host MCU can understand which device can support what kind of digital radio standards.

The MRC Status parameter is used only in the response of PN_CMD_SYS_GET_CONFIG. The PN_CMD_SYS_SET_CONFIG command does not use this parameter.

Table 7-3 System configuration Subsequent data

Item	Position	Description	Values
DATA	Byte #0	Total number of Instance.	0x01~0x05
	Byte #1~4	Instance 0 Standard support information. Each byte of this section represents possible standard support ID. There will be at least 1 instance for WWR solution. The byte order in standard support is irrelevant. Standard ID is as follows - DAB : 0x01 - DRM : 0x02 - FMRDS : 0x03 - Others for future use (0x00 is reserved) Not used : 0xFF	0x########
	Byte #5~8	Instance 1 Standard support information. Each byte of this section represents possible standard support ID. There will be at least 1 instance for WWR solution. The byte order in standard support is irrelevant. Standard ID is as follows - DAB : 0x01 - DRM : 0x02 - FMRDS : 0x03 - Others for future use (0x00 is reserved) Not used : 0xFF	0x########

	Byte #9~12	Instance 2 Standard support information. Each byte of this section represents possible standard support ID. There will be at least 1 instance for WWR solution. The byte order in standard support is irrelevant. Standard ID is as follows - DAB : 0x01 - DRM : 0x02 - FMRDS : 0x03 - Others for future use (0x00 is reserved) Not used : 0xFF	0x########
	Byte #13~16	Instance 3 Standard support information. Each byte of this section represents possible standard support ID. There will be at least 1 instance for WWR solution. The byte order in standard support is irrelevant. Standard ID is as follows - DAB : 0x01 - DRM : 0x02 - FMRDS : 0x03 - Others for future use (0x00 is reserved) Not used : 0xFF	0x########
	Byte #17~20	Instance 4 Standard support information. Each byte of this section represents possible standard support ID. There will be at least 1 instance for WWR solution. The byte order in standard support is irrelevant. Standard ID is as follows - DAB : 0x01 - DRM : 0x02 - FMRDS : 0x03 - Others for future use (0x00 is reserved) Not used : 0xFF	0x########
	Byte #21~25	Current Standard Configuration - Byte #1 : Operating standard ID for Instance 0 - Byte #2 : Operating standard ID for Instance 1 - Byte #3 : Operating standard ID for Instance 2 - Byte #4 : Operating standard ID for Instance 3	0x##########

		- Byte #5 : Operating standard ID for Instance 4 Standard ID is as follows - DAB : 0x01 - DRM : 0x02 - FMRDS : 0x03 - Others for future use (0x00 is reserved) Not used : 0xFF		
	Byte #26	MRC Status	No MRC	0x00
			Single MRC (Instance 0 and 1)	0x01
			Single MRC (Instance 2 and 3)	0x02
			Dual MRC	0x03

For example, if the WWR solution is using 2 Instances, one of them can support DAB and DRM and the other can support only DAB, then this standard support information can be as follows.

Byte #0 : 0x02

Byte #1~4 : either 0x0102FFFF or 0x0201FFFF

Byte #5~8 : 0x01FFFFFF

Byte #9~12 : 0xFFFFFFFF

Byte #13~16 : 0xFFFFFFFF

Byte #17~20 : 0xFFFFFFFF

Byte #21 : either 0x01 or 0x02

Byte #22 : 0x01

Byte #23 : 0xFF

Byte #24 : 0xFF

Byte #25 : 0xFF

7.1.1.2 DAB Configuration

This Configuration shall be used for defining parameters of the DAB solution.

In this case, the DEV STD value is 1.

Because of the nature of the functionality of this command, it is better not to be used during the radio operation except after system reset. However, sending this command during the radio operation is still valid and shall work as intended with one exception case. Due to the reason that the parameters are highly related to tune process, it is forbidden to send this command during the tune process.

Table 7-4 DAB configuration Subsequent data

Item	Position	Description		Values
DATA	Byte #0~5	Time out Setting (Instance 0)	Lock check time out in scan state Lock Check Time = (N) ms default value : 0x0A (=10 msec)	0x##
			Lock check time out in service state Service time out in 10msec unit Lock Check Time = (N) * 10 ms default value : 0x0A (=100 msec)	0x##
			OFDM lock check waiting time (Signal Check waiting time is included in this timer) OFDM Check Waiting Time = (N) * 10 ms default value : 0x50 (=800 msec) This value means total time of Signal check waiting time + actual OFDM check time. This value is user defined value, but there is a F/W default value. This value represents the maximum waiting time. Therefore, if OFDM lock checking is done before the time out, then the process shall move to FIC decoding stage without	0x##

			further waiting.	
			FIC decode timeout FIC decoding time out in 100msec unit All previous stages time is NOT included in this timer setting. FIC decoding time out = (N) * 100 msec Default value = 0x28 (= 4000msec)	0x01~0x46
			Zero BER check time out Zero BER check time out in 100msec unit Zero BER Check Time = (N) * 100 ms default value : 0x07 (=700 msec)	0x##
			RS BER Monitoring time out Audio(DAB+ or T-DMB) RS BER monitoring period in 120msec unit. Monitoring period = (N+1) * 120ms default value : 0x05 ((5+1)*120=720 msec) This value must be maintained constantly since this value will affect on overall performance evaluation. In normal range, there may be no big difference, but if it is too small, then the accuracy will be getting lower.	0x00~0x3F
	Byte #6~11	Time out Setting (Instance 1)	Lock check time out in scan state	0x##
			Lock check time out in service state	0x##
			OFDM lock timeout	0x##
			FIC decode timeout	0x##
			Zero BER check time out	0x##
			RS BER Monitoring time out	0x##
	Byte #12~17	Time out Setting (Instance 2)	Lock check time out in scan state	0x##
			Lock check time out in service state	0x##
			OFDM lock timeout	0x##
			FIC decode timeout	0x##
			Zero BER check time out	0x##

			RS BER Monitoring time out	0x##
	Byte #18~23	Time out Setting (Instance 3)	Lock check time out in scan state	0x##
			Lock check time out in service state	0x##
			OFDM lock timeout	0x##
			FIC decode timeout	0x##
			Zero BER check time out	0x##
			RS BER Monitoring time out	0x##
	Byte #24~29	Time out Setting (Instance 4)	Lock check time out in scan state	0x##
			Lock check time out in service state	0x##
			OFDM lock timeout	0x##
			FIC decode timeout	0x##
			Zero BER check time out	0x##
			RS BER Monitoring time out	0x##
	Byte #30	Data Service (Instance 0)	Disable	0x00
			Raw Data Dump	0x01
			TDC / MOT Dump	0x02
	Byte #31	Data Service (Instance 1)	Disable	0x00
			Raw Data Dump	0x01
			TDC / MOT Dump	0x02
	Byte #32	Data Service (Instance 2)	Disable	0x00
			Raw Data Dump	0x01
			TDC / MOT Dump	0x02
	Byte #33	Data Service (Instance 3)	Disable	0x00
			Raw Data Dump	0x01
			TDC / MOT Dump	0x02
	Byte #34	Data Service (Instance 4)	Disable	0x00
			Raw Data Dump	0x01
			TDC / MOT Dump	0x02
	Byte #35	Announcement	Manual	0x00
			Auto	0x01

7.1.1.3 DRM Configuration

This Configuration shall be used for defining parameters of the DRM solution.

In this case, the DEV STD value is 2.

Table 7-5 DRM configuration Subsequent data

Item	Position	Description		Values
DATA	Byte #0~4	Time out Setting (Instance 0)	Lock check time out in scan state Lock Check Time = (N) ms default value : 0x0A (=10 msec)	0x##
			Lock check time out in service state Service time out in 10msec unit Lock Check Time = (N) * 10 ms default value : 0x0A (=100 msec)	0x##
			OFDM lock check waiting time (Signal Check waiting time is included in this timer) OFDM Check Waiting Time = (N) * 10 ms default value : 0x50 (=800 msec) This value means total time of Signal check waiting time + actual OFDM check time. This value is user defined value, but there is a F/W default value. This value represents the maximum waiting time. Therefore, if OFDM lock checking is done before the time out, then the process shall move to FIC decoding stage without further waiting.	0x##
			SI decode time out SI decoding time out in 100msec unit All previous stages time is NOT included in this timer setting.	0x01~0x46

			FIC decoding time out = (N) * 100 msec Default value = 0x28 (= 4000msec)	
			Zero BER check time out Zero BER check time out in 100msec unit Zero BER Check Time = (N) * 100 ms default value : 0x07 (=700 msec)	0x##
	Byte #5~9	Time out Setting (Instance 1)	Lock check time out in scan state	0x##
			Lock check time out in service state	0x##
			OFDM lock timeout	0x##
			SI decode timeout	0x##
			Zero BER check time out	0x##
	Byte #10~14	Time out Setting (Instance 2)	Lock check time out in scan state	0x##
			Lock check time out in service state	0x##
			OFDM lock timeout	0x##
			SI decode timeout	0x##
			Zero BER check time out	0x##
	Byte #15~19	Time out Setting (Instance 3)	Lock check time out in scan state	0x##
			Lock check time out in service state	0x##
			OFDM lock timeout	0x##
			SI decode timeout	0x##
			Zero BER check time out	0x##
	Byte #20~24	Time out Setting (Instance 4)	Lock check time out in scan state	0x##
			Lock check time out in service state	0x##
			OFDM lock timeout	0x##
			SI decode timeout	0x##
			Zero BER check time out	0x##
	Byte #25	Data Service (Instance 0)	Disable	0x00
			Raw Data Dump	0x01
			TDC / MOT Dump	0x02
	Byte #26	Data Service (Instance 1)	Disable	0x00
			Raw Data Dump	0x01
			TDC / MOT Dump	0x02
	Byte #27	Data Service (Instance 2)	Disable	0x00
			Raw Data Dump	0x01

			TDC / MOT Dump	0x02
	Byte #28	Data Service (Instance 3)	Disable	0x00
			Raw Data Dump	0x01
			TDC / MOT Dump	0x02
	Byte #29	Data Service (Instance 4)	Disable	0x00
			Raw Data Dump	0x01
			TDC / MOT Dump	0x02

7.1.1.4 RDS Configuration

This Configuration shall be used for defining parameters of the RDS solution.

In this case, the DEV STD value is 3.

Table 7-6 RDS configuration Subsequent data

Item	Position	Description		Values
DATA	Byte #0	RDS decoding (Dump)	RDS Dump Disable	0x00
			RDS Dump Enable	0x01
	Byte #1	RDS mode	SOFT Decision	0x00
			HARD Decision	0x01

7.1.2 PN_CMD_SYS_GET_CONFIG (0x03) / RSP (0x83)

This command is used to get configuration information of the system or standard.
User can get information about the system or standard environment is set up.

Following is the message configuration of PN_CMD_SYS_GET_CONFIG.

Table 7-7 PN_CMD_SYS_GET_CONFIG message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.	0x03
DEV STD	1 byte	System level message has predefined value for this field	0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x00
RSP STATUS	1 byte	Response status for command message.	0x00
DATA IDX	1 byte	Not Used.	0x00
CHKSUM	4 bytes	Check Sum value	0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

For the contents of subsequent data, see PN_CMD_SYS_SET_CONFIG description.

The response message is PN_CMD_SYS_GET_CONFIG_RSP and its configuration is shown on following table.

Table 7-8 PN_CMD_SYS_GET_CONFIG_RSP message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.	0x83
DEV STD	1 byte	System level message has predefined value for this field	0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a response message, data length is pre-defined.	0x####
RSP STATUS	1 byte	Response status for command message	0x##
DATA IDX	1 byte	Not Used.	0x00
DATA	Byte #0 ~	Subsequent Data	~
CHKSUM	4 bytes	Check Sum value	0x########

7.1.3 PN_CMD_SYS_GET_VERSION (0x04) / RSP (0x84)

This command shall be used for retrieving the current WWR S/W version. Since the function of this command is simple, there is no special parameter to control. This command can be sent by the host MCU at any moment of the system operation.

This command is also used to determine if the system has booted up is finished normally.

The parameter is F/W version information.

Following is the message configuration of PN_CMD_SYS_GET_VERSION.

Table 7-9 PN_CMD_SYS_GET_VERSION message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.	0x04
DEV STD	1 byte	System level message has predefined value for this field	0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x00
RSP STATUS	1 byte	Response status for command message.	0x00
DATA IDX	1 byte	Not Used.	0x00
CHKSUM	4 bytes	Check Sum value	0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

The response message is PN_CMD_SYS_GET_VERSION_RSP and its configuration is shown on following table.

Table 7-10 PN_CMD_SYS_GET_VERSION_RSP message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.	0x84
DEV STD	1 byte	System level message has predefined value for this field	0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a response message, data length is pre-defined.	0x04
RSP STATUS	1 byte	Response status for command message	0x##
DATA IDX	1 byte	Not Used.	0x00
DATA	Byte #0~3	Firmware version	0x##~##
CHKSUM	4 bytes	Check Sum value	0x########

7.1.4 PN_CMD_SYS_DIVERSITY_ENABLE (0x11) / RSP (0x91)

This command is for MRC (diversity) setup using two devices at the same time. By using this command, the host can get the MRC (diversity) signal.

This command is used to select the service for each device.

Following is the message configuration of PN_CMD_SYS_DIVERSITY_ENABLE.

Table 7-11 PN_CMD_SYS_DIVERSITY_ENABLE message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.		0x11
DEV STD	1 byte	System level message has predefined value for this field.		0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x02
RSP STATUS	1 byte	Response status for command message.		0x00
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	Target Device ID (There are maximum of 4 different device can be used)		0x00~0x03
	Byte #1	Diversity Enable	OFF	0x00
			ON	0x01
CHKSUM	4 bytes	Check Sum value		0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

The response message is PN_CMD_SYS_DIVERSITY_ENABLE_RSP and its configuration is

shown on following table.

Table 7-12 PN_CMD_SYS_DIVERSITY_ENABLE_RSP message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.	0x91
DEV STD	1 byte	System level message has predefined value for this field.	0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a response message, data length is pre-defined.	0x00
RSP STATUS	1 byte	Response status for command message	0x##
DATA IDX	1 byte	Not Used.	0x00
CHKSUM	4 bytes	Check Sum value	0x########

7.1.5 PN_CMD_SYS_SET_SOFTMUTE (0x12) / RSP (0x92)

This command shall be used for controlling the soft mute function.

The parameters of each command written to the WWR solution according to the function code.

Following is the message configuration of PN_CMD_SYS_SET_SOFTMUTE.

Table 7-13 PN_CMD_SYS_SET_SOFTMUTE message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.		0x12
DEV STD	1 byte	System level message has predefined value for this field.		0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x####
RSP STATUS	1 byte	Response status for command message.		0x00
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	Function Code	Reserved	0x00
			Soft Mute Configuration	0x01
			Instant Mute Threshold Configuration	0x02
			Mute Generation Configuration	0x03
			Mute Threshold Configuration	0x04
	Byte #1 ~	Subsequent Data		~
CHKSUM	4 bytes	Check Sum value		0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

The response message is PN_CMD_SYS_SET_SOFTMUTE_RSP and its configuration is shown on following table.

Table 7-14 PN_CMD_SYS_SET_SOFTMUTE_RSP message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.		0x92
DEV STD	1 byte	System level message has predefined value for this field.		0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a response message, data length is pre-defined.		0x01
RSP STATUS	1 byte	Response status for command message		0x##
DATA IDX	1 byte	Not Used.		0x0000
DATA	Byte #0	Function Code	Reserved	0x00
			Soft Mute Configuration	0x01
			Instant Mute Threshold Configuration	0x02
			Mute Generation Configuration	0x03
			Mute Threshold Configuration	0x04
CHKSUM	4 bytes	Check Sum value		0x########

7.1.5.1 Soft Mute Configuration

This command shall be used for controlling the soft mute function. The soft mute function is basically controlling the final audio output volume level depends on user requirement. For example, when there is an incoming call while audio listening, the audio output has to be smoothly muted, then unmuted after the call. For this kind of purpose, this soft mute function can be used.

This command has 3 parameters for volume level control. First parameter is target audio index. Second parameter is ramp time in millisecond unit and the third parameter is target attenuation level index.

Soft Mute Configuration scales the codec output. In WWR, dual decoding is performed, and codec index must be specified. Codec index has the same meaning as Audio index. Note that if Seamless Linking is enabled, the output of the codec output can be used as a seamless linking input.

As long as the target attenuation level index is not equal to zero, it will be considered as muted status.

This command can be used at any moment of system operation.

Following is the message configuration of Soft Mute Configuration subsequent data.

Table 7-15 Soft Mute Configuration Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	Audio channel	First Audio	0x00
			Second Audio	0x01
			First and Second Audio	0x02
	Byte #2~3	Mute/Unmute ramp time in millisecond unit Range from 0 to 5000msec		0x0001~0x1388
	Byte #4	Target attenuation level index. Range from 0 to 248		0x00~0xF8

7.1.5.2 Instant Mute Threshold Configuration

This command shall be used for instant error concealment mute and unmute threshold value configuration change. The main purpose of this command is to test various configuration setups without re-flashing the serial flash memory. Unlike "Mute Threshold Configuration" command, this command is not a permanent setup for the system. In other words, if the user changes the audio service, this instant configuration shall be discarded even the user comes back to original audio service. Once the instant configuration is discarded, the configuration values which are stored in the flash memory or the new configuration done by "Mute Threshold Configuration" command shall be used.

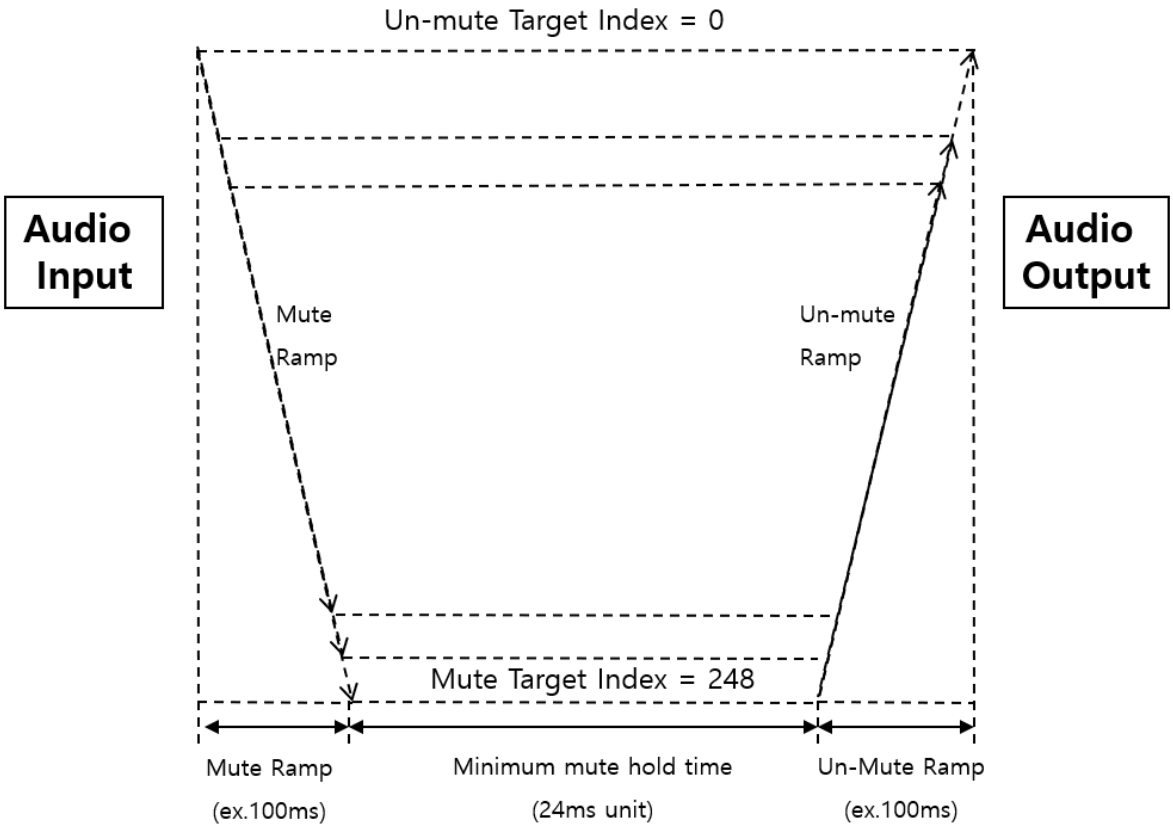

Figure 7-1 Instant Mute Threshold diagram

By using this command, optimized error concealment configuration for each target system can be easily found.

There are 8 parameters for this command. The first one is for selecting target audio channel between 2 possible audio outputs. Other parameters are related to actual mute/unmute thresholds, mute/unmute ramp time, and mute/unmute target audio level in dB scale. Lastly, there is one special parameter that can be used for preventing frequent audio mute and unmute transition. This called mute hold time.

Unlike other system level commands, this command can be used while at least one audio service is selected and playing regardless of its standard.

Following is the message configuration of Instant Mute Threshold Configuration subsequent data.

Table 7-16 Instant Mute Threshold Configuration Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	Audio channel	First Audio	0x00
			Second Audio	0x01
	Byte #2	Audio mute threshold value. [0x00 : No noise only, 0x3F: No concealment]		0x00~0x3F
	Byte #3	Audio unmute threshold value. [0x00 : No noise only, 0x3F: No concealment]		0x00~0x3F
	Byte #4~5	Mute Ramp time in millisecond unit. The maximum value is 5000msec		0x0001 ~ 0x1388
	Byte #6~7	Mute target attenuation index in dB scale [0x00 : Original level, 0xF8 : Total Mute].		0x00~0xF8
	Byte #8~9	Unmute Ramp time in millisecond unit. The maximum value is 5000msec		0x0001 ~ 0x1388
	Byte #10~11	Unmute target attenuation index in dB scale [0x00 : Original level, 0xF8 : Total Mute].		0x00~0xF8
	Byte #12~13	Minimum mute hold time - It must be a value of [N x 24(ms)] - Default Value 960ms (Ex. target time = 24ms → value= 0x18) “0x0000” means disable this function.		0x0000 ~ 0xFFF0

7.1.5.3 Mute Generation Configuration

This command shall be used for setting the error concealment of the audio output regardless of digital radio standard. In some audio codec such as AAC has an error concealment feature in the codec standard. However, this error concealment can provide smooth audio transitions between full volume level and the complete mute. Basically, when digital radio signal becomes weak, there can be audio artifacts which may disturb the listener. To minimize this uncomfortable feeling, this function can be used. Actual threshold setting for the error concealment shall be described on "Mute Threshold".

This command sets Soft Mute Configuration regardless of BER.

To control this function, there shall be seven parameters that are audio channel and digital radio standard type, Mute and Unmute Audio Ramp Time, Mute and Unmute Target Attenuation Index, and Mute Hold Time. By using these seven parameters, the mute and unmute behavior can be fully defined by the system. In detail, firstly, the audio channel and the digital radio standard type values shall define the activation target. Mute and unmute ramp time shall define the time duration of this smooth transition in millisecond. Mute Target attenuation index shall define the wanted volume level of when error concealment is fully applied, normally a complete mute. Nevertheless, the system can define any possible volume level if necessary. For the actual volume level in dB scale of the mute index. Lastly, the mute hold time shall define a minimum mute duration in millisecond. This parameter can be used to prevent the frequent transition between mute and unmute. Once this time parameter is defined and mute is applied, the mute duration shall remain at least indicated duration regardless of signal quality.

Following is the message structure of Mute Generation Configuration subsequent data, and the description of each fields are also shown.

Table 7-17 Mute Generation Configuration Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	Audio channel	First Audio	0x00
			Second Audio	0x01
	Byte #2	Digital Radio Standard type value	DAB	0x00
			DAB+	0x01
			DMB Audio	0x02

			DRM	0x03
			DRM+	0x04
	Byte #3~4	Mute Ramp time in millisecond unit. The maximum value is 5000msec		0x0001 ~ 0x1388
	Byte #5~6	Mute target attenuation index in dB scale [0x00 : Original level, 0xF8 : Total Mute].		0x00~0xF8
	Byte #7~8	Unmute Ramp time in millisecond unit. The maximum value is 5000msec		0x0001 ~ 0x1388
	Byte #9~10	Unmute target attenuation index in dB scale [0x00 : Original level, 0xF8 : Total Mute].		0x00~0xF8
	Byte #11~12	Minimum mute hold time - It must be a value of [N x 24(ms)] - Default Value 960ms (Ex. target time = 24ms → value= 0x18) “0x0000” means disable this function.		0x0000 ~ 0xFFF0

7.1.5.4 Mute Threshold Configuration

This command shall be used for setting the mute and unmute threshold values which are the triggering points of the error concealment. On previous "Mute Generation Configuration", it was about how to operate the error concealment and this chapter is about when to operate.

Mute and unmute threshold values are different representation of BER based re-calculated values to generate time variant parameter which relatively follows signal quality change in time. Eventually, this signal quality determines the audio quality and these values can be considered as audio quality level because of this reason.

By setting a different mute and unmute threshold values, hysteresis approach of error concealment can be done.

In this command, there 28 parameters and 26 of them are purely for threshold setting. First two parameters are the target audio channel and digital radio standard type.

Following is the message configuration of Mute Threshold Configuration subsequent data.

Table 7-18 Mute Threshold Configuration Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	Audio channel	First Audio	0x00
			Second Audio	0x01
	Byte #2	Digital Radio Standard type value	DAB	0x00
			DAB+	0x01
			DMB Audio	0x02
			DRM	0x03
			DRM+	0x04
	Byte #3	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP1 mute threshold value For DRM and DRM+ - TBD		0x00~0x3F
	Byte #4	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio		0x00 ~ 0x3F

		- UEP2 mute threshold value For DRM and DRM+ - TBD	
	Byte #5	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP3 mute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #6	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP4 mute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #7	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP5 mute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #8	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP1A mute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #9	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP2A mute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #10	Audio quality level index [0x00 : No noise only, 0x3F: No concealment]	0x00 ~ 0x3F

		For DAB, DAB+, and DMB audio - EEP3A mute threshold value For DRM and DRM+ - TBD	
	Byte #11	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP4A mute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #12	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP1B mute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #13	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP2B mute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #14	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP3B mute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #15	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP4B mute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #16	Audio quality level index	0x00 ~ 0x3F

		[0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP1 Unmute threshold value For DRM and DRM+ - TBD	
	Byte #17	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP2 Unmute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #18	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP3 Unmute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #19	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP4 Unmute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #20	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP5 Unmute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #21	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP1A Unmute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F

	Byte #22	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP2A Unmute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #23	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP3A Unmute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #24	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP4A Unmute threshold value For DRM and DRM+ TBD	0x00 ~ 0x3F
	Byte #25	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP1B Unmute threshold value For DRM and DRM+ - TBD	0x00~0x3F
	Byte #26	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP2B Unmute threshold value For DRM and DRM+ - TBD	0x00~0x3F
	Byte #27	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP3B Unmute threshold value For DRM and DRM+	0x00 ~ 0x3F

		- TBD	
	Byte #28	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP4B Unmute threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F

7.1.6 PN_CMD_SYS_SL (0x13) / RSP (0x93)

This command shall be used for configuring audio seamless linking.

Seamless Linking is aimed at seamless service connection between two services by combining with alternate audio service to supplement coverage of currently playing audio service. By default, the DAB service connects to the FM service and can be connected to other DAB services. FM can be connected to Internal FM, but External FM is used by default.

In WWR, basic seamless linking guarantees audio quality when connecting to the service. It can control the operation from Start / Stop Command in SL Ready, but it can reduce the operation error by controlling SL Configuration in detail in the Host.

Depending on the operation status of Seamless Linking, the SL status will be changed continuously, and the Host should maintain the good audio output by adjusting the SL Configuration referring to the SL Status.

The parameters of each command written to the WWR solution according to the function code.

Following is the message configuration of PN_CMD_SYS_SL.

Table 7-19 PN_CMD_SYS_SL message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.	0x13
DEV STD	1 byte	System level message has predefined value for this field.	0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x####
RSP STATUS	1 byte	Response status for command message.	0x00
DATA IDX	1 byte	Not Used.	0x00

DATA	Byte #0	Function Code	Reserved	0x00
			SL Configuration	0x01
			SL Ready	0x02
			SL RF2RSSI	0x03
			SL Manual Return	0x04
			SL Instant Threshold Configuration	0x05
			SL Link Threshold Configuration	0x06
			SL Status	0x07
	Byte #1 ~	Subsequent Data (Except Function code "SL Status")		~
CHKSUM	4 bytes	Check Sum value		0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

The response message is PN_CMD_SYS_SL_RSP and its configuration is shown on following table.

Table 7-20 PN_CMD_SYS_SL_RSP message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.	0x93
DEV STD	1 byte	System level message has predefined value for this field	0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a response message, data length is pre-defined.	0x####
RSP STATUS	1 byte	Response status for command message	0x##
DATA IDX	1 byte	Not Used.	0x00

DATA	Byte #0	Function Code	Reserved	0x00
			SL Configuration	0x01
			SL Ready	0x02
			SL RF2RSSI	0x03
			SL Manual Return	0x04
			SL Instant Threshold Configuration	0x05
			SL Link Threshold Configuration	0x06
			SL Status	0x07
	Byte #1 ~	Subsequent Data (Used Function code "SL Status")		~
CHKSUM	4 bytes	Check Sum value		0x########

7.1.6.1 Seamless Linking Configuration

This command shall be used for configuring audio seamless linking. The audio seamless linking function is for audio source change without any audible artifacts on the audio. To perform this, both current and target audio sources have to be the same contents except time and volume differences. To compensate these differences, WWR solution provides seamless linking function. This seamless linking function can be applied between any digital radio standards and audio input from an I2S port.

SL configuration can be divided into two types, one is a window setting for a measurement and the other is a functional parameter setting.

First, Seamless Linking is basically a structure of DAB1-FM-DAB2, which is divided into two DABs and one FM. It can also be expressed as RF1, RF2, and RF3, and FM is RF2. This is 3Way Seamless Linking. Seamless Linking There are sequences and scenarios according to the situation inside the operation. Basically, it has a structure to measure time difference and level difference in two signal units. This is called Measure for Relation.

In the SL Configuration, you can set the window for measuring two signals. Window for each Relation is preset in the FW, and one Relation can be modified in SL Configuration. If using SL Configuration is not Window setting for Measure, it uses default value.

The second is the functional parameter setting. Here, you can set the level difference, High Cut, SWA function applied to FM, Quick Search Window for TSM, Cross Fading and Measure working for audio processing.

Following is the message configuration of Seamless Linking Configuration subsequent data.

Table 7-21 Seamless Linking Configuration Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	Relation number		0x00~0x02
	Byte #2~5	Positive window border marker in millisecond unit		0x########
	Byte #6~9	Negative window border marker in millisecond unit		0x########
	Byte #10~13	Searching start point in millisecond unit		0x########
	Byte #14	Linking Target audio source	DAB(+) to FM	0x00
			DAB(+) to DAB(+)	0x01
			DAB(+) to DAB(+) and FM	0x11

	Byte #15	Automatic re-calculation interval in 10sec unit - Automatic re-calculation OFF : 0x00000000 - Range from 10 ~ 1000sec (default : 0sec)		0x00000000 ~ 0x00000064
	Byte #16	Search start point type	Decide mode	0x00
			Store mode	0x01
			Default mode	0x02
			Advanced mode	0x03
	Byte #17	High Cut	Disable	0x00
			Enable	0x01
	Byte #18	Cutoff frequency for high cut It can be adjusted up to 18 kHz at 2 kHz intervals. (Default : 0x00, It is natural frequency)		0x00~0x12
	Byte #19	Stereo Width Adaptation	Disable	0x00
			Enable	0x01
	Byte #20	SWA time It is to perform a gradual Stereo width re-adaptation to play the original DAB audio.		0x01~0x07
	Byte #21	Time stretching machine	Disable	0x00
			Enable	0x01
	Byte #22	Maximum stretching time It is to do stretching the audio signal being played back, it is to readjust the alternate audio signal and the time line.		10, 20, 30, 45, 60, 90, 120, 150
	Byte #23	Time stretching option	Repeat Only	0x00
			Stretching & Repeat	0x01
	Byte #24	Moving level difference	Disable	0x00
			Enable	0x01
	Byte #25	Level balance between DAB and DAB	Disable	0x00
			Enable	0x01
	Byte #26	Level balance between DAB and FM	Disable	0x00
			Enable	0x01
	Byte #27	FM compensation level control		0x##
	Byte #28	Direct digital (FM first start)	Disable	0x00
			Enable	0x01

	Byte #29	Cross Fading (20ms/2000ms)	Disable	0x00
			Enable	0x01
	Byte #30	FM Natural Speed	Disable	0x00
			Enable	0x01
	Byte #31	Quick search window	Disable	0x00
			Enable	0x01
	Byte #32	Measure Inverse (priority DAB2FM)	Disable	0x00
			Enable	0x01
	Byte #33	Compensation level limit	Disable	0x00
			Enable	0x01
	Byte #34	Minimum level limit		0x##
	Byte #35	Maximum level limit		0x##

7.1.6.2 Seamless Linking Ready

This command shall be used for controlling the audio seamless linking start or stop.

Notice : Current message format is only considering DAB2FM or DAB2DAB seamless linking. Therefore, there will be major update on this message configuration in near future.

There are 3 parameters to control the audio seamless linking function. First one is for starting or stopping the function. Second one is for linking threshold setting of FM audio input via IIS port. The last one is for the IIS input audio sampling frequency setting.

This command can be used after 2 audio sources, the original and the target, are available.

Following is the message configuration of Seamless Linking Ready subsequent data.

Table 7-22 Seamless Linking Ready Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	Audio seamless linking control	Stop	0x00
			Start	0x01
	Byte #2~5	FM RSSI threshold value in -dBμV unit. (default : -70 dBμV)		0x########
	Byte #6	IIS audio input sampling frequency	24KHz	0x00
			32KHz	0x01
			44.1KHz	0x02
			48KHz	0x03 (default)

7.1.6.3 Seamless Linking RF2RSSI

This command is the Threshold of the FM signal is changed by the user.

User can change the Threshold Seamless Linking the FM signal during operation.

When Seamless linking starts, threshold values of the FM signal is defined.

This applies in DAB2FM, DAB2InternalFM. In other words, User can easily switch to DAB, depending on the value of the FM threshold.

Following is the message configuration of Seamless Linking RF2RSSI subsequent data.

Table 7-23 Seamless Linking RF2RSSI Subsequent Data

Item	Position	Description	Values
DATA	Byte #1~4	Current FM RSSI value in -dBμV unit	0x########

7.1.6.4 Seamless Linking Manual Return

This command shall be used for manually returning back from the “linked” audio source to the original one. For any reason, the host MCU may want to link back to the original audio source regardless of the status of the original audio source.

In order to connect with other signal by manual method, it needs condition that can be switched. In other words, the current signal state and the alternate signal state must be "Good" to be connected to an alternate signal. If the alternate signal is "BAD", it will stay in the current signal state.

We use the SL old version to input the time difference and level difference directly to connect the two signals. Now that there are three signals, the time difference and the level difference are applied to each relation. This can also be used with stored value. When the measure is not complete, let us have an option. One more thing, we can only change the audio output automatically if we have calculated time difference values. This is an optional part, so be careful when using it. Even if you enter a command, it may be different from the actual action if it differs from the condition.

There are 3 parameters for this command. The first sets the relationship between the time difference and the audio source to which the level difference is to be input, or sets the audio output to be changed. The second and last ones are user defined time and volume differences accordingly. These values will be used when automatic argument selection is disabled.

This command can be used while audio seamless linking function is activated by “Seamless Linking Ready” command.

Following is the message configuration of Seamless Linking Manual Return subsequent data.

Table 7-24 Seamless Linking Manual Return Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	Manual Linking Type	REL0(RF1-RF2)	0x00
			REL1(RF1-RF3)	0x01
			REL2(RF2-RF3)	0x02
			SRC1(Optional)	0x03
			SRC2(Optional)	0x04
			SRC3(Optional)	0x05
	Byte #2~5	User defined time difference value in millisecond unit		0x########
	Byte #6~9	User defined volume difference value in 1dB unit		0x########

7.1.6.5 Seamless Linking Instant Threshold Configuration

This command shall be used for instant seamless linking forward and backward threshold value configuration change. The main purpose of this command is to test various configuration setups without re-flashing the serial flash memory. Unlike "Seamless Linking Configuration" command, this command is not a permanent setup for the system. In other words, if the user changes the audio service, this instant configuration shall be discarded even the user comes back to original audio service. Once the instant configuration is discarded, the configuration values which are stored in the flash memory or the new configuration done by "Seamless Linking Configuration" command shall be used.

By using this command, optimized seamless linking threshold configuration for each target system can be easily found.

There are 3 parameters for this command. The first one is for selecting original audio channel between 2 possible audio outputs. Other parameters are related to actual link forward and backward thresholds. For the link forward and backward threshold values, these are representing the quality of audio level. 0x00 represents the best quality audio and 0x3F means heavily noisy audio quality. These values are having same magnitude of error concealment mute and unmute threshold values. As a reference, please refer "Mute Threshold Configuration" command description.

Unlike other system level commands, this command can be used while at least one audio service is selected and playing regardless of its standard.

Following is the message configuration of Seamless Linking Instant Threshold Configuration subsequent data.

Table 7-25 Seamless Linking Instant Threshold Configuration Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	Original audio source's channel	First Audio	0x00
			Second Audio	0x01
	Byte #2	Link forward threshold value. Please refer mute and unmute threshold values in "Mute Threshold Configuration" command description for audio quality level		0x00~0x3F
	Byte #3	Link backward threshold value		0x00~0x3F

		Please refer mute and unmute threshold values in "Mute Threshold Configuration" command description for audio quality level	

7.1.6.6 Seamless Linking Link Threshold Configuration

This command shall be used for setting the link forward and backward threshold values which are the triggering points of the audio seamless linking. Link forward and backward threshold values are different representation of BER based re-calculated values to generate time variant parameter which relatively follows signal quality change in time. Eventually, this signal quality determines the audio quality and these values can be considered as audio quality level because of this reason.

By setting a different link forward and backward threshold values, hysteresis approach of audio quality control over seamless linking can be done.

In this command, there 28 parameters and 26 of them are purely for threshold setting. First two parameters are the target audio channel and digital radio standard type.

Following is the message configuration of Seamless Linking Link Threshold Configuration subsequent data.

Table 7-26 Seamless Linking Link Threshold Configuration Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	Audio channel	First Audio	0x00
			Second Audio	0x01
	Byte #2	Digital Radio Standard type value	DAB	0x00
			DAB+	0x01
			DMB Audio	0x02
			DRM	0x03
			DRM+	0x04
	Byte #3	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP1 link forward threshold value For DRM and DRM+ - TBD		0x00~0x3F
	Byte #4	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP2 link forward threshold value		0x00 ~ 0x3F

		For DRM and DRM+ - TBD	
	Byte #5	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP3 link forward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #6	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP4 link forward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #7	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP5 link forward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #8	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP1A link forward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #9	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP2A link forward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #10	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio	0x00 ~ 0x3F

		- EEP3A link forward threshold value For DRM and DRM+ - TBD	
	Byte #11	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP4A link forward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #12	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP1B link forward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #13	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP2B link forward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #14	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP3B link forward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #15	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP4B link forward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #16	Audio quality level index [0x00 : No noise only, 0x3F: No concealment]	0x00 ~ 0x3F

		For DAB, DAB+, and DMB audio - UEP1 link backward threshold value For DRM and DRM+ - TBD	
	Byte #17	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP2 link backward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #18	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP3 link backward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #19	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP4 link backward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #20	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - UEP5 link backward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #21	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP1A link backward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #22	Audio quality level index	0x00 ~ 0x3F

		[0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP2A link backward threshold value For DRM and DRM+ - TBD	
	Byte #23	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP3A link backward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #24	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP4A link backward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #25	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP1B link backward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #26	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP2B link backward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F
	Byte #27	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP3B link backward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F

	Byte #28	Audio quality level index [0x00 : No noise only, 0x3F: No concealment] For DAB, DAB+, and DMB audio - EEP4B link backward threshold value For DRM and DRM+ - TBD	0x00 ~ 0x3F

7.1.6.7 Seamless Linking Status

This is used response function code.

This response shall be used for indicating current seamless linking status and configuration monitoring. The purpose of this message is for indication of the seamless linking status.

Following is the message configuration of Seamless Linking Status subsequent data.

Table 7-27 Seamless Linking Status Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	Relation Number	RF1-RF2	0x00
			RF1-RF3	0x01
			RF2-RF3	0x02
	Byte #2	Audio Source	RF1	0x00
			RF2	0x01
			RF3	0x02
	Byte #3~6	Time Difference	Calculating	0x7FFFFFFE
			Not Ready	0x7FFFFFFF
			Others	0x########
	Byte #7~10	Level Difference	Calculating	0x7FFFFFFE
			Not Ready	0x7FFFFFFF
			Others	0x########
	Byte #11	Measure Mode	QUICK_SEARCH_MANUAL_MODE	0x00
			Others	0x##
	Byte #12	Measure Status	MEASUREMENT_NOT_STARTED	0x00
			MEASUREMENT_IN_PROGRESS	0x01
			MEASUREMENT_FOUND	0x02
	Byte #13	Correlation Status	BAD_CORRELATION	0x00
			NORMAL_CORRELATION	0x01
			GOOD_CORRELATION	0x02
			BEST_CORRELATION	0x03

	Byte #14~17	Frame Counter		0x########
	Byte #18	Seamless Status	SEAMLESS_RUNNING	0x00
			SEAMLESS_STOPPED	0x01
	Byte #19	Co-Loop Count		0x##
	Byte #20	RF1 status SL BER threshold	BAD	0x00
			GOOD	0x01
	Byte #21	RF1 status SL buffer	BAD	0x00
			GOOD	0x01
	Byte #22	TSM option status (RF1-RF2)	TSM ON	0x00
			TSM OFF	0x01
	Byte #23	TSM enable status (RF1-RF2)	TSM STOP	0x00
			TSM START	0x01
	Byte #24	TSM applied time (RF1-RF2) - Valid value(ms) : 0/10/20/30/45/60/90/150		0x##
	Byte #25	TSM process Status (RF1-RF2)	Idle	0x00
			Running	0x01
			Completed	0x02
			Failed	0x03
	Byte #26	TSM required Status (RF1-RF2)	Normal Play	0x00
			Call TSM working	0x01
	Byte #27	TSM repeat status (RF1-RF2)	Normal Play	0x00
			Repeat process	0x01
	Byte #28	TSM stretching Status (RF1-RF2)	Normal Play	0x00
			Stretching process	0x01
	Byte #29~32	TSM stretching target time (RF1-RF2)		0x########
	Byte #33~36	TSM stretching progress time (RF1-RF2)		0x########
	Byte #37	RF2 status SL BER threshold	BAD	0x00
			GOOD	0x01
	Byte #38	RF2 status SL buffer	BAD	0x00
			GOOD	0x01
	Byte #39	TSM option status (RF1-RF3)	TSM ON	0x00
			TSM OFF	0x01
	Byte #40	TSM enable status (RF1-RF3)	TSM STOP	0x00
			TSM START	0x01

	Byte #41	TSM applied time (RF1-RF3) - Valid value(ms) : 0/10/20/30/45/60/90/150		0x##
	Byte #42	TSM process Status (RF1-RF3)	Idle	0x00
			Running	0x01
			Completed	0x02
			Failed	0x03
	Byte #43	TSM required Status (RF1-RF3)	Normal Play	0x00
			Call TSM working	0x01
	Byte #44	TSM repeat status (RF1-RF3)	Normal Play	0x00
			Repeat process	0x01
	Byte #45	TSM stretching Status (RF1-RF3)	Normal Play	0x00
			Stretching process	0x01
	Byte #46~49	TSM stretching target time (RF1-RF3)		0x########
	Byte #50~53	TSM stretching progress time (RF1-RF3)		0x########
	Byte #54	RF3 status SL BER threshold	BAD	0x00
			GOOD	0x01
	Byte #55	RF3 status SL buffer	BAD	0x00
			GOOD	0x01
	Byte #56	TSM option status (RF2-RF3)	TSM ON	0x00
			TSM OFF	0x01
	Byte #57	TSM enable status (RF2-RF3)	TSM STOP	0x00
			TSM START	0x01
	Byte #58	TSM applied time (RF2-RF3) - Valid value(ms) : 0/10/20/30/45/60/90/150		0x##
	Byte #59	TSM process Status (RF2-RF3)	Idle	0x00
			Running	0x01
			Completed	0x02
			Failed	0x03
	Byte #60	TSM required Status (RF2-RF3)	Normal Play	0x00
			Call TSM working	0x01
	Byte #61	TSM repeat status (RF2-RF3)	Normal Play	0x00
			Repeat process	0x01
	Byte #62	TSM stretching Status (RF2-RF3)	Normal Play	0x00
			Stretching process	0x01

	Byte #63~66	TSM stretching target time (RF2-RF3)	0x########
	Byte #67~70	TSM stretching progress time (RF2-RF3)	0x########

7.1.7 PN_CMD_SYS_CHG_AUD_PATH (0x22) / RSP (0xA2)

This command shall be used for defining audio output path of the solution.

The WWR solution can support up to four I2S output ports as well as two audio decodes at the same time. Basically, I2S output port is defined for first output audio path. Therefore, audio data finished audio decoding is output to the selected I2S output port. This command can change the audio path of the I2S output port. It should be noted that this does not change the I2S output for audio output.

For example, the first audio outputs of DAC0 and DAC1 are preset to Audio0 and Audio1, and now output audio data respectively. Using this command, if you change DAC0 to Audio1 and DAC1 to Audio0, the audio outputs of DAC0 and DAC1 will change each other. Changing the audio output must be accepted in the RSP message.

Following is the message configuration of PN_CMD_SYS_CHG_AUD_PATH.

Table 7-28 PN_CMD_SYS_CHG_AUD_PATH message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.		0x22
DEV STD	1 byte	System level message has predefined value for this field.		0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x02
RSP STATUS	1 byte	Response status for command message.		0x00
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	Audio channel	First Audio	0x00

			Second Audio	0x01
	Byte #1	DAC number		0x00 ~ 0x03
CHKSUM	4 bytes	Check Sum value		0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

The response message is PN_CMD_SYS_CHG_AUD_PATH_RSP and its configuration is shown on following table.

Table 7-29 PN_CMD_SYS_CHG_AUD_PATH_RSP message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.	0xA2
DEV STD	1 byte	System level message has predefined value for this field.	0x00
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a response message, data length is pre-defined.	0x00
RSP STATUS	1 byte	Response status for command message	0x##
DATA IDX	1 byte	Not Used.	0x00
CHKSUM	4 bytes	Check Sum value	0x########

8. DAB Operation Protocol

This chapter describes all DAB related operation protocol. In other words, standard specific commands shall be available. For other standards, there will be a lot of similarities, but standard dependent unique protocol is inevitable.

This is one layer higher than system level protocol, thus all system level configuration shall be applied regardless of the DAB configuration.

8.1 Command Sets / Responses

In this sub chapter, each command and the response will be described in detail. First, the functionality and purpose of the command, then actual message configuration and parameter values will be explained. Lastly, the meaning of each parameter and its value range will be given.

For a response message, there shall be various types of status indication at the header section eleventh byte of the response message. One is “Command Accepted”, and the others are “Error Detected”. From the data section, there can be additional information for some command. This will be described on each command and response message description.

These command and response messages shall be delivered via SPI interface.

Notice 1: Once a response message is received on the host MCU, the host MCU must check the response message indicator before performing any further action on the digital radio solution.

Notice 2: As a consequence, consecutive command shall not be sent out at the host side before receiving and checking the previous command’s response message.

8.1.1 PN_CMD_DAB_STATUS (0x47) / RSP (0xC7)

This command shall be used to get various events of the digital radio solution.

The purpose of this command is to inform the status of the WWR event. To inform this status information, there are various notification parameters in this response message.

This command shall be used for indicating current health status and configuration monitoring. The purpose of this command is for indication of the system status. At the host side, all these parameters shall be monitored to ensure that system operation. and this command shall be used to get the signal quality information to the host.

The host MCU will check various notification parameters to know which command to use next.

Following is the message configuration of PN_CMD_DAB_STATUS.

Table 8-1 PN_CMD_DAB_STATUS message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.	0x47
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x00
RSP STATUS	1 byte	Response status for command message.	0x00
DATA IDX	1 byte	Not Used.	0x00

CHKSUM	4 bytes	Check Sum value	0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

The first parameter is the notification information ready for use.

And other parameters are tuned audio frame counter, frequency, signal variance, FIC BER and CRC, and BER values for each data transmission channel MSC, FIC, various CRC values depends on DAB and DAB+ configuration, Signal strength, SNR of the DAB signal.

The response message is PN_CMD_DAB_STATUS_RSP and its configuration is shown on following table.

Table 8-2 PN_CMD_DAB_STATUS_RSP message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.		0xC7
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.		b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.		b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x37
RSP STATUS	1 byte	Response status for command message		0x##
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0~3	**Notification**	**Command**	**Parameters**

		RESERVED		0x80000000
		RESERVED		0x40000000
		RESERVED		0x20000000
		TUNE_STATUS	PN_CMD_DAB_TUNE_STATUS	0x10000000
		ENSEMBLE_INFO	PN_CMD_DAB_GET_INFO	0x08000000
		SERVICE_INFO	PN_CMD_DAB_GET_INFO	0x04000000
		SRVCOMP_INFO	PN_CMD_DAB_GET_INFO	0x02000000
		RESERVED		0x01000000
		RESERVED		0x00800000
		SL_STATUS	PN_CMD_SYS_SL	0x00400000
		AUDIO_PLAY_INFO	PN_CMD_DAB_PLAY_INFO	0x00200000
		TEXT_DLS_INFO	PN_CMD_DAB_GET_TEXT	0x00100000
		TEXT_DLPLUS_INFO	PN_CMD_DAB_GET_TEXT	0x00080000
		TEXT_INTELLITEXT_INFO	PN_CMD_DAB_GET_TEXT	0x00040000
		DATA_SERVICE 0	PN_CMD_DAB_GET_DATA	0x00020000
		DATA_SERVICE 1	PN_CMD_DAB_GET_DATA	0x00010000
		DATA_SERVICE 2	PN_CMD_DAB_GET_DATA	0x00008000
		DATA_SERVICE 3	PN_CMD_DAB_GET_DATA	0x00004000
		RESERVED		0x00002000
		BER_MEASUREMENT	PN_CMD_DAB_GET_BER	0x00001000
		RESERVED		0x00000800
		RESERVED		0x00000400
		USER_APPTYPE_INFO	PN_CMD_DAB_GET_SI_INFO	0x00000200
		DATE_TIME	PN_CMD_DAB_GET_SI_INFO	0x00000100
		RESERVED		0x00000080
		ANOUNCEMENT_SUPPORT_INFO	PN_CMD_DAB_GET_SI_INFO	0x00000040
		ANNOUNCEMENT_SWITCH_INFO	PN_CMD_DAB_GET_SI_INFO	0x00000020
		FREQUENCY_INFO	PN_CMD_DAB_GET_SI_INFO	0x00000010
		OTHER_ENSEMBLE_INFO	PN_CMD_DAB_GET_SI_INFO	0x00000008
		SEAMLESS_LINKING_INFO	PN_CMD_DAB_GET_SI_INFO	0x00000004
		REGION_INFO	PN_CMD_DAB_GET_SI_INFO	0x00000002
		TII_INFO	PN_CMD_DAB_GET_SI_INFO	0x00000001
	Byte #4	Reserved		0x00
	Byte #5	Audio Mute Status		0x00 or 0x01

	Byte #6~9	Audio Frame Counter		0x########
	Byte #10~13	Frequency value in KHz unit		0x########
	Byte #14~15	Signal Variance value		0x####
	Byte #16	FIC CRC count value		0x##
	Byte #17~20	FIC BER value in floating type		0x########
	Byte #21	Sub-channel ID of first audio.		0x##
	Byte #22	Sub-channel ID of second audio		0x##
	Byte #23	Sub-channel ID of first selected data.		0x##
	Byte #24	Sub-channel ID of second selected data.		0x##
	Byte #25	Sub-channel ID of third selected data.		0x##
	Byte #26	Sub-channel ID of forth selected data.		0x##
	Byte #27~29	Reserved		0x## ~0x##
	Byte #30	RF signal Status	RF signal not exists	0x00
			RF signal exists	0x01
	Byte #31~34	MSC BER in floating point value		0x########
	Byte #35~38	FIC BER in floating point value		0x########
	Byte #39~42	For DAB audio, number of Header CRC error, 4 bytes floating point, For DAB+, number of AU CRC error, 4 bytes floating point For DMB-A, RS Alarm Flag Therefore, if there is no audio play using this device, this field shall be 0xFFFFFFFF.		0x########
	Byte #43~46	For DAB audio, it shall be SCF CRC, 4bytes floating point, For DAB+ and DMB-A, it shall be Pre-RS decoder BER, 4bytes floating point Therefore, if there is no audio play using this device, this field shall be 0xFFFFFFFF.		0x########
	Byte #47~50	RF signal strength in -dBm unit		0x########
	Byte #51~54	SNR in dB scale.		0x########
CHKSUM	4 Bytes	Check Sum value		0x########

8.1.2 PN_CMD_DAB_TUNE (0x43) / RSP (0xC3)

This command shall be used for tuning to specific frequency. To receive a DAB signal, frequency tuning is the first step to do. Once frequency tuning is finished, all audio and data services that are contained in the DAB ensemble can be selected.

There is only one parameter for a tuning process which is the target frequency.

In terms of system operation, this command shall be used in several cases. In case of a seek function between ensembles, repeated tune command shall be applied until any available DAB signal is found. In the same manner, back scan or normal scan function can be achieved. If the host MCU sends a tune command without following action, the WWR device shall stay on the target frequency regardless of signal availability. In other words, even if there is no DAB signal on the target frequency, the WWR device shall remain on the frequency until further command is received. To stop this tuning function, PN_CMD_DAB_ACTSTOP or another PN_CMD_DAB_TUNE command can be used.

Following is the message structure of PN_CMD_DAB_TUNE, and the description of each fields are also shown.

Table 8-3 PN_CMD_DAB_TUNE message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.	0x43
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages.	0x01

		The segmented message counter starts from 1.	
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x04
RSP STATUS	1 byte	Response status for command message.	0x00
DATA IDX	1 byte	Not Used.	0x00
DATA	Byte #0~3	Frequency in 'KHz'	0x########
CHKSUM	4 bytes	Check Sum value	0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU. There is one additional parameter which reconfirms the given target frequency.

The response message is PN_CMD_DAB_TUNE_RSP and its configuration is shown on following table.

Table 8-4 PN_CMD_DAB_TUNE_RSP message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.	0xC3
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x04
RSP STATUS	1 byte	Response status for command message	0x##
DATA IDX	1 byte	Not Used.	0x00
DATA	Byte #0~3	Frequency in 'KHz'	0x########

CHKSUM	4 bytes	Check Sum value	0x########

8.1.3 PN_CMD_DAB_TUNE_STATUS (0x49) / RSP (0xC9)

This command shall be used for checking the current tuner status. This command is needed in case the host MCU needs to know the most current status. This command is the only way to check the most current status of the tuner.

Unlike other commands, this command does not require any parameter to send since all necessary information is contained in the message header part.

Following is the message structure of PN_CMD_DAB_TUNE_STATUS, and the description of each fields are also shown.

Table 8-5 PN_CMD_DAB_TUNE_STATUS message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.	0x49
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message	b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x0000
RSP STATUS	1 byte	Response status for command message.	0x00
DATA IDX	1 byte	Not Used.	0x00
CHKSUM	4 bytes	Check Sum value	0x########

As an indicator of the command reception, WWR device will send a response message to the host

MCU.

The response message is PN_CMD_DAB_TUNE_STATUS_RSP and its configuration is shown on the following table.

Table 8-6 PN_CMD_DAB_TUNE_STATUS_RSP message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.		0xC9
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.		b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.		b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x12
RSP STATUS	1 byte	Response status for command message		0x##
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	RF signal Status	RF signal not exists	0x00
			RF signal exists	0x01
	Byte #1	OFDM Lock status	OFDM lock valid	0x01
			OFDM lock invalid	0xFF
	Byte #2	DAB Transmission Mode	Mode I	0x01
			Mode II	0x02
			Mode III	0x03
			Mode IV	0x04
	Byte #3~6	Currently tuned frequency in KHz unit		0x########

	Byte #7	Audio play status for first Instance	Audio is not playing	0x00
			Audio is playing	0x01
	Byte #8	Audio play status for second instance	Audio is not playing	0x00
			Audio is playing	0x01
	Byte #9~12	TII value		0x########
	Byte #13	Availability of tune status information.	Tune Done	0x01
			Tune Doing	0x00
	Byte #14	Scan Done Flag	FIC parsing Done	0x01
			FIC parsing Fail	0xFF
	Byte #15	Number of scanned services Only valid when FIC parsing is done		0x##
	Byte #16	Number of scanned audio service components Only valid when FIC parsing is done		0x##
	Byte #17	Number of scanned data service components Only valid when FIC parsing is done Stream service + Packet service		0x##
CHKSUM	4 bytes	Check Sum value		0x########

For the most cases of mobile reception, there can be signal quality change. Therefore, the host MCU has to be know for every RF signal status change.

In the response message, there are several parameters which are RF Signal existence, OFDM Lock status, DAB transmission Mode, tuned frequency, current audio playing status, TII information, and availability of tune status information.

There are other several parameters which tell basic information of the DAB ensemble in case the tuning is successfully done.

And next parameter shall show the actual status of obtaining FIC information. Rest of the parameters shall show the number of services in total, audio, and data service.

By checking these parameters, the host MCU can understand the results of the tuning process.

8.1.4 PN_CMD_DAB_SCAN (0x44) / RSP (0xC4) - TBD

This command shall be used for scanning to all DAB frequency.

To receive a DAB signal, frequency tuning is the first step to do. Once frequency tuning is finished, all audio and data services that are contained in the DAB ensemble can be response to host device.

There is three parameters for a scanning process.

Depending on the setting of the parameters, host can select to scan whether only Band 3 or both Band 3 and L-band.

And also host can select to scan whether only once or continuously.

To stop this tuning function, PN_CMD_DAB_ACTSTOP command can be used.

Following is the message structure of PN_CMD_DAB_SCAN, and the description of each fields are also shown.

Table 8-7 PN_CMD_DAB_SCAN message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.	0x44
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x03
RSP STATUS	1 byte	Response status for command message.	0x00
DATA IDX	1 byte	Not Used.	0x00

DATA	Byte #0	Band 3	Not Used	0x00
			Korea Band 3.	0x01
			Europe Band 3.	0x02
			China Band 3.	0x03
	Byte #1	L-Band	Not Used	0x00
			Europe L-Band.	0x01
			Canada L-Band.	0x02
	Byte #2	Scan Numbers	One Time.	0x00
			Continuous	0x01
CHKSUM	4 bytes	Check Sum value		0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

There is one additional parameter.

If a service list is created by a channel lock during a scan, the function code becomes "Get All Service List" and Subsequent Data are available.

For the Subsequent Data, see "Get All Service List" of PN_CMD_DAB_GET_INFO.

The response message is PN_CMD_DAB_SCAN_RSP and its configuration is shown on following table.

Table 8-8 PN_CMD_DAB_SCAN_RSP message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.	0xC4
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001

MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x04
RSP STATUS	1 byte	Response status for command message		0x##
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	Function code	Command Response	0x00
			End Scan	0x01
			Get All Service List	0x04
	Byte #1~	Subsequent Data		~
CHKSUM	4 bytes	Check Sum value		0x########

8.1.5 PN_CMD_DAB_GET_INFO (0x4D) / RSP (0xCD)

This command shall be used to get DAB information.

The parameters of each command written to the WWR solution according to the function code

Following is the message configuration of PN_CMD_DAB_GET_INFO.

Table 8-9 PN_CMD_DAB_GET_INFO message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.		0x4D
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.		b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.		b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x01
RSP STATUS	1 byte	Response status for command message.		0x00
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	Function Code	Reserved	0x00
			Ensemble Information	0x01
			Service Information	0x02
			Service Component Information	0x03
			Get All Service List	0x04

CHKSUM	4 bytes	Check Sum value	0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

The response message is PN_CMD_DAB_GET_INFO_RSP and its configuration is shown on the following table.

Table 8-10 PN_CMD_DAB_GET_INFO_RSP message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.		0xCD
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.		b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.		b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00~0x02
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01~0x03
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x####
RSP STATUS	1 byte	Response status for command message		0x##
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	Function Code	Reserved	0x00
			Ensemble Information	0x01
			Service Information	0x02
			Service Component Information	0x03
			Get All Service List	0x04
	Byte #1 ~	Subsequent Data		~

CHKSUM	4 bytes	Check Sum value	0x########

8.1.5.1 Ensemble Information

This response shall be used to deliver specific ensemble information after a FIC parsing.
In DAB standard, ensemble means a group of services delivered in single frequency.
Following is the subsequent data of Ensemble, and the description of each fields are also shown.

Table 8-11 Ensemble Subsequent Data

Item	Position	Description	Values
DATA	Byte #1	Version of this ensemble information When the frequency is tuned, this value is 0. If the information is changed, this value will be increased.	0x00~0xFF (Modulo-256)
	Byte #2~5	Frequency in KHz	0x########
	Byte #6~7	Ensemble ID	0x####
	Byte #8	Extended country code, which is gathered via FIG0/9 packet. *Note1)	0x##
	Byte #9~24	Ensemble name	0x## ~ ##
	Byte #25~26	Ensemble label flag	0x####
	Byte #27	Select an international table*Note2)	0x##
	Byte #28	Character set for the ensemble label	0x##
	Byte #29~30	Number of service information	0x01~0x####
	Byte #31~32	Number of audio service component in an ensemble	0x00~0x####
	Byte #33~34	Number of data service component in an ensemble.	0x00~0x####

Note 1) Ensemble ECC
Please refer FIG Type0 Extension 9.
Ensemble ECC (Extended Country Code): this 8-bit field shall make the Ensemble Id unique worldwide. The ECC shall be as defined in TS 101 756 [16], tables 3 to 7.

Note 2) Inter. Table Id
Please refer FIG Type0 Extension 9.
Inter. (International) Table Id: this 8-bit field shall be used to select an international table. The interpretation of this field shall be as defined in TS 101 756 [16], table 11.

8.1.5.2 Service Information

This response shall be used to deliver specific service information after a FIC parsing.

Once the host receives this response, it is possible to make service information database for user interface for other purpose.

In Service Information, service information is continuously received as many as the number of services except version information.

N is the number of services.

Following is the subsequent data of Service information, and the description of each fields are also shown.

Table 8-12 Service Subsequent Data

Item	Position	Description	Values
DATA	Byte #1	Version of this service information. When the frequency is tuned, this value is 0. If the information is changed, this value will be increased.	0x00~0xFF (Modulo-256)
	Byte #2~5 * N	Service ID	0x########
	Byte #6~21 * N	Service label	0x## ~ ##
	Byte #22~23 * N	Service label flag	0x####
	Byte #24 * N	Character set of service label	0x##
	Byte #25 * N	Static Service Program type code*Note1)	0x##
	Byte #26 * N	Dynamic Service Program type code*Note1)	0x##
	Byte #27 * N	Number of service components.	0x##
	Byte #38~31 * N	Frequency of this service	0x########
	Byte #32~33 * N	Ensemble ID of this service	0x####
	Byte #34 * N	Reserved field for future use	0x00

Note 1) SPType & DPType

The Program Type feature allows program contents to be categorized according to their intended audience.

The Program Type feature is encoded in Extension 17 of FIG type 0 (FIG 0/17). It consists of at least

one code from the international set of codes followed by an optional additional code. The Program Type codes apply to all the audio components of the service. The language field allows the language of the primary service component to be signaled. In addition, one language can be signaled for the secondary service component(s).

S/D (Static/Dynamic): this 1-bit flag shall indicate that the Program Type code and language (when present), signaled in the program type field, represent the current program contents, as follows:
0(Static): Program Type codes and language (when present), may not represent the current program contents;
1(Dynamic): Program Type codes and language (when present), represent the current program contents.

Int. (International) code: this 5-bit field shall specify the basic Program Type category. This code is chosen from an international table (Inter. Table Id)

8.1.5.3 Service Component Information

This response shall be used to deliver specific service component information after a FIC parsing.

Each service can have several service components and each service component will be the actual service for the user.

At the host side, each of service component information can be used for making service list database for the user, and the user can choose each service from the list.

In Service Component Information, service component information is continuously received as many as the number of services component except version information.

M is the number of services component.

Following is the service component information subsequent data and description of each item.

Table 8-13 Service Component Subsequent Data

Item	Position	Description	Values
DATA	Byte #1	Version of this service component information. When the frequency is tuned, this value is 0, and if the information is changed, this value is increased.	0x00~0xFF (Modulo-256)
	Byte #2~5 * M	Service identifier	0x########
	Byte #6 * M	Transport mechanism identifier*Note1)	0x##
	Byte #7 * M	Audio/Data service component type*Note2)	0x##
	Byte #8 * M	Sub-channel identifier (or FIDC ID)	0x##
	Byte #9 * M	Primary or secondary service flag	0x##
	Byte #10~11 * M	Service Component identifier	0x####
	Byte #12 * M	Service Component identifier within the service	0x##
	Byte #13~14 * M	Packet address for the packet component*Note3)	0x####
	Byte #15~16 * M	Bit rate in kbps	0x####
	Byte #17 * M	Protection Level *Note4)	0x##
	Byte #18~33 * M	Service component label	0x## ~ ##
	Byte #34~35 * M	Service component label flag	0x####
	Byte #36~39 * M	Frequency of this service component	0x########
	Byte #40~41 * M	Ensemble ID of this service component	0x####

	Byte #42 * M	Language type of this service component which is contained in FIG 0/5	0x##
	Byte #43 * M	Character set of Label	0x##
	Byte #44 * M	CAS flag distinguish of CA service or not	0x00 ~ 0x01

Note 1) TMID description

TMId (Transport Mechanism Identifier): this 2-bit field shall indicate the transport mechanism used, as follows:

0x00: MSC - Stream mode - audio;

0x01: MSC - Stream mode - data;

0x02: FIDC;

0x03: MSC - Packet mode - data.

Note 2) ADSCType description

[AUDIO case]

ASCTy (Audio Service Component Type): this 6-bit field shall indicate the type of the audio service component. The following types are defined (the remaining types are reserved for future use):

0x00: foreground sound (MPEG I or II (Layer II or reserved) coding);

0x01: background sound (MPEG I or II (Layer II or reserved) coding);

0x02: multi-channel audio extension (MPEG II (Layer II or reserved) coding);

0x3F: AAC audio services (DAB+).

[DATA case]

DSCTy (Data Service Component Type): this 6-bit field shall indicate the type of the data service component. The interpretation of this field shall be as defined in TS 101 756 [16], table 2.

Note 3) Packet Address

This value is packet address. It is only valid for TMID is Packet Data (0x03).

In other words, it is only valid for Packet data service. (For the audio service, it will be discarded.)

Note 4) Protection Level description

[Un-equal Error Protection(UEP, Short form) case]

UEP level 1 = “0x01” **/** UEP level 2 = “0x02” / UEP level 3 = “0x03” / UEP level 4 = “0x04” / UEP level 5 = “0x05”

b7 (1bit)	b6 (1bit)	b5 (1bit)	b4 (1bit)	b3 (1bit)	b0 ~ b2 (3bit)
Short (0) / Long form	**0**	**0**	**0**	**0**	**Protection level**

[Equal Error Protection(UEP, Long form) case]

EEP level 1A = “0x80“ / EEP level 2A = “0x84” / EEP level 3A = “0x88” / EEP level 4A = “0x8C”

EEP level 1B = “0x90” / EEP level 2B = “0x94” / EEP level 3B = “0x98” / EEP level 4B = “0x9C”

b7 (1bit)	b4 ~ b6 (3bit)	b2 ~ b3 (2bit)	b1 (1bit)	b0 (1bit)
Short / Long form (1)	**Option (A or B)**	**Protection level**	**0**	**0**

8.1.5.4 Get All Service List

This response shall be used to deliver all channel information after a FIC parsing.

See the Ensemble, Service, and Service Component information previously described.

N is the number of service information (Byte #29~30).

M is the sum of the number of audio service component information(Byte #31~32) and the number of data service component information(Byte #33~34).

Following is the all service information subsequent data and description of each item.

Table 8-14 ALL Service List Subsequent Data

Item	Position	Description	Values
DATA	Byte #1	Version of this service component information. When the frequency is tuned, this value is 0, and if the information is changed, this value is increased.	0x00~0xFF (Modulo-256)
	Byte #2~5	Frequency in KHz	0x########
	Byte #6~7	Ensemble ID	0x####
	Byte #8	Extended country code, which is gathered via FIG0/9 packet.	0x##
	Byte #9~24	Ensemble name	0x## ~ ##
	Byte #25~26	Ensemble label flag	0x####
	Byte #27	Select an international table	0x##
	Byte #28	Character set for the ensemble label	0x##
	Byte #29~30	Number of service information	0x####
	Byte #31~32	Number of audio service component in an ensemble	0x####
	Byte #33~34	Number of data service component in an ensemble.	0x####
	Byte #35~38 * N	Service ID	0x########
	Byte #39~54 * N	Service label	0x## ~ ##
	Byte #55~56 * N	Service label flag	0x####
	Byte #57 * N	Character set of service label	0x##
	Byte #58 * N	Static Service Program type code*Note1)	0x##
	Byte #59 * N	Dynamic Service Program type code*Note1)	0x##

	Byte #60 * N	Number of service components.	0x##
	Byte #61~64 * N	Frequency of this service	0x########
	Byte #65 ~66 * N	Ensemble ID of this service	0x####
	Byte #67 * N	Reserved field for future use	0x00
	Byte #67 * N + 1~4 * M	Service identifier	0x########
	Byte #67 * N + 5 * M	Transport mechanism identifier	0x##
	Byte #67 * N + 6 * M	Audio/Data service component type	0x##
	Byte #67 * N + 7 * M	Sub-channel identifier (or FIDC ID)	0x##
	Byte #67 * N + 8 * M	Primary or secondary service flag	0x##
	Byte #67 * N + 9~10 * M	Service Component identifier	0x####
	Byte #67 * N + 11 * M	Service Component identifier within the service	0x##
	Byte #67 * N + 12~13 * M	Packet address for the packet component	0x####
	Byte #67 * N + 14~15 * M	Bit rate in kbps	0x####
	Byte #67 * N + 16 * M	Protection Level	0x##
	Byte #67 * N + 17~32 * M	Service component label	0x## ~ ##
	Byte #67 * N + 33~34 * M	Service component label flag	0x####
	Byte #67 * N + 35~38 * M	Frequency of this service component	0x########
	Byte #67 * N + 39~40 * M	Ensemble ID of this service component	0x####
	Byte #67 * N + 41 * M	Language type of this service component which is contained in FIG 0/5	0x##
	Byte #67 * N + 42 * M	Character set of Label	0x##
	Byte #67 * N + 43 * M	CAS flag distinguish of CA service or not	0x00 ~ 0x01

8.1.6 PN_CMD_DAB_SET_AUDIO (0x45) / RSP (0xC5)

This command shall be used for selecting an audio service from a DAB ensemble. To select a service within DAB ensemble, it is required to have a scanned DAB ensemble database or tuned on a DAB signal. Once a list of service is available on the host MCU side, this command can be used for actual audio service selection.

To select a specific DAB audio service, seven parameters are needed which are the DAB ensemble frequency, the unique Service ID, the Ensemble ID, a Sub Channel ID, Bit rate information, the Service Component Type, and Audio Index. The target frequency value is needed when the currently tuned frequency is not same as the desired one. In other words, even if the user selects a service which is contained in other DAB ensemble, other frequency, this command shall allow automatically tuning on the designated frequency. This automatic tune process shall prevent unnecessary tune command from the host MCU. From the second to sixth parameters are used for indicating a specific audio service with an audio play mode. The last parameter is needed to specify logical channel mapping with desired output path.

Following is the message structure of PN_CMD_DAB_SET_AUDIO, and the description of each fields are also shown.

Table 8-15 PN_CMD_DAB_SET_AUDIO message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.	0x45
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00

MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x10
RSP STATUS	1 byte	Response status for command message.	0x00
DATA IDX	1 byte	Not Used.	0x00
DATA	Byte #0~3	Target Frequency in KHz unit	0x########
	Byte #4~7	Unique Service ID	0x########
	Byte #8~9	Unique Ensemble ID	0x####
	Byte #10	Sub Channel ID	0x##
	Byte #11~12	Bit Rate of the audio service	0x####
	Byte #13	Service Component Type	0x##
	Byte #14~15	Reserved	0x####
CHKSUM	4 bytes	Check Sum value	0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU. There are four additional parameters which reconfirm the given Service ID, Sub Channel ID, Service Component Type.

The response message is PN_CMD_DAB_SET_AUDIO_RSP and its configuration is shown on following table.

Table 8-16 PN_CMD_DAB_SET_AUDIO_RSP message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.		0xC5
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.		b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.		b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x08
RSP STATUS	1 byte	Response status for command message		0x##
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0~3	Unique Service ID		0x########
	Byte #4	Sub Channel ID		0x##
	Byte #5	Service Component Type		0x##
	Byte #6	Audio Index	First audio channel	0x00
			Second audio channel	0x01
	Byte #7	Reserved		0x##
CHKSUM	4 bytes	Check Sum value		0x########

8.1.7 PN_CMD_DAB_SET_DATA (0x46) / RSP (0xC6)

This command shall be used for selecting a data service within a DAB ensemble. Overall usage of the command is quite similar as selecting an audio service. To select a data service within DAB multiplex, it is required to have a scanned DAB ensemble database or tuned on a DAB signal. Once a list of service is available on the host MCU side, this command can be used for actual data service selection.

To select a specific DAB data service, ten parameters are needed which are the DAB ensemble frequency, the unique Service ID, unique Ensemble ID, Sub Channel ID, the Bit rate information, Service Component Type, Service Component ID, Data Type, Packet Address, Streaming Dump Type. The target frequency value is needed when the currently tuned frequency is not same as the desired one. In other words, even if the user selects a service which is contained in other DAB ensemble, other frequency, this command shall allow automatically tuning on the designated frequency. This automatic tune process shall prevent unnecessary tune command from the host MCU. From the second thru the eighth parameters are used for indicating a specific data service within a DAB ensemble. The second last parameter is for selecting the level of data streaming and the last parameter is needed to specify logical channel mapping with desired output path.

The actual data shall be transmitted within PN_CMD_DAB_GET_DATA / RSP messages.

Following is the message structure of PN_CMD_DAB_SET_DATA, and the description of each fields are also shown.

Table 8-17 PN_CMD_DAB_SET_DATA message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.	0x46
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001

MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x14
RSP STATUS	1 byte	Response status for command message.		0x00
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0~3	Target Frequency in KHz unit		0x########
	Byte #4~7	Unique Service ID		0x########
	Byte #8~9	Unique Ensemble ID		0x####
	Byte #10	Sub Channel ID, In case of FIDC, the value shall be the FIDC ID		0x##
	Byte #11~12	Bit Rate of the audio service		0x####
	Byte #13	Service Component Type		0x##
	Byte #14~15	Service Component ID		0x####
	Byte #16	Data Type	Audio service	0x00
			Stream Data service	0x01
			FIDC data	0x02
			Packet data	0x03
	Byte #17~18	Packet Address Only valid when Data Type = 0x03. Otherwise, it shall be 0x0000		0x####
	Byte #19	Streaming Dump Type	Packet level (TBC)	0x01
			Data Group level (TBC)	0x02
			Whole Sub Channel	0x03
CHKSUM	4 bytes	Check Sum value		0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU. There are five additional parameters which reconfirm the given Service ID, Sub Channel ID, Service Component ID, Packet Address, Data Type.

The response message is PN_CMD_DAB_SET_DATA_RSP and its configuration is shown on the following table.

Table 8-18 PN_CMD_DAB_SET_DATA_RSP message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.	0xC6
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the DRM standard to be engaged to the message.	b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x0B
RSP STATUS	1 byte	Response status for command message	0x##
DATA IDX	1 byte	Not Used.	0x00
DATA	Byte #0~3	Unique Service ID	0x########
	Byte #4	Sub Channel ID	0x##
	Byte #5~6	Service Component ID	0x####
	Byte #7~8	Packet Address. If not applicable, then the value becomes 0x0000	0x####
	Byte #9	Data Type	0x##
	Byte #10	Reserved	0x##
CHKSUM	4 bytes	Check Sum value	0x########

8.1.8 PN_CMD_DAB_ACTSTOP (0x42) / RSP (0xC2)

This command is for stopping current action of a WWR device. By using this command, the host MCU can stop playing audio, sub channel data streaming, or frequency tuning. In general, all these actions shall be continued if there is no interruption. Because of this, the host MCU needs to send this command when the action needs to be stopped. There are two parameters which are Application index and Sub channel ID. The first parameter is also shall be used in case of stop tuning on a DAB ensemble. The application index is a logical channel of the audio or data path.

Following is the message structure of PN_CMD_DAB_ACTSTOP, and the description of each fields are also shown.

Table 8-19 PN_CMD_DAB_ACTSTOP message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.	0x42
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x02
RSP STATUS	1 byte	Response status for command message.	0x00
DATA IDX	1 byte	Not Used.	0x00

DATA	Byte #0	Stop Audio Decoding	First device Audio	0x00
			Second device Audio	0x01
		Stop Data Decoding	First device First Data	0x02
			First device Second Data	0x03
			First device Third Data	0x04
			First device Forth Data	0x05
			Second device First Data	0x06
			Second device Second Data	0x07
			Second device Third Data	0x08
			Second device Forth Data	0x09
		Stop Frequency Tuning		0xFF
	Byte #1	Sub channel ID value		0x00~0x3F
CHKSUM	4 bytes	Check Sum value		0x#########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

The response message is PN_CMD_DAB_ACTSTOP_RSP and its configuration is shown on following table.

Table 8-20 PN_CMD_DAB_ACTSTOP_RSP message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.	0xC2
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001

MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x00
RSP STATUS	1 byte	Response status for command message	0x##
DATA IDX	1 byte	Not Used.	0x00
CHKSUM	4 bytes	Check Sum value	0x########

[Tune mode]

Command: Byte #0: 0xFF (Always), Byte #1: Don’t Care

[Play mode]

Command: Byte #0: Application Index, Byte #1: Sub Channel ID (0 ~63).

8.1.9 PN_CMD_DAB_DRC (0x4B) / RSP (0xCB)

This command shall be used for triggering the DRC function of currently playing audio service. DRC is an enhanced volume control in audio processing. Therefore, it may not fit on all listener's favor. Due to this reason, DRC operation is provided as an optional feature.

Since the functionality of the command is simple, there is only one parameter in this command which controls the DRC function. However, if the current audio does not support DRC, then there shall be no different even if DRC feature is enabled.

Following is the message structure of PN_CMD_DAB_DRC, and the description of each fields are also shown.

Table 8-21 PN_CMD_DAB_DRC message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.		0x4B
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.		b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.		b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x01
RSP STATUS	1 byte	Response status for command message.		0x00
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	DRC feature control	Disable	0x00

			Enable	0x01
CHKSUM	4 bytes	Check Sum value		0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

The response message is PN_CMD_DAB_DRC_RSP and its configuration is shown on the following table.

Table 8-22 PN_CMD_DAB_DRC_RSP message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.		0xCB
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.		b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.		b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x01
RSP STATUS	1 byte	Response status for command message		0x##
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	Current status of DRC	Disable	0x00
			Enable	0x01
CHKSUM	4 bytes	Check Sum value		0x########

8.1.10 PN_CMD_DAB_ANN_MANUAL (0x48) / RSP (0xC8)

This command shall be used for starting an announcement function which is supported by a WWR device. In this process, the host uses the HMI to get the user's decision of an announcement and establish the database information for given announcement information and the user selection. Once the WWR notifies that there is an event for a specific announcement, the host shall decide whether this announcement has to be provided to the user or not.

Therefore, if this command is received at the WWR device side, audio service switching to indicated announcement shall happened. Once the announcement is finished, the host MCU shall send a PN_CMD_DAB_SET_AUDIO command to switch back to the original service. Otherwise, the audio service shall remain at the same service even after the announcement.

To understand that the announcement is finished at the host MCU side, the host has to check a PN_CMD_DAB_GET_SI_INFO_RSP "Announcement" response message and a timer. This timer is used in case the car moves into the no-reception area such as a tunnel. In this case, the WWR device cannot indicate the end of the announcement due to signal loss, the device cannot send PN_CMD_DAB_GET_SI_INFO_RSP "Announcement" response message to the host MCU side.

To overcome this situation, the host MCU has to check the interval of the PN_CMD_DAB_GET_SI_INFO_RSP "Announcement" response message and RF signal status. If the RF signal reception stays in bad condition and there is no PN_CMD_DAB_GET_SI_INFO_RSP "Announcement" response message more than certain duration, the host has to decide to go back to the original service or not. This is decision is totally depends on host S/W control. Therefore, it may different from each system design.

Following is the message structure of PN_CMD_DAB_ANN_MANUAL, and the description of each fields are also shown.

Table 8-23 PN_CMD_DAB_ANN_MANUAL message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.	0x48

DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.		b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.		b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x03
RSP STATUS	1 byte	Response status for command message.		0x00
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	Cluster ID		0x##
	Byte #1	Sub Channel ID		0x##
	Byte #2	Related audio channel	First device Audio	0x00
			Second device Audio	0x01
CHKSUM	4 bytes	Check Sum value		0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU. There is no additional parameter in this response message.

The response message is PN_CMD_DAB_ANN_MANUAL_RSP and its configuration is shown on the following table.

Table 8-24 PN_CMD_DAB_ANN_MANUAL_RSP message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.	0xC8
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx

	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined	0x00
RSP STATUS	1 byte	Response status for command message	0x##
DATA IDX	1 byte	Not Used.	0x00
CHKSUM	4 bytes	Check Sum value	0x########

8.1.11 PN_CMD_DAB_PLAY_INFO (0x4E) / RSP (0xCE)

This command shall be used when the host MCU selects one of the available audio services or when any of the parameter is changed during the play.

Following is the message structure of PN_CMD_DAB_PLAY_INFO, and the description of each fields are also shown.

Table 8-25 PN_CMD_DAB_PLAY_INFO message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.	0x4E
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x00
RSP STATUS	1 byte	Response status for command message.	0x00
DATA IDX	1 byte	Not Used.	0x00
CHKSUM	4 bytes	Check Sum value	0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

This response message shall inform basic audio parameters which needs to be indicated by the

host processor.

There are ten parameters in this response message which are DRC setting status, audio validity, audio sampling frequency, Codec type, audio mode, Music/Speech mode, error concealment status, audio language information, and the audio service index. First five parameters are normally not changed during the play, but the concealment status can be changed according to the DAB signal quality level.

The response message is PN_CMD_DAB_PLAY_INFO_RSP and its configuration is shown on the following table.

Table 8-26 PN_CMD_DAB_PLAY_INFO_RSP message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for this response message.		0xCE
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.		b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.		b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x0A
RSP STATUS	1 byte	Response status for command message		0x##
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	DRC Setting Status	DRC support is disabled	0x00
			DRC support is enabled	0x01

	Byte #1	Audio validity	Valid audio	0x00
			Invalid audio	0xFF
	Byte #2	Audio Sampling Frequency	8000Hz	0x01
			11025Hz	0x02
			12000Hz	0x03
			16000Hz	0x04
			22050Hz	0x05
			24000Hz	0x06
			31250Hz	0x07
			32000Hz	0x08
			44100Hz	0x09
			48000Hz	0x0A
			51200Hz	0x0B
			Invalid Sampling Frequency	0xFF
	Byte #3	Codec Type	DAB MP2	0x00
			DAB+ AAC	0x01
			Reserved	0x02
			T-DMB BSAC	0x03
			T-DMB AAC	0x04
			DAB+ AAC SBR	0x05
			T-DMB AAC SBR	0x06
			Invalid	0xFF
	Byte #4	Audio Mode	Mono	0x00
			Stereo	0x01
			Joint Stereo	0x02
			Dual Channel	0x03
			Parametric Stereo	0x04
			5.1Ch MPEG Surround	0x05
			7.1Ch MPEG Surround	0x06
			Other MPEG Surround	0x07
			Invalid	0xFF
	Byte #5	Music / Speech Flag (F-PAD)	Music	0x00
			Speech	0x01
			Invalid	0xFF

	Byte #6	Error Concealment Status	Unmute	0x00
			Mute	0x01
	Byte #7	Audio Language Information - Language value(When “L Flag” of FIG 0/17 is ‘1’) : 0x## - Default (When “L Flag” of FIG 0/17 is ‘0’) : 0xFF		0x##
	Byte #8	Currently used Audio	First device Audio	0x00
			Second device Audio	0x01
	Byte #9	DRC data availability	No DRC data available in PAD	0x00
			DRC data is available in PAD	0x01
			Not checked yet	0xFF
CHKSUM	4 bytes	Check Sum value		0x########

8.1.12 PN_CMD_DAB_GET_DATA (0x4C) / RSP (0xCC)

This command shall be used after the WWR device receives PN_CMD_DAB_SET_DATA.

This command is used to dump the data service.

The Data index field can be divided into raw data service dump and TDC / MOT data service dump. These two fields can be customized according to customer's needs.

Therefore, only one of the two fields can be used according to the customer's request.

The customer must decide in advance whether to dump with raw data or to dump with TDC or MOT data.

Raw data service dump and TDC, MOT data service dump can not be used at the same time.

Following is the message structure of PN_CMD_DAB_GET_DATA, and the description of each fields are also shown.

Table 8-27 PN_CMD_DAB_GET_DATA message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.	0x4C
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.	0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.	0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.	0x02
RSP STATUS	1 byte	Response status for command message.	0x00

DATA IDX	1 byte	Not Used.			0x00
DATA	Byte #0	Data Index	Raw	First selected data	0x00
				Second selected data	0x01
				Third selected data	0x02
				Forth selected data	0x03
			TDC / MOT	First selected audio data	0x00
				Second selected audio data	0x01
				First selected packet data	0x02
				Second selected packet data	0x03
CHKSUM	4 bytes	Check Sum value			0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

The DATA IDX field of the message header is the only response message used.

DATA IDX used for raw data service dump is 0x00 ~ 0x03. If it is dumped in TDC form, DATA IDX is 0xC0 ~ 0xC3. If it is dumped in MOT form, it has DATA IDX value of 0xE0 ~ 0xE3.

The response message is PN_CMD_DAB_GET_DATA_RSP and its configuration is shown on the following table.

Table 8-28 PN_CMD_DAB_GET_DATA_RSP message configuration

Item	Position	Description	Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.	0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.	0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for this response message.	0xCC
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.	b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.	b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is	0x00~0x1F

		segmented into multiple messages.		
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01 ~0x20
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x####
RSP STATUS	1 byte	Response status for command message		0x##
DATA IDX	1 byte	Raw	First selected data	0x02
			Second selected data	0x03
			Third selected data	0x04
			Forth selected data	0x05
		TDC	First selected audio TDC data	0xC0
			Second selected audio TDC data	0xC1
			First selected packet TDC data	0xC2
			Second selected packet TDC data	0xC3
		MOT	First selected audio MOT data	0xE0
			Second selected audio MOT data	0xE1
			First selected packet MOT data	0xE2
			Second selected packet MOT data	0xE3
		FIC or SI raw data		0xF3
		First Instance Raw PAD data		0xF0
		Second Instance Raw PAD data		0xF1
DATA	Byte #0 ~	Data		0x##~0x##
CHKSUM	4 bytes	Check Sum value		0x########

8.1.13 PN_CMD_DAB_GET_SI_INFO (0x4F) / RSP (0xCF)

This command is used to get various information used in DAB.
The parameters of each command written to the WWR solution according to the function code.

Following is the message configuration of PN_CMD_DAB_GET_SI_INFO.

Table 8-29 PN_CMD_DAB_GET_SI_INFO message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.		0x4F
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.		b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.		b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x01
RSP STATUS	1 byte	Response status for command message.		0x00
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	Function Code	Reserved	0x00
			Announcement Support	0x01
			Announcement Switch	0x02
			Frequency Information	0x03
			Other Ensemble	0x04

			Seamless Linking	0x05
			TII	0x06
			Region	0x07
			User Application Type	0x08
			Date and Time	0x09
CHKSUM	4 bytes	Check Sum value		0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

The response message is PN_CMD_DAB_GET_SI_INFO_RSP and its configuration is shown on following table.

Table 8-30 PN_CMD_DAB_GET_SI_INFO_RSP message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message		0xCF
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.		b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.		b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a response message, data length is pre-defined.		0x####
RSP STATUS	1 byte	Response status for command message		0x##
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	Function Code	Reserved	0x00

			Announcement Support	0x01
			Announcement Switch	0x02
			Frequency Information	0x03
			Other Ensemble	0x04
			Seamless Linking	0x05
			TII	0x06
			Region	0x07
			User Application Type	0x08
			Date and Time	0x09
	Byte #1 ~	Subsequent Data		~
CHKSUM	4 bytes	Check Sum value		0x########

8.1.13.1 Announcement Information

This response message shall be used to notify the current announcement event to the host. When the host receives this information, the host uses the User interface to get the user's decision of an announcement and establish the database information for given announcement information and the user selection.

Once the WWR device notifies that there is an event for a specific announcement, the host shall decide whether this announcement has to be provided to the user or not.

There are two major parameters in this response message which are Announcement type and Announcement support or switch list.

Announcement Support and Switch subsequent data is shown below.

Table 8-31 Announcement Support Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	OE Flag	This Ensemble	0x00
			Other Ensemble	0x01
	Byte #2	P/D Flag	Programme (audio) Service	0x00
			Data Service	0x01
	Byte #3	CN(SIV) Flag	Start of database (Change Event)	0x00
			Continuation of database	0x01
	Bytes #4~5	Sid (Service Identification)		0x####
	Bytes #6~7	ASu (Announcement Support) flags		0x####
	Byte #8	Number of Clusters (K) ("ASu flag = 0x0000" and "K= 0x00" means CEI)		0x##
	K Bytes	Cluster IDs		0x##

Table 8-32 Announcement Switch Subsequent Data

Item	Position	Description			Values
DATA	Byte #1	Cluster ID which the announcement service is linked to			0x##
	Byte #2	Sub-Channel ID which identifies the sub-channel for the announcement			0x##
	Byte #3	New Flag		Repeated announcement	0x00
				Newly introduced announcement	0x01
	Bytes #4~5	ASw (Announcement Switch) flags			0x####
	Byte #6	b7	Region Flag	Region field absent	b'0
				Region field present	b'1
		b6	Reserved		'0'
		b5 ~ b0	Identify the region to which the announcement is targeted.		b' ######

8.1.13.2 Frequency Information

This response message shall be used to notify the service linking information which was transmitted on FIG 0/21 to the host MCU side. This service linking information is sets of alternative frequency for current service. When the host receives this information, it shall establish the database information from received service linking information.

Once the WWR device notifies the service linking information, the host shall decide whether to change the frequency or not based on current signal quality. There can be several services linking information at the same time.

Moreover, these information can be updated (add or removed) at any moment of the radio operation. Therefore, there must be total number control and index for each information set to handle service linking database in host side.

Following is the subsequent data structure of frequency information, and the description of each fields are also shown.

Table 8-33 Frequency Information Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	OE Flag	This Ensemble	0x00
			Other Ensemble	0x01
	Byte #2	P/D Flag	Programme (audio) Service	0x00
			Data Service	0x01
	Byte #3	CN(SIV) Flag	Start of database (Change Event)	0x00
			Continuation of database	0x01
	Byte #4~5	Region ID	Region Identifier If the Region ID is 0x0000, no area is specified.	0x####
	Byte #6~7	ID field	Ensemble ID in case of DAB linking	0x####
			RDS PI code in case of FM RDS linking	0x####
			Dummy value in case of AM or FM linking	0x####
	Byte #8	R & M (Range and	DAB ensemble (no local windows)	0x00
			DRM	0x06

		Modulation)	FM with RDS	0x08
			FM without RDS	0x09
			AM (MW in 9kHz step & LW)	0x0A
			AM (MW in 5kHz step & SW)	0x0C
			AMSS	0x0E
	Byte #9	Continuity Flag	Continuity Flag	0x##
	Byte #10	Number of Frequency	Number of alternative frequency for the given ID (K) (“K= 0x00” means CEI)	0x##
	Byte #11~	Frequency Information LIST (When “K > 0”) Please refer below table for the detailed information		

Alternative Frequency Information list is shown below

Table 8-34 Frequency information List field configuration in DAB CASE

Item	Position	Description	Values
DATA	Byte #(11+5*(K-1))'	If R&M = 0000 or 0001, this field becomes K^{th} Control Field1 (only use DAB Ensemble) If R&M = 0110 or 1110, this field becomes K^{th} ID field2 (For more detailed information, please refer DAB specification figure 52: Structure of the Frequency Information field) (1 byte data field)	0x##
	Byte #(12+5*(K-1))' ~ #(15+5*(K-1))'	K^{th} alternative frequencies for given ID in ‘KHz’ (4 bytes data field)	0x########

8.1.13.3 Other Ensemble

This response message shall be used to notify the other ensemble service linking information which was transmitted on FIG 0/24 to the host MCU side. This service linking information is sets of alternative ensemble information for current service. When the host receives this information, it shall establish the database information from received service linking information.

Once the WWR device notifies the service linking information, the host shall decide whether to change the frequency or not based on current signal quality. There can be several services linking information at the same time. Moreover, these information can be updated (add or removed) at any moment of the radio operation. Therefore, there must be total number control and index for each information to handle service linking database in host side.

Following is the subsequent data structure of other ensemble, and the description of each fields are also shown.

Table 8-35 Other Ensemble Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	OE Flag	This Ensemble	0x00
			Other Ensemble	0x01
	Byte #2	P/D Flag	Programme (audio) Service	0x00
			Data Service	0x01
	Byte #3	CN(SIV) Flag	Start of database (Change Event)	0x00
			Continuation of database	0x01
	Byte #4~7	SID	Service ID linked DAB service	0x########
	Byte #8	CAID	Conditional Access Identifier	0x##
	Byte #9	Number of EID	Number of alternative ensembles which contains the given SID (K) (“K= 0x00” means CEI)	0x##
	Byte #10~	Ensemble ID	‘K’ number of alternative Ensemble ID for given SID (2 bytes for each item)	0x##~##

8.1.13.4 Seamless Linking

This response message shall be used to notify the hard or soft service linking information which was transmitted on FIG 0/6 to the host. This service linking information is more complicated information than others.

Once the WWR device notifies the soft/hard service linking information, the host shall decide whether to change the frequency or not based on current signal quality. There can be several services linking information at the same time. Moreover, these information can be updated (add or removed) at any moment of the radio operation. Therefore, there must be total number control and index for each information to handle service linking database in host side.

Following is the subsequent data structure of Seamless linking, and the description of each fields are also shown.

Table 8-36 Seamless Linking Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	OE Flag	This Ensemble	0x00
			Other Ensemble	0x01
	Byte #2	P/D Flag	Programme (audio) Service	0x00
			Data Service	0x01
	Byte #3	CN(SIV) Flag	Start of database (Change Event)	0x00
			Continuation of database	0x01
	Byte #4	Id List Flag	Id list and the preceding byte absent (“0x00” means CEI)	0x00
			Id list and the preceding byte present	0x01
	Byte #5	Linkage Actuator	Potential future link or De-activated link	0x00
			Active link	0x01
	Byte #6	Soft/Hard Link	Soft Link	0x00
			Hard Link	0x01
	Byte #7	International Linkage set indicator	National Link	0x00
			International Link (or DRM or AMSS)	0x01

	Byte #8~9	Link Set Number *1	Identifies number of the link set	0x####
	Byte #10	IDLQ (Valid in case of PD = 0 and Id list flag = 1)	DAB Sid	0x00
			RDS PI- Code	0x01
			AM or FM (no RDS) service	0x02
			DRM service ID or AMSS Service ID	0x03
	Byte #11	SHD (Valid in case of PD = 0 and Id list flag = 1)	Short Hand Indicator If 'ON' = 0x01, 'OFF' = 0x00	0x00~0x01
	Byte #12	Number of IDs	Number of IDs (DAB SIDs or FM RDS PI codes) in Link set (K)	0x00~0xFF
	Byte #13~	ID [Num Of Id] (4 bytes for each item)	Array of DAB SIDs*2 when link_type is equal to DAB	0x########
			FM RDS PI codes when link_type is equal to FM RDS	0x########
			Dummy-Value when link_type is equal to FM or AM	0x########

*1 note)

In case of "Id list flag =0", the parameters are valid until "Link Set Number"(LSN) byte#8.

*2 note)

In case of 16bit DAB SID, the MSB 2-byte will be padded with "0x0000"

8.1.13.5 TII

This response message shall be used to notify transmitter identification information (TII) which was transmitted through FIG 0/22 to the host. This service linking information is more complicated information than others.

Once the WWR device notifies transmitter identification information, the host shall decide whether to change the frequency or not based on current signal quality. There are two way of obtaining TII data which are FIC and RF signal Null Symbol, but the device does not know which one is the correct information. In detail, the TII information over PN_CMD_DAB_GET_SI_INFO_RSP "TII" is obtained from FIC data, but another TII data that is contained in PN_CMD_DAB_TUNE_STATUS / RSP is from RF signal null symbol. Therefore, the information contained in PN_CMD_DAB_GET_SI_INFO_RSP "TII" is more reliable in general. If the TII data in PN_CMD_DAB_TUNE_STATUS / RSP and PN_CMD_DAB_GET_SI_INFO_RSP "TII" are different, then it is better to use the value in PN_CMD_DAB_GET_SI_INFO_RSP "TII".

Following is the subsequent data structure of TII, and the description of each fields are also shown.

Table 8-37 TII Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	OE Flag	This Ensemble	0x00
			Other Ensemble	0x01
	Byte #2	P/D Flag	Programme (audio) Service	0x00
			Data Service	0x01
	Byte #3	CN(SIV) Flag	Start of database (Change Event)	0x00
			Continuation of database	0x01
	Byte #4	M/S flag	Main identifier flag	0x00
			Sub identifier flag	0x01
	Byte #5	Main Id	Main Identifier	0x##
	Byte #6	TII List depends on M/S flag. Please refer below table for detailed information		0x##~##

Transmitter identification information (TII) list is shown below

Table 8-38 Transmitter Identification Information List depends on M/S Flag

Item	Position	Description			Values
TII List based of M/S Flag	Byte #6	In case of M/S Flag (0x01)	Num Of Sub ID field	number of SubId fields (K) [“K= 0x00” means CEI]	0x##
	Byte # 7~		Sub id field structure	Please refer below SubId field structure table	0x##
	Byte #6~7	In case of M/S Flag (0x00)	Latitude coarse	Coarse Latitude	0x#####
	Byte #8~9		Longitude coarse	Coarse Longitude	0x#####
	Byte #10		Latitude fine	Fine Latitude	0x##
	Byte #11		Longitude fine	Fine Longitude	0x##

Table 8-39 SubId Field Structure

Item	Position	Description	Values
SubId field structure	Byte #7'	Sub Identifier	0x##
	Byte #8'~9'	TD	0x#####
	Byte #10'~11'	Latitude offset	0x#####
	Byte #12'~13'	Longitude offset	0x#####

8.1.13.6 Region

This response message shall be used to notify the regional identification information which was transmitted through FIG 0/11 to the host. This regional identification information is more complicated information than others.

Once the WWR device notifies region information, the host shall decide whether to change the frequency or not based on current signal quality.

Following is the subsequent data structure of Region, and the description of each fields are also shown.

Table 8-40 Region Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	OE Flag	This Ensemble	0x00
			Other Ensemble	0x01
	Byte #2	P/D Flag	Programme (audio) Service	0x00
			Data Service	0x01
	Byte #3	CN(SIV) Flag	Start of database (Change Event)	0x00
			Continuation of database	0x01
	Byte #4	GATy	Geographical area	0x00
			geographical co-ordinates	0x01
	Byte #5	G/E Flag	Ensemble coverage area	0x00
			Global coverage area	0x01
	Byte #6~7	RegionId	upper part (b'10~b'6) and lower part (b'5~b'0)	0x####
	Byte #8~	Regional ID information List Structure. Please refer below table for detailed information		0x##~##

Regional Identification Information list is shown below

Table 8-41 Regional Identification Information List

Item	Position	Description			Values
Regional ID Information List Structure	Byte #8~9	If GATy= 0x01	Latitude Coarse	coarse latitude of a corner of the spherical rectangle	0x####
	Byte #10~11		Longitude coarse	coarse longitude of a corner of the spherical rectangle	0x####
	Byte #12~13		Extent Latitude	extent of latitude of the spherical rectangle (12 bit)	0x####
	Byte #14~15		Extent Longitude	extent of longitude of the spherical rectangle (12 bit)	0x####
	Byte #8	If GATy= 0x00	Number of TII Groups = K	Number of TII group field (K). Actual configuration group field is described in following table. If this value is =0x00, it means CEI.	0x##
	Byte #9~		K^{th} TII Group	K^{th} TII group field. This field can be multiple entities depends on K value.	0x##~##

Table 8-42 Configuration of K^{th} TII group field

Item	Position	Description		Values
K^{th} TII group field.	Byte #9'	Main ID	Main Identifier	0x##
	Byte #10'	Number of SubId List	Number of SubId list field (N)	0x##
	Byte #11'	SubId List	1^{st} SubId List	0x##
	…	…	…	0x##
	Byte #11'+N	SubId List	N^{th} SubId List	0x##

8.1.13.7 User Application Type

This response message shall be used to notify user application type which was transmitted through FIG 0/13 to the host.

Once the WWR device notifies user application information, the host shall decide whether to change service type. In detail about the user application information over User Application Type is shown on the EN 300 401 Chapter 6.3.6.

Following is the subsequent data structure of User application type, and the description of each fields are also shown.

Table 8-43 User Application Type Subsequent Data

Item	Position	Description	Values
DATA	Byte# 1~4	SID	0x########
	Byte #5	SCIdS	0x##
	Byte #6	Number of User Application Type Field (N)	0x##
	Byte #7 ~	User Application Type structure (repeat N)	0x##~##

User Application Type field list is shown below

Table 8-44 User Application Type Field structure

Item	Position	Description	Values
User Application Type Field structure	Byte #7'~8'	User application type	0x####
	Byte #9'	User application data length (K)	0x##
	Byte #10'~(K+3)	User application data	0x####

8.1.13.8 Date and Time

This response message shall be used to notify time information which was transmitted through FIG 0/9 & 0/10 to the host. In detail about the time information over Date and Time is shown on the EN 300 401 Chapter 8.1.3.

Following is the subsequent data structure of date and Time, and the description of each fields are also shown.

Table 8-45 Date and Time Subsequent Data

Item	Position	Description	Values
DATA	Byte #1~2	Year value	0x####
	Byte #3	Month value	0x##
	Byte #4	Day value	0x##
	Byte #5	Hour value	0x##
	Byte #6	Minute value	0x##

8.1.14 PN_CMD_DAB_GET_TEXT (0x4A) / RSP (0xCA)

This command is used to get various text information used in DAB.

The parameters of each command written to the WWR solution according to the function code.

Following is the message configuration of PN_CMD_DAB_GET_TEXT.

Table 8-46 PN_CMD_DAB_GET_TEXT message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the command message.		0x4A
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.		b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.		b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a command message, data length is pre-defined.		0x01
RSP STATUS	1 byte	Response status for command message.		0x00
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	Function Code	Reserved	0x00
			DLS	0x01
			DL Plus	0x02
			IntelliText	0x03
CHKSUM	4 bytes	Check Sum value		0x########

As an indicator of the command reception, WWR device will send a response message to the host MCU.

The response message is PN_CMD_DAB_GET_TEXT_RSP and its configuration is shown on following table.

Table 8-47 PN_CMD_DAB_GET_TEXT_RSP message configuration

Item	Position	Description		Values
MAGIC ID	3 bytes	Used to synchronize a message and detect the communication error. It is fixed.		0x574452 →'WDR'
MSG NUM	1 byte	Message count number which is increased by 1 for every message. Transmitted and received message counters are independent.		0x00 ~ 0x7F (Modulo-128)
CMD ID	1 byte	Unique ID value for the response message.		0xCA
DEV STD	b7~b4	Device ID : identifying the specific device to be engaged to the message.		b'xxxx
	b3~b0	Standard ID : identifying the DAB standard to be engaged to the message.		b'0001
MSG CUR	1 byte	Current segmented message number. It must be started from 0 up to 31. Valid only when the original message is segmented into multiple messages.		0x00
MSG COUNT	1 byte	Total message counter of the segmented messages. The segmented message counter starts from 1.		0x01
DATA LEN	2 bytes	For a response message, data length is pre-defined.		0x####
RSP STATUS	1 byte	Response status for command message.		0x##
DATA IDX	1 byte	Not Used.		0x00
DATA	Byte #0	Function Code	Reserved	0x00
			DLS	0x01
			DL Plus	0x02
			IntelliText	0x03
	Byte #1~	Subsequent Data		~
CHKSUM	4 bytes	Check Sum value		0x########

8.1.14.1 DLS

This response message shall be used to notify the DLS data to the host when the new DLS data is received in current audio service.

Following is the subsequent data structure of DLS, and the description of each fields are also shown.

Table 8-48 DLS Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	Audio service with this DLS message.	First device Audio	0x00
			Second device Audio	0x01
	Byte #2	Character Set.		0x##
	Byte #3	Total length of DLS data. If the character set = 0xFF and the total length of DLS data is equal to zero, then it shall mean to clear the current DLS display.		0x##
	Byte #4~N	DLS data		0x########

8.1.14.2 DL Plus

This response message shall be used to when a WWR receives the data for DL Plus service on PAD section of the current audio service.

There are 11 parameters which are the character set, Index and over various data.

Following is the subsequent data structure of DL Plus, and the description of each fields are also shown.

Table 8-49 DL Plus Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	Audio service with this DL Plus message.	First device Audio	0x00
			Second device Audio	0x01
	Byte #2	Character Set.		0x##
	Byte #3	Tag Index.		0x##
	Byte #4	Item Toggle Bit.		0x##
	Byte #5	Item Running Bit.		0x##
	Byte #6	Number of DL Tag fields.		0x##
	Byte #7	Delete Bit.	New Object flag	0x00
			Object delete flag	0x01
	Byte #8	DL+ content type.		0x##
	Byte #9	DL+ text start point.		0x##
	Byte #10	DL+ text character size **M.**		0x##
	Byte #11~	DL + text, maximum 128 characters. - If Character set = 0x00, then the length of this field = M bytes - If Character set = 0x06 or 0x0F, then the length of this field = 2*M bytes		0x##~##

8.1.14.3 INTELLITEXT

This response message shall be used to when a WWR receives the data for intellitext service on PAD section of the current audio service.

There are 12 parameters which are the value, Index and Counter and each of them has Main/Sub/Data basically following the Intellitext standard form. Among them Index value always starts from 0, and Counter always starts from 1.

Following is the subsequent data structure of Intellitext, and the description of each fields are also shown.

Table 8-50 IntelliText Subsequent Data

Item	Position	Description		Values
DATA	Byte #1	Audio service with this IntelliText message.	First device Audio	0x00
			Second device Audio	0x01
	Byte #2	Character Set.		0x##
	Byte #3	Main index.		0x##
	Byte #4	Sub index.		0x##
	Byte #5	Data Index.		0x##
	Byte #6	Main menu counter.		0x##
	Byte #7	Sub menu counter.		0x##
	Byte #8	Data menu counter.		0x##
	Byte #9	Time to Live : <time_to_live> the (optional) lifetime of the data items. - 0x01 : 1 hour - 0x0C : 12 hours - 0x18 : 24 hours - 0x00 : No given Time to Live value		0x##
	Byte #10~25	Main Menu Name characters. (16bytes)		0x##~##
	Byte #26~41	Sub Menu Name characters (16bytes)		0x##~##
	Byte #42~	Data Menu Name characters (128bytes)		0x##~##

9. Chipset Operation Scenarios

9.1 Reset Flow

After turn on the power or when there is a problem of the chipset, the host can reset the WWR device with following procedure. However, following procedure is only valid for a device which has DSP inside. Otherwise, there is no need to wait for the boot up process.

1. Set the WWR device boot pin to boot mode by using GPIO pin of the host processor
2. Set the reset pin of WWR device from low to high
3. The host must wait minimum 2 seconds to check the completion of boot up procedure in WWR device, because the WWR device needs to read the booting image data from the serial flash.
4. After certain time, the host have to send the PN_CMD_SYS_GET_VERSION message to the WWR device
5. If the RESET procedure is complete, the WWR device will send a PN_CMD_SYS_GET_VERSION_RSP message to the host.

Following figure shows the Reset flow.

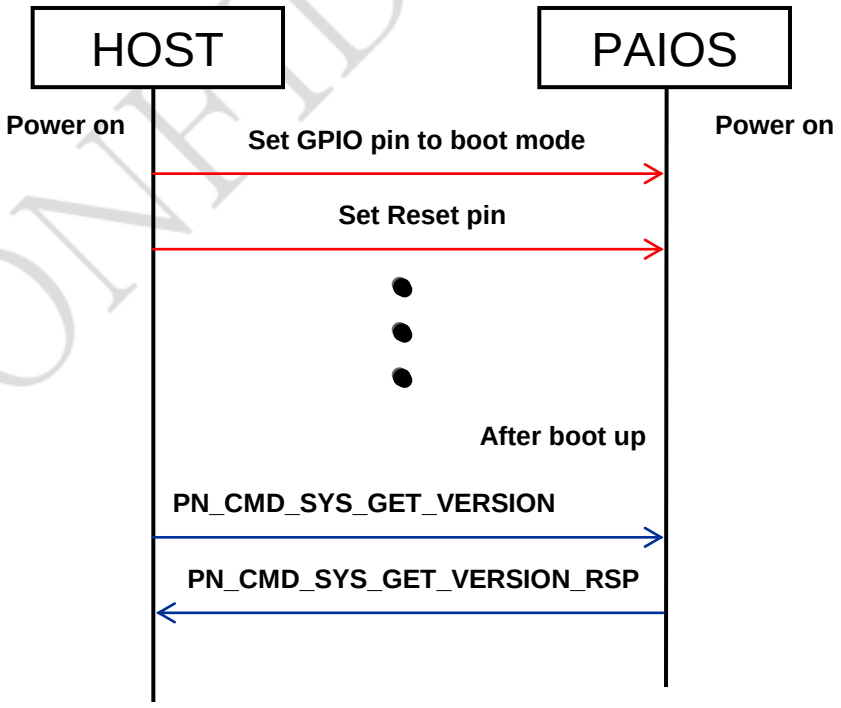

Figure 9-1 WWR Solution reset flow diagram

9.2 Firmware Upgrade Flow

In case of firmware change, actual data has to be stored in the serial flash memory. Thus the host has to follow strict procedure of firmware download.

Following is the detailed firmware upgrade flow.

1. Set the boot pin to SPI upgrade mode
2. Set the reset pin of WWR device from low to high
3. Send the new binary image data to the WWR device according to the guideline and reference source code from PnpNetwork.
4. After finishing the transmission of new binary firmware image, the host must set the boot pin to boot mode
5. Set the reset pin of WWR device from low to high

Following figure shows the procedure of upgrade.

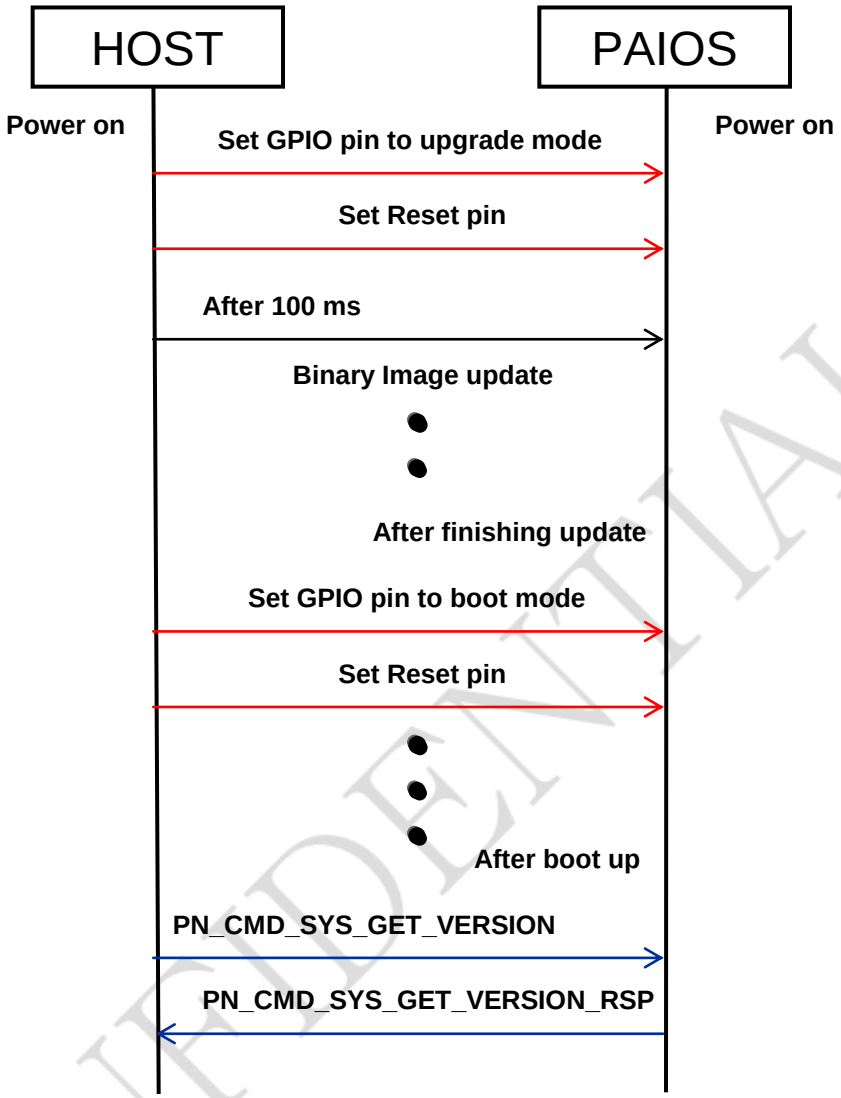

Figure 9-2 WWR Firmware upgrade flow diagram

9.3 Frequency Tune Flow

To start providing a service to the user, the host MCU needs to send a command for a frequency tuning. When a TUNE command is sent to a WWR device, the device will make a response for the TUNE command first.

After certain period of time that is needed for actual tuner control and baseband demodulation, the device will check whether digital radio signal exists on the frequency or not.

After the signal checking, between WWR device and host MCU side shall used a PN_CMD_DAB_TUNE_STATUS / RSP with signal result and FIC parsing result indicator.

To stop tune process, the host MCU must send a PN_CMD_DAB_ACTSTOP command.

If the desired digital radio signal exists and the channel information parsing is done, then host MCU side shall send a PN_CMD_DAB_GET_INFO messages to WWR device and then WWR device shall send a PN_CMD_DAB_GET_INFO_RSP messages to the host MCU side.

Following is the diagram of PN_CMD_DAB_TUNE command.

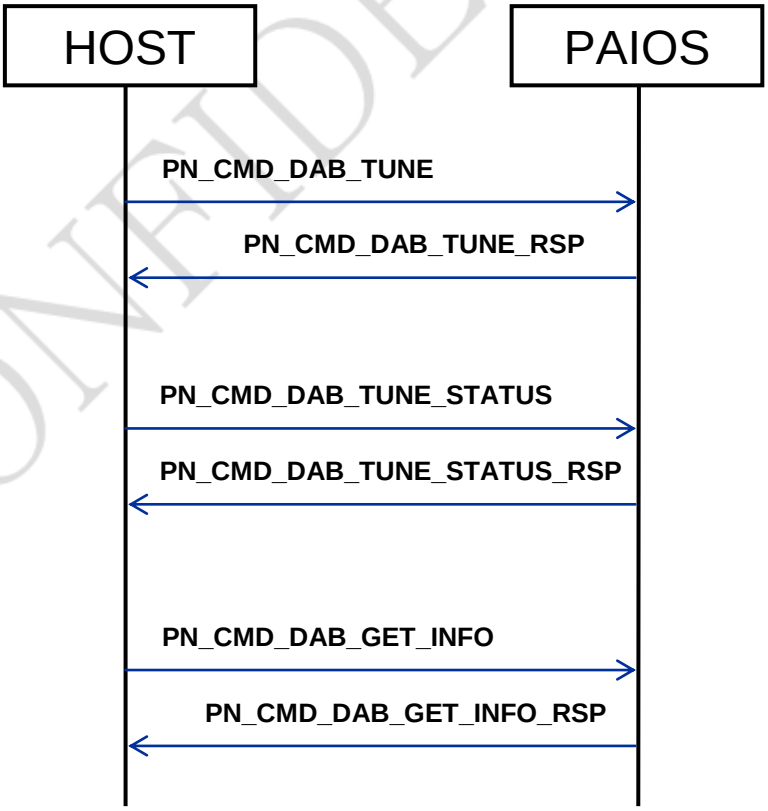

Figure 9-3 WWR DAB Frequency tune flow diagram

9.4 Scan Flow - TBD

To start providing a service to the user, the host MCU needs to send a command for a frequency tuning. When a TUNE command is sent to a WWR device, the device will make a response for the TUNE command first.

To stop tune process, the host MCU must send a PN_CMD_DAB_ACTSTOP command.

If digital radio signal exists and the channel information parsing is done, then WWR device shall send a PN_CMD_DAB_SCAN_RSP messages with function code "Get All Service List" to the host MCU side.

The signal check process is repeated by the frequency table.

Following is the diagram of PN_CMD_DAB_SACN command.

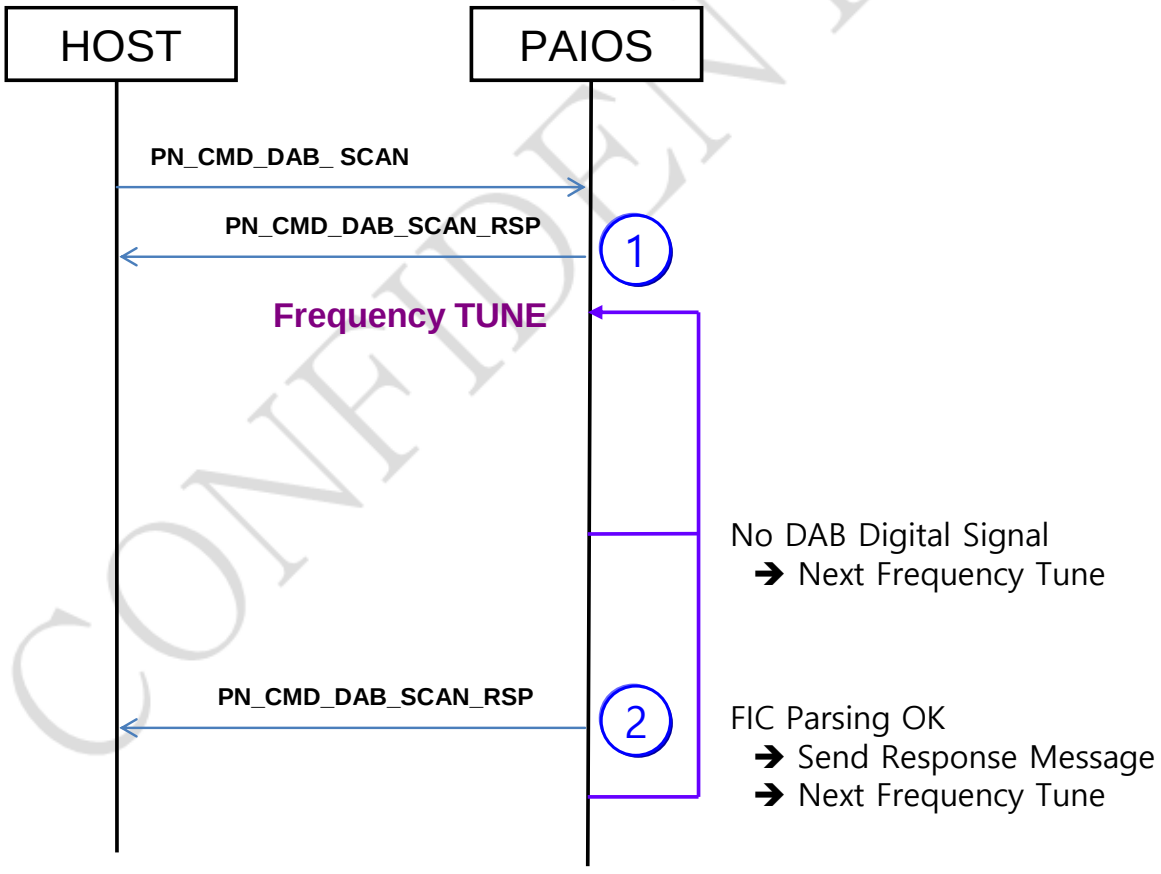

Figure 9-4 WWR DAB Scan flow diagram

9.5 Audio Service Select Flow

When all the information about current service is received at the host side, the host can select one of the current services to provide actual service to the user.

The PN_CMD_DAB_SET_AUDIO command is used to select an audio service in the specific frequency.

If the PN_CMD_DAB_SET_AUDIO command requires to change the frequency, the PN_CMD_DAB_GET_INFO / RSP with version number 0 will be used to the host when frequency tuning and the FIC parsing is done. After that, these messages will be sent again whenever the reconfiguration occurs.

When the play status is changed, for example sampling rate change, the PN_CMD_DAB_PLAY_INFO / RSP message will be used. If the host wants to stop the playing audio, just sending an PN_CMD_ACTSTOP command to the WWR device is needed.

Following figure shows above audio select explanation.

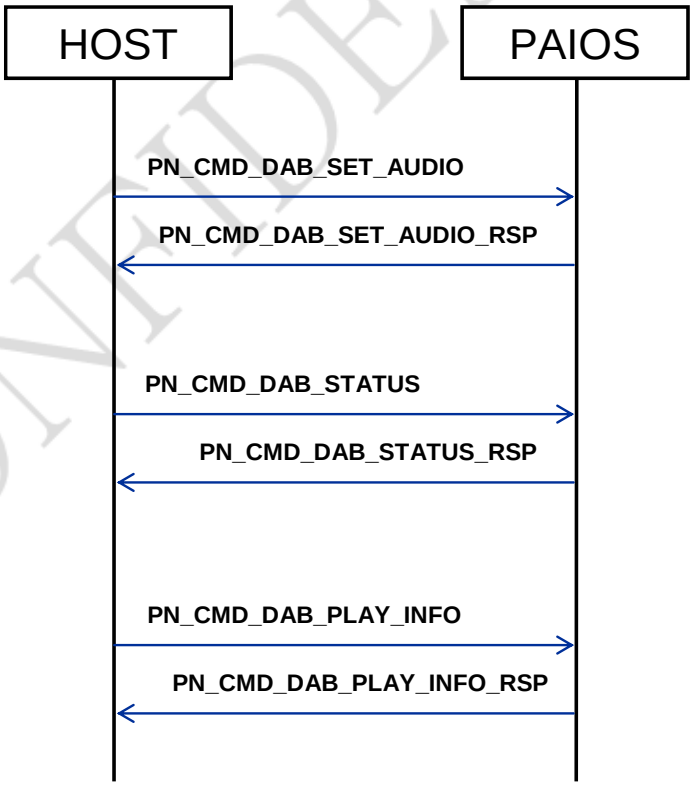

Figure 9-5 WWR DAB Audio service select flow diagram

When the Text (DLS, DL Plus, Intellitext) message is changed, the PN_CMD_DAB_GET_TEXT / RSP message shall be used.

Following figure shows above text message explanation.

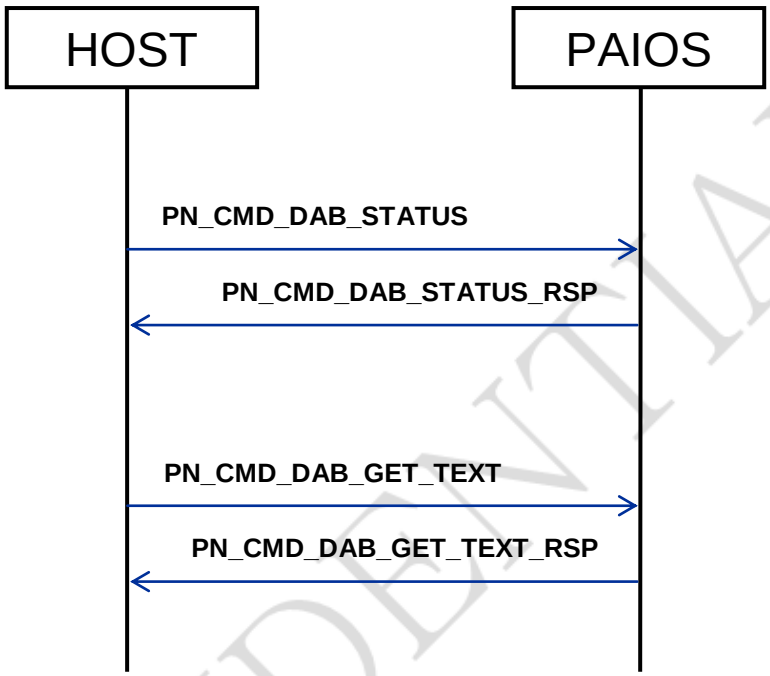

Figure 9-6 WWR DAB Get text service flow diagram

9.6 Data Service Select Flow

Since WWR device can support DAB data services such as EPG and TPEG raw data, Data service flow shall be defined. This flow is activated by sending the PN_CMD_DAB_SET_DATA command to a WWR device, then the device sends the data packets to the host using PN_CMD_DAB_GET_DATA / RSP message. However, other than some small data services, the actual sub channel raw data will be delivered to the host. If the host wants to stop the data service, PN_CMD_DAB_ACTSTOP command can be used.

Following is the data service flow diagram for better understanding.

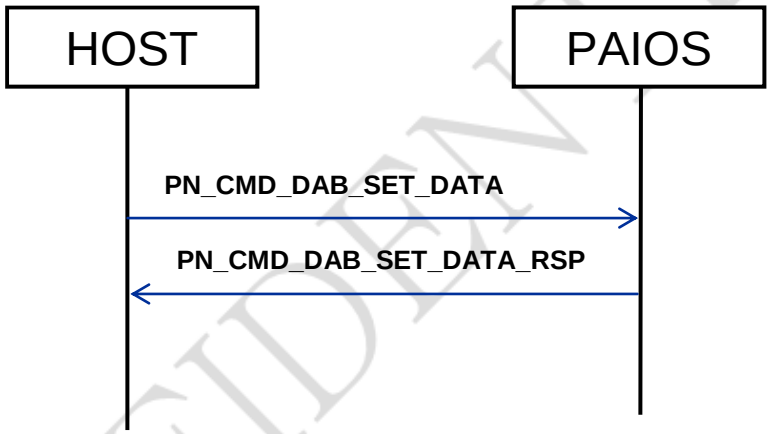

Figure 9-7 WWR DAB Data service flow diagram

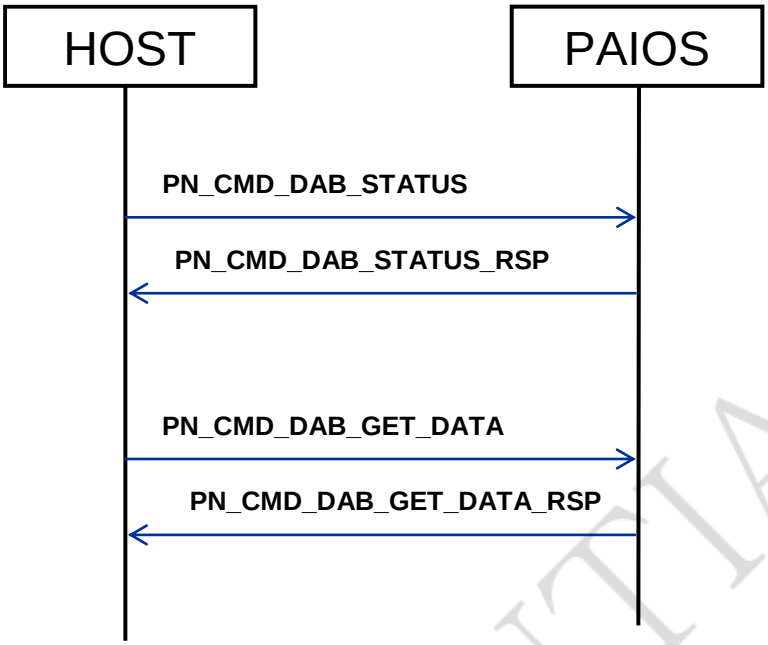

Figure 9-8 WWR DAB Get data service flow diagram

9.7 Normal Flow

In the normal state, PN_CMD_DAB_STATUS / RSP is exchanged between the WWR device and the HOST with a proper period so that the status of the system can be known.

The PN_CMD_DAB_STATUS / RSP parameter can be used to determine the state of the WWR device, and the Host can forward the command to the WWR device as needed.

Following figure shows the flow of normal state.

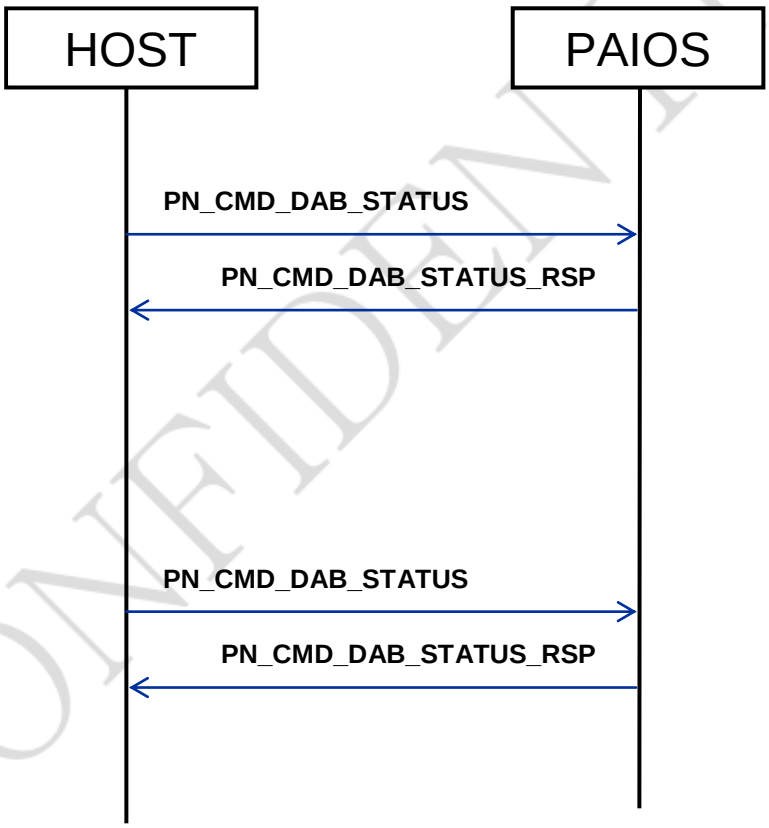

Figure 9-9 WWR DAB Normal flow diagram