RF Characteristic Evaluation Program for Renesas Sub-GHz Transceiver
Operation Manual (For V100)

Introduction

This document describes the software for the Renesas Sub-GHz transceiver R9A06G062 that can evaluate the basic characteristics of IEEE 802.15.4-compliant RF by issuing serial commands from a PC (hereinafter the RF characteristic evaluation program).

This RF characteristic evaluation program is a sample program intended to be used as a reference program in the product development process at your company and is provided for free without a guarantee. It does not guarantee the normal operation of your product. When installing this RF characteristic evaluation program, you are advised to perform a thorough evaluation of the entire system.

This RF characteristic evaluation program is not designed to achieve compliance with the Radio Act. It is your responsibility to take adequate measures in handling the program, such as using an anechoic chamber.

Target Device

R9A06G062

Contents

1. Overview

Figure 1-1 shows the configuration of this RF characteristic evaluation program. The program consists of an RF driver, peripheral utility program, and UART communication program.
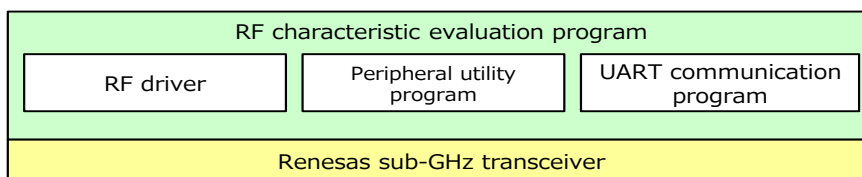
Figure 1-1 Software Configuration

This RF characteristic evaluation program makes the RF function work by using the API provided by the RF driver for the Renesas Sub-GHz transceiver.

2. Operation Overview

This RF characteristic evaluation program executes the RF characteristic evaluation function by issuing commands from a PC, with an R9A06G062 reference evaluation board connected to the PC via a serial cable, as shown in Figure 2-1.

Eva Board   Eva Board
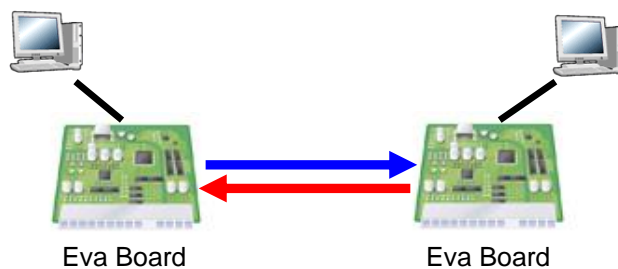
Figure 2-1 The Evaluation System

R9A06G062 reference evaluation board:
RTK0EE0013D10001BJ, RTK0EE0013D10002BJ, RTK0EE0013D10003BJ

2.1 Serial Terminal Settings

The serial terminal software enables data to be input to and output from a serial console.

The serial terminal settings (example settings of Teraterm) are as shown in Table 2.1.

Table 2.1 Serial Terminal Settings

Setting item	Setting value
Baud rate	500000 bps
Data	8 bits
Parity	None
Stop bit	1 bit
Flow control	Not used
Newline code	Reception: LF or AUTO Transmission: LF
Local echo	Enabled

2.2 Operation Check

   When the RF characteristic evaluation program is started, the serial terminal software displays a window like the one shown in Figure 2-2. When this window appears, you are ready to enter commands. This state is called the "command menu mode".

```
//////////////////////////////////////////////////////
/// IEEE802.15.4g (SubGHz) RF Evaluation Program
///          RF EvaProg Version = V078_00xxx
///          RF Driver Version  = V078_00xxx
///                    RX65N  CPU CLOCK  96MHz
///                           SPI CLOCK  24MHz
/// Copyright (c) 2022 Renesas Electronics Corp.
///                  All Rights Reserved
//////////////////////////////////////////////////////


# ---------------------------------------------------
# RF Evaluation Command Menu
# ---------------------------------------------------
#  tboot ----> RF device boot
#  tinit ----> Initialize [t1]
# --- Common Setting -------------------------------
#  tope -----> PHY Operating Mode Setting
#  tch ------> Channel Number Setting [t2]
#  ttxpow ---> Output Power Setting (FSK, OFDM) [t4]
#  ttxpowd --> Output Power Setting in dBm (FSK, OFDM)
#  tftxpowd -> Output Power Setting in dBm (FSK)
#  totxpowd -> Output Power Setting in dBm (OFDM)
#  tfrlen ---> Tx Packet Length Setting [t5]
#  ti -------> Tx Interval Setting
# --- FSK Setting ----------------------------------
#  tsfd -----> FSK SFD Mode Setting
#  tfpl -----> FSK Preamble Length Setting [tpl]
#  tdw ------> FSK Data Whitening Setting
#  tffcs ----> FSK FCS Length Setting [tfcs]
#  tfscheme -> FSK FEC Scheme Setting
#  tffecrx --> FSK FEC RX Auto Setting [tfecrx]
# --- OFDM Setting ---------------------------------
#  tofcs ----> OFDM FCS Length Setting
#  tointl ---> Interleaving Mode Setting
#  toscr ----> Scrambler Setting
#  tostf ----> Extend STF Length Setting
# --- CCA Setting ----------------------------------
#  tccam ----> CCA Mode Setting
#  tfcdr ----> FSK CCA Duration Setting [tcdr]
#  tfccavt --> FSK CCA Level Threshold [tccavt]
#  tfccavtd -> FSK CCA Level Threshold in dBm
#  tocdr ----> OFDM CCA Duration Setting
#  toccavt --> OFDM CCA Level Threshold
#  toccavtd -> OFDM CCA Level Threshold in dBm
# --- Execute Command ------------------------------
#  tftx -----> FSK Packet Tx [t6]
#  totx -----> OFDM Packet Tx
#  tfpn9-----> FSK Continuous Modulated PN9 Tx [tpn]
#  topn9-----> OFDM Continuous Modulated PN9 Tx
#  tnmtx ----> Continuous Unmodulated Tx [t9]
#  tfrx -----> FSK Packet Rx [t7]
#  torx -----> OFDM Packet Rx
#  te -------> ED
#  tcca -----> CCA
#  tmstxs ---> NewModeFrame Tx Preset
#  tmstx  ---> ModeSwitch Tx
#  tmsrxs ---> NewModeFrame Rx Preset
#  tmsrx  ---> ModeSwitch Rx
```

```
#  tsleep ---> To be RF Sleep Mode
# --- Miscellaneous ---------------------------------
#  tgpios ---> GPIO0-12 Function Select Setting
#  tgpio  ---> GPIO0-12 Display Current Setting
#  tgpioo ---> GPIO0-12 Output Level Setting
#  tgpioi ---> GPIO0-12 Input Level Acquiring
#  tberlen --> Frame length for RX BER Setting
#  tberpn9 --> PN9 mode for BER Setting
#  tffh -----> Frequency Hopping Test (FSK Tx)
#  tofh -----> Frequency Hopping Test (OFDM Tx)
#  reg ------> Read/Write RF device Register/RAM
#  ram ------> Read/Write MCU RAM for Tx and Expected Rx data
#  tttl -----> Tx Total Time Limit, Max Tx Duration and Min Pause Duration Setting
#  tantdv ---> Antenna Diversity Setting
#  tantnum --> Number of Antennas Setting
#  tantsel --> Antenna Number Select Setting
#  trxgain --> Rx External Gain Setting
#  trxgaind -> Rx External Gain Setting in dB
#  twgain ---> AGC Wait Gain Offset Setting
# --- Application option------------------------------
#  rst ------> Reset Application and RF device
#  opt ------> Display option
#  val ------> Dump Application Variable Values
#  help -----> Command list
# ---------------------------------------------------

command (and SetData[Dec])? >
```

Figure 2-2 Start Window

3. Command Specifications

When the RF characteristic evaluation program is started after the reset state is cleared, it enters the "command menu mode (a state in which the commands listed below (Table 3.1) can be accepted)".

3.1 Command List

To execute the function of a command, enter the command and then press the return key. When the command has an argument, enter the command, a space and the argument, and then press the return key.

Table 3.1 Command List

Command	Function	Argument	Default	Compatible command name
tboot	Renesas Sub-GHz transceiver bootstrapping	Boot mode	---	---
tinit	Test function initialization and reset Renesas Sub-GHz transceiver	(None)	---	t1
tope	PHY operation mode setting	FSK/OFDM operation mode	Refer to Table 3.2	---
tch	Channel number setting	Channel number	9	t2
ttxpow	FSK and OFDM transmission output power setting	Transmission output power value (Index number)	FSK:-26 (-13.0dBm) OFDM:-24 (-12.0dBm) (*1)	t4
ttxpowd	FSK and OFDM transmission output power setting (dBm)	Transmission output power value (dBm)	FSK : -13.0 OFDM: -12.0 (dBm) (*1)	---
tftxpowd	FSK transmission output power setting (dBm)	FSK transmission output power value (dBm)	-13.0 (dBm) (*1)	---
totxpowd	OFDM transmission output power setting (dBm)	OFDM transmission output power value (dBm)	-12.0 (dBm) (*1)	---
tfrlen	Transmission packet length setting	Transmission packet length	20	t5
ti	Continuous transmission interval time setting	Continuous transmission interval time setting	2000 (usec)	---
ttxopt	Transmission option setting	Transmission option	0 (No CCA)	---
tsfd	FSK SFD mode setting	FSK SFD mode	0 (Mode 0)	---
tfpl	FSK Preamble length setting	FSK Preamble length	15	tpl
tdw	FSK Data whitening option setting	FSK Data whitening option	1 (Enabled)	---
tffcs	FSK FCS length setting	FSK FCS length	2 (16bit CRC)	tfcs
tfscheme	FSK FEC scheme setting	FSK FEC Scheme	0	---
tffecrx	FSK Reception packet FEC setting	FSK FEC setting	0	tfecrx
tofcs	OFDM FCS length setting	FSK FCS length (CRC bit width)	2 (16bit CRC)	---

tointl	OFDM Interleaving mode setting	Interleaving mode	0	---
toscr	OFDM Scrambler value setting	OFDM Scrambler value	0	---
tostf	OFDM STF length setting	OFDM STF length	4	---
tccam	CCA mode setting	CCA mode	0 (Mode1)	---
tfcdr	CCA duration setting for FSK	CCA duration for FSK	0xFFFF (auto)	tcdr
tfccavt	CCA level threshold for FSK	CCA level threshold value for FSK	0xFF5A (-83.0 dBm)	tccavt
tfccavtd	CCA level threshold for FSK in dBm	CCA level threshold value (dBm) for FSK	-83.0 (dBm)	---
tocdr	CCA duration setting for OFDM	CCA duration for OFDM	0xFFFF (auto)	---
toccavt	CCA level threshold for OFDM	CCA level threshold value for OFDM	0xFF5A (-83.0 dBm)	---
toccavtd	CCA level threshold for OFDM in dBm	CCA level threshold value (dBm) for OFDM	-83.0 (dBm)	---
tgpios	GPIO terminal setting	GPIO terminal function	GPIO0,1,2,6,7,8: Reserved (*1) GPIO3,4,5,9,10,11,12: Input port with pull-up register (*1)	---
tgpio	Get the current settings of the GPIO terminal	(None)	---	---
tgpioo	GPIO output port voltage level setting	GPIO output port voltage level	0	---
tgpioi	Get the GPIO input port voltage level	GPIO port number	---	---
tberlen	Frame length for RX BER setting	Frame length for RX BER	20	---
tberpn9	PN9 mode for BER setting	PN9 mode for BER	0	---
tffh	Frequency hopping transmission (FSK)	Setting for frequency hopping transmission	---	---
tofh	Frequency hopping transmission (OFDM)	Setting for frequency hopping transmission	---	---
ram	RAM read and write mode	read and write mode setting	---	---
reg	Register read and write mode	read and write mode setting	---	---
tftx	FSK Packet transmission	Number of transmissions	---	t6
totx	OFDM Packet transmission	Number of transmissions	---	---
tfpn9	FSK PN9 continuous modulated transmission	(None)	---	tpn
topn9	OFDM PN9 continuous modulated transmission	(None)	---	---
tnmtx	Continuous unmodulated transmission	(None)	---	t9
tfrx	FSK Packet reception	Reception option	---	t7
torx	OFDM Packet reception	Reception option	---	---
te	ED measurement	(None)	---	---
tcca	CCA execution	(None)	---	---
tmstxs	Tx setting for ModeSwitch & New Mode Frame	Setting option	---	---
tmstx	ModeSwitch & New Mode Frame transmission	Number of transmissions	---	---

tmsrxs	Rx setting for ModeSwitch & New Mode Frame	Setting option	---	---
tmsrx	ModeSwitch & New Mode Frame reception	Reception options	---	---
tttl	Regulation mode setting (Tx Total Time Limit, Max Tx Duration and Min Pause Duration Setting)	Regulation mode and parameters	OFF	---
tantdv	Antenna diversity setting	Enable / Disable	0 (Disable)	---
tantnum	Setting the number of antennas to use	Number of antennas	1　(*1)	---
tantsel	Setting the antenna number used for Tx / Rx	Antenna number	0 (Antenna 0)	---
trxgain	External Gain of Received Signal setting	External gain value for RF input signal	RP_USR_RF_RX_ EXTERNAL_GAIN (defined in r_phy_config.h)	---
trxgaind	External Gain of Received Signal setting in dB	External gain value (dB) for RF input signal	RP_USR_RF_RX_ EXTERNAL_GAIN (defined in r_phy_config.h)	---
twgain	FSK reception standby gain setting when using external LNA	FSK reception standby gain	RP_USR_AGC_ WAIT_GAIN_OFFSET (defined in r_phy_config.h)	---
tfreqo (TBD)	Frequency Offset setting	Correction value for channel frequency (Hz)	0	---
rst	Reset all (Test function, RF driver and Renesas Sub-GHz transceiver)	(None)	---	---
opt	Test function option setting	Display mode of Test function	1	---
val	Test function settings display	(None)	---	---
help	Command list display	(None)	---	---
tsleep	Sleep Mode Setting	(None)	---	---

*1 : This setting value is the setting of the R9A06G062 reference evaluation board. Since it depends on the specifications of each board, the initial value may differ depending on the firmware that supports the board.

Table 3.2 PHY Operation Mode default setting

modulation	default setting
FSK	domain: Japan phytype: FSK without FEC phymode: 2-FSK, 50kbps, m=1.0 ChanPlanID: 21
OFDM	domain: Japan phytype: Option4 phymode: MCS4 ChanPlanID: 21

3.2 Examples of the Command Input Sequence

3.2.1   Bootstrapping of the Renesas Sub-GHz transceiver

This section shows an example of executing the Sub-GHz transceiver reset and boot sequence by instructing the Sub-GHz transceiver to boot (boot mode 11, refer to Table 3.6).

command (and SetData[Dec])? >tboot 11 return key

(Use "tboot 11" for the R9A06G062 Reference Board.)

By executing this command, the screen shown in Figure 3-1 is displayed on the serial terminal software, and booting is completed.

Each item displayed in NowSetVal shows the current setting status for each command of this application.

```
command (and SetData[Dec])? >tboot 11
  RF Device booting ...
  Boot RF device: Normal mode (11) / Clock:Ext In / Ext clock out:ON / DCDC:ON
  Boot completed.

 NowSetVal:
  tope(FSK)  = domain:JP  phytype:2FSK w/o FEC  phymode:50Kbps M=1.0 #1b chplan:21 sp:200000[Hz] freq0:920600000[Hz]
  tope(OFDM) = domain:JP  phytype:OFDM Option4  phymode:MCS4           chplan:21 sp:200000[Hz] freq0:920600000[Hz]
  tch=9        tfrlen=20       ti=2000us       ttxopt=0       ttxpow= FSK:-13.0dBm  OFDM:-12.0dBm  BBFREQ=922400000
  tsfd=0       tfpl=15         tdw=1           tffcs=2        tfscheme=0      tffecrx=0       trxgain=128 (16.000dB)
  tofcs=2      tointl=0        toscr=0         tostf=4                        twgain=22       tfreqo=0
  tccam=0      tfcdr=0xFFFF    tfccavt=-83.0dBm               tocdr=0xFFFF    toccavt=-83.0dBm
  tberlen=20   tberpn9=0       tmstxs ccaoff   tttl OFF       tantdv=0        tantnum=1       tantsel=0
```

Figure 3-1 executing example of tboot command

3.2.2   Setting the PHY Operating Mode

This section shows an example in which the setting of the PHY operating mode.
(FSK modulation, Japan, FEC enabled, phymode=#2b, ChanPlanID=22)

command (and SetData[Dec])? >tope FSK JP FSKwFEC 2b 22 return key

APL ---> STACK set PhyOperatingMode Setvalue =FSK / JP / 2FSK with FEC / 100Kbps M=1.0 #2b / ChanPlan:22

3.2.3   Setting the Channel Number

Setting the Channel Number to 10 (0x0a)

command (and SetData[Dec])? >tch 10(or 0x0a) return key

3.2.4   Displaying a Received Frame in a Simple Format

This section shows an example in which the content of a received frame is displayed as data is received frame by frame.

(1) Put the receiving terminal in the "FSK packet reception" state.
command (and SetData[Dec])? >tfrx 0 return key
    APL ------> STACK FSK RX
        Now Receiving...   Freq = 924900000 [Hz]   // Receiving channel frequency (example)

(2) Transmit a packet from the transmitting terminal.
command (and SetData[Dec])? >tftx 1 return key
    APL ------> STACK FSK TX
        Now Sending...   Freq = 924900000 [Hz]   // Receiving channel frequency (example)

(3) The receiving terminal displays the content of the received frame.
    APL ------> STACK FSK RX
    Now Receiving...   Freq = 924900000 [Hz]

    Data Received (1)   // The number means the reception count from the start of reception
    modulation   :   0 (FSK)   // Modulation of the received frame (0:FSK, 1:OFDM)
    channel   :   25   // Channel currently used
    lqi   : 254   // LQI value of the received frame
    rssi   : -14.0 (dBm)   // RSSI value of the received frame
    antenna   :   0   // Receiving antenna (*1)
    length   :   30   // Received frame length (including FCS)
    status   : 0x00 (SUCCESS)   // Reception status - 0x00: reception success
                                        //   0x0E: FCS error
    RcvData(Hex)   :   // Received data (not including FCS)
    01,EC,12,FE,CA,02,00,00,00,00,00,00,00,02,00,00,
    00,00,00,00,00,15,16,17,18,19,1A,1B,

*1 When reception antenna diversity is disable, it always shows '0'.
   When reception antenna diversity is enabled, it shows antenna terminal number which corresponds to evaluation board specification (antenna diversity is not supported in this version).

3.2.5   Measuring the PER

This section shows an example in which the PER is measured by transmitting 1000 FSK packets.

(1) Put the receiving terminal in the "FSK packet reception" state.
command (and SetData[Dec])? > tfrx 18(or 0x12) return key

    APL ------> STACK FSK RX

        Now Receiving...   Freq = 924900000 [Hz]

(2) Transmit 1000 FSK packets from the transmitting terminal.
command (and SetData[Dec])? >tftx 1000 return key

    APL ------> STACK FSK TX

        Now Sending...   Freq = 924900000 [Hz]

        . . . .   // The one dot means that 100 packets have been sent.

(3) The measurement result of the receiving terminal is displayed.

When you press the return key to end the "packet reception state" after checking that 1000 packets have been transmitted, the following items are displayed (for details of the display items, see Table 3-2).

        Stop Receiving

  FSK TotalPckt= 999   OKPckt= 998   NGPckt= 1   (NowNG= 1)

  FSK RSSI(dBm)= -34.00 (Ave), -33.00 (Max), -35.00 (Min), 0.00 (Var), 998 (Count)

  FSK LQI   = 254.0 (Ave),   255 (Max),   253 (Min), 0.00 (Var), 998 (Count)

  ANT0 = 999, ANT1 = 0, ANT2 = 0, ANT3 = 0

Table 3.3 Details of the Items Displayed in the Measurement Result

Display item	Details	Remark
TotalPckt	Number of received packets	
OKPckt	Number of received packets without a CRC error	
NGPckt	Number of received packets with a CRC error	The value in (NowNG=) is undefined.
RSSI	Statistics (average, maximum, minimum, variance) and total number of measurement targets of RSSI value of the received packets (*1)	
LQI	Statistics (average, maximum, minimum, variance) and total number of measurement targets of LQI value of the received packets (*1)	This LQI value shows the result of the calculation algorithm of the sample code. If necessary, please change the algorithm.
ANT0 - ANT3	Receive count on each antenna that received a packet without CRC error	When the Antenna diversity is disabled, it is the antenna number selected by tantsel command.

*1: Only received packets without CRC error are targeted for measurement.

3.2.6   Example of the PER Calculation

In the PER calculation for the display example in 3.2.3, the denominator is the number of packets transmitted from the transmitting terminal (1000 packets) and the numerator is the number of packets received by the receiving terminal ((1000 - OKPckt (= 998)) = 2), as shown below.

PER = ((1000-OKPckt) / 1000) x 100 = (2 / 1000) x 100 = 0.2(%)

3.2.7   Measuring the BER

This section shows an example in which the BER is measured by transmitting 1000 FSK packets. To measure the BER, the frame length, data whitening option, and FCS length need to be the same for both the transmitting terminal and receiving terminal. In this example, the transmitting terminal continuously transmits PN9 data whose frame length is 64 bytes, for which data whitening is enabled, and whose FCS length is 2 bytes. If the receiving terminal receives any frame whose frame length is not 64 bytes, for which data whitening is disabled, or whose FCS length is not 2 bytes, it does not include that frame in the received frames because of a PHY header error and drops the frame (The bits of the frame are not counted as bit errors).

(1) For the receiving terminal, enable the PN9 mode for BER to define PN9 data as the expected value.
  command (and SetData[Dec])? >tberpn9 1 return key
(2) For the receiving terminal, specify 64 as the length of a frame to be received during the BER measurement, including the FCS length.
  command (and SetData[Dec])? >tberlen 64 return key
(3) For the receiving terminal, specify the length of an FSK FCS to be received during the BER measurement.
  command (and SetData[Dec])? >tffcs 2 return key
(4) For the receiving terminal, enable the FSK data whitening option for the BER measurement.
  command (and SetData[Dec])? >tdw 1 return key
(5) Put the receiving terminal in the "FSK packet reception" state.
  command (and SetData[Dec])? >tfrx 17(or 0x11) return key
          APL ------> STACK RX
              Now Receiving...   Freq = 924900000 [Hz]
(6) For the transmitting terminal, enable the PN9 mode for BER to transmit the PN9 data.
  command (and SetData[Dec])? >tberpn9 1 return key
(7) For the transmitting terminal, specify 64 as the frame length.
  command (and SetData[Dec])? >tfrlen 64 return key
(8) For the transmitting terminal, specify the FSK FCS length of the frames to be transmitted.
  command (and SetData[Dec])? >tffcs 2 return key
(9) For the transmitting terminal, enable the FSK data whitening option of the frames to be transmitted.

command (and SetData[Dec])? >tdw 1 return key

(10) Transmit 1000 FSK packets from the transmitting terminal.

command (and SetData[Dec])? >tftx 1000 return key

       APL ------> STACK TX

         Now Sending...   Freq = 924900000 [Hz]

(11) The measurement result of the receiving terminal is displayed.

  When you press the return key to end the "packet reception state" after checking that 1000 packets have been transmitted, the following items are displayed (for details of the display items, see Table 3.4).

    Stop Receiving

  FSK TotalPckt= 859   OKPckt= 474   NGPckt= 385   (NowNG= 385)
  FSK TotalBit = 00068050h OKBit = 00067C22h NGBit = 0000042Eh (NowNG= 0000042Eh) BER =0.25%
  FSK RSSI(dBm)= -112.80 (Ave), -108.50 (Max), -115.50 (Min), 2.11 (Var), 859 (Count)
  FSK LQI   =   0.0 (Ave),   0 (Max),   0 (Min), 0.00 (Var), 859 (Count)
  ANT0 = 859, ANT1 = 0, ANT2 = 0, ANT3 = 0

Table 3.4 Details of the Items Displayed in the Measurement Result

Display item	Details	Remark
TotalPckt	Number of received packets	
OKPckt	Number of received packets without a CRC error	
NGPckt	Number of received packets with a CRC error	The value in (NowNG=) is undefined.
TotalBit	Number of received bits	
OKBit	Number of bits matching the reference	
NGBit	Number of bits not matching the reference	
BER	Bit error rate ((NGBit / TotalBit) × 100)	The error rate is not displayed when the total number of received bits is less than 3000 bits.
RSSI	Statistics (average, maximum, minimum, variance) and total number of measurement targets of RSSI value of the received packets (*1)	
LQI	Statistics (average, maximum, minimum, variance) and total number of measurement targets of LQI value of the received packets (*1)	This LQI value shows the result of the calculation algorithm of the sample code. If necessary, please change the algorithm.
ANT0 - ANT3	Receive count on each antenna that received a packet without CRC error	When the Antenna diversity is disabled, it is the antenna number selected by tantsel command.

 *1: All received packets are measured regardless of the CRC check result.

3.2.8 Example of the BER Calculation

In the BER calculation for the display example in 3.2.5, the denominator is the total number of bits of the received packets (TotalBit) and the numerator is the number of bits that do not match the expected value (NGBit), as shown below.

Note that, since the PHY header and FCS are not compared with the expected value, they are not included in TotalBit, OKBit, or NGBit.

BER = (NGBit / TotalBit) × 100 = (42Eh / 67C22h) × 100 = 0.25(%)

3.2.9 Setting the Transmission Data (Expected Reception Data Value) Using the ram Command

This command is used to:
- Set the transmission data to be used when packets are transmitted by the tftx command / totx command with the PN9 mode for BER disabled.
- Set the expected reception data value to be used when the BER is measured by the tfrx 17 (0x11) command / torx 17 (0x11) command.

This section describes how to set the transmission data (expected reception data value) by using the ram command.

Set the transmission data (expected reception data value) in the RAM area from 0x000 to 0x7FC (the offset address is added by used MCU automatically). The PHY header and FCS are not included in the transmission data (expected reception data value).

(1) Set 0xff in the first byte of the transmission data (expected reception value data).
command (and SetData[Dec])? >ram -wB 0x00 0xff
    Address: Write Read
     0x0000: 0xFF 0xFF

(2) Set 0xfe in the second byte of the transmission data (expected reception value data).
command (and SetData[Dec])? >ram -w 0x01 0xfe
    Address: Write Read
     0x0001: 0xFE 0xFE

(3) Set 0xfc in the 2045th byte of the transmission data (expected reception value data).
command (and SetData[Dec])? >ram -w 0x7fc 0xfc
    Address: Write Read
     0x07FC: 0xFC 0xFC

3.2.10 About the PN9 Data

This section describes the PN9 data.

When the PN9 mode for BER setting is enabled using the tberpn9 command, the tftx command / totx command transmits PN9 data.

The PN9 data is repetitions of the 511-bit pattern shown in Figure 3-2 below.


```
11111111100000111101111100010111001100100000100101001110110100011110011111001
10110001010100100011100011011010101110001001100010001000000001000010001100001
00111001010101100001101111010011011100100010100001010110100111111011001001001
01101111110010011010100110011000000011000110010100011010010111111101000101100
01110101100101100111100011111011110100000110101101101110110000101101011111010
10101000000101000101011110010111011100000011100111010010011110101110101000100
00001100111000010111101101100110100001101111110000
```

Figure 3-2 PN9 Bit Pattern

Therefore, while the bit pattern shown above is transmitted as is for the 0th to 62nd bytes, the pattern is one bit short for the 63rd byte. In the most significant bit (511th bit) of the 63rd byte, the 0th bit of the PN9 data is set. For the subsequent bytes up to the 126th byte, the data sequence is shifted by one bit relative to the 0th to 62nd bytes. In the two most significant bits of the 127th byte, the 0th bit and the 1st bit of the PN9 data is set, and for the 128th to 190th bytes, the data sequence is shifted by two bits relative to the 0th to 62nd bytes. For the 511th and subsequent bytes, the data sequence returns to its original state.

Figure 3-2 below shows the 511 bytes of the PN9 data.

0xFF,0xC1,0xFB,0xE8,0x4C,0x90,0x72,0x8B,0xE7,0xB3,0x51,0x89,0x63,0xAB,0x23,0x23,
0x02,0x84,0x18,0x72,0xAA,0x61,0x2F,0x3B,0x51,0xA8,0xE5,0x37,0x49,0xFB,0xC9,0xCA,
0x0C,0x18,0x53,0x2C,0xFD,0x45,0xE3,0x9A,0xE6,0xF1,0x5D,0xB0,0xB6,0x1B,0xB4,0xBE,
0x2A,0x50,0xEA,0xE9,0x0E,0x9C,0x4B,0x5E,0x57,0x24,0xCC,0xA1,0xB7,0x59,0xB8,0x87,
0xFF,0xE0,0x7D,0x74,0x26,0x48,0xB9,0xC5,0xF3,0xD9,0xA8,0xC4,0xB1,0xD5,0x91,0x11,
0x01,0x42,0x0C,0x39,0xD5,0xB0,0x97,0x9D,0x28,0xD4,0xF2,0x9B,0xA4,0xFD,0x64,0x65,
0x06,0x8C,0x29,0x96,0xFE,0xA2,0x71,0x4D,0xF3,0xF8,0x2E,0x58,0xDB,0x0D,0x5A,0x5F,
0x15,0x28,0xF5,0x74,0x07,0xCE,0x25,0xAF,0x2B,0x12,0xE6,0xD0,0xDB,0x2C,0xDC,0xC3,
0x7F,0xF0,0x3E,0x3A,0x13,0xA4,0xDC,0xE2,0xF9,0x6C,0x54,0xE2,0xD8,0xEA,0xC8,0x88,
0x00,0x21,0x86,0x9C,0x6A,0xD8,0xCB,0x4E,0x14,0x6A,0xF9,0x4D,0xD2,0x7E,0xB2,0x32,
0x03,0xC6,0x14,0x4B,0x7F,0xD1,0xB8,0xA6,0x79,0x7C,0x17,0xAC,0xED,0x06,0xAD,0xAF,
0x0A,0x94,0x7A,0xBA,0x03,0xE7,0x92,0xD7,0x15,0x09,0x73,0xE8,0x6D,0x16,0xEE,0xE1,
0x3F,0x78,0x1F,0x9D,0x09,0x52,0x6E,0xF1,0x7C,0x36,0x2A,0x71,0x6C,0x75,0x64,0x44,
0x80,0x10,0x43,0x4E,0x35,0xEC,0x65,0x27,0x0A,0xB5,0xFC,0x26,0x69,0x3F,0x59,0x99,
0x01,0x63,0x8A,0xA5,0xBF,0x68,0x5C,0xD3,0x3C,0xBE,0x0B,0xD6,0x76,0x83,0xD6,0x57,
0x05,0x4A,0x3D,0xDD,0x81,0x73,0xC9,0xEB,0x8A,0x84,0x39,0xF4,0x36,0x0B,0xF7,0xF0,
0x1F,0xBC,0x8F,0xCE,0x04,0x29,0xB7,0x78,0x3E,0x1B,0x95,0x38,0xB6,0x3A,0x32,0x22,
0x40,0x88,0x21,0xA7,0x1A,0xF6,0xB2,0x13,0x85,0x5A,0x7E,0x93,0xB4,0x9F,0xAC,0xCC,

```
0x80,0x31,0xC5,0xD2,0x5F,0x34,0xAE,0x69,0x1E,0xDF,0x05,0x6B,0xBB,0x41,0xEB,0xAB,
0x02,0xA5,0x9E,0xEE,0xC0,0xB9,0xE4,0x75,0x45,0xC2,0x1C,0x7A,0x9B,0x85,0x7B,0xF8,
0x0F,0xDE,0x47,0x67,0x82,0x94,0x5B,0x3C,0x9F,0x8D,0x4A,0x1C,0x5B,0x1D,0x19,0x11,
0x20,0xC4,0x90,0x53,0x0D,0x7B,0xD9,0x89,0x42,0x2D,0xBF,0x49,0xDA,0x4F,0x56,0x66,
0xC0,0x98,0x62,0xE9,0x2F,0x1A,0xD7,0x34,0x8F,0xEF,0x82,0xB5,0xDD,0xA0,0xF5,0x55,
0x81,0x52,0x4F,0x77,0xE0,0x5C,0xF2,0xBA,0x22,0x61,0x0E,0xBD,0xCD,0xC2,0x3D,0xFC,
0x07,0xEF,0xA3,0x33,0x41,0xCA,0x2D,0x9E,0xCF,0x46,0x25,0x8E,0xAD,0x8E,0x8C,0x08,
0x10,0x62,0xC8,0xA9,0x86,0xBD,0xEC,0x44,0xA1,0x96,0xDF,0x24,0xED,0x27,0x2B,0x33,
0x60,0x4C,0xB1,0xF4,0x17,0x8D,0x6B,0x9A,0xC7,0x77,0xC1,0xDA,0x6E,0xD0,0xFA,0xAA,
0x40,0xA9,0xA7,0x3B,0x70,0x2E,0x79,0x5D,0x91,0x30,0x87,0xDE,0x66,0xE1,0x1E,0xFE,
0x83,0xF7,0xD1,0x99,0x20,0xE5,0x16,0xCF,0x67,0xA3,0x12,0xC7,0x56,0x47,0x46,0x04,
0x08,0x31,0xE4,0x54,0xC3,0x5E,0x76,0xA2,0x50,0xCB,0x6F,0x92,0xF6,0x93,0x95,0x19,
0x30,0xA6,0x58,0xFA,0x8B,0xC6,0x35,0xCD,0xE3,0xBB,0x60,0x6D,0x37,0x68,0x7D,0x55,
0xA0,0xD4,0xD3,0x1D,0x38,0x97,0xBC,0xAE,0x48,0x98,0x43,0x6F,0xB3,0x70,0x0F,
```

Figure 3-3 PN9 Data

3.3 Command Description

3.3.1 Bootstrapping of the Renesas Sub-GHz transceiver

Table 3.5 Description of the tboot Command

Command	tboot (compatible name: tb)
Argument	Boot mode (Refer to Table 3.6)
Function	This command initializes the test function, execute the hardware reset of the Sub-GHz transceiver, and execute the start procedure of the Sub-GHz transceiver to transit to the IDLE state with the specified boot mode. Please be sure to execute this command first after starting this application. It can also execute by "tb". If executed with no arguments, it displays help for this command.
Notice	Specify the boot mode that matches using reference evaluation board. Please note that if you specify a different mode, it will not operate normally, such as stopping operation and not starting. Specify boot mode 11 when using the following reference evaluation boards: RTK0EE0013D10001BJ, RTK0EE0013D10002BJ, RTK0EE0013D10003BJ

Table 3.6 Argument of the tboot command

Boot mode	Functional behavior		
	RF reference clock	CKOUT output	Setting of the DDC
0 (0x00)	Crystal resonator	Disable	Disable
1 (0x01)			Enable
2 (0x02)		Enable	Disable
3 (0x03)			Enable
8 (0x08)	External clock	Disable	Disable
9 (0x09)			Enable
10 (0x0A)		Enable	Disable
11 (0x0B)			Enable

3.3.2 Test Function Initialization

Table 3.7 Description of the tinit Command

Command	tinit (compatible name: t1)
Argument	None
Function	This command initializes the test function, execute the hardware reset of the Sub-GHz transceiver and execute the start procedure of the Sub-GHz transceiver to transit to the IDLE state with the specified boot mode in tboot command. Execute this command if necessary. Note that after completing booting with the tboot command, it is not necessary to execute this command because it is in an initialized state.
Notice	-

3.3.3 PHY Operation Mode Setting

Table 3.8 Description of the tope command

Command	tope

Argument	PHY Operation mode（Sub-GHz transceiver transmission and reception mode）
	① tope [modulation] [domain (NS/JP/EU/JP)] [phytype] [phymode] [ChanPlanID]
	② tope [modulation][domain (UD)] [phytype] [phymode] [chspace] [chfreq0]
	
	[ ] in the following indicates the abbreviated name when it can be specified.
	Refer to Table 3.9, Table 3.10 and Table 3.12 for combination of each argument.
	
	modulation: FSK, OFDM
	domain: EU：Europe (863-876MHz)
	            NA：North America (902-928MHz)
	            BZ：Brazil (902-907.5MHz & 915-928MHz)
	            JP：Japan (920-928MHz)
	            UD：User define
	phytype: FSKwoFEC [f] : FSK without FEC
	            FSKwFEC [ff] : FSK with FEC
	            OFDMOP1 [op1] : OFDM Option1
	            OFDMOP2 [op2] : OFDM Option2
	            OFDMOP3 [op3] : OFDM Option3
	            OFDMOP4 [op4] : OFDM Option4
	phymode (phytype=FSK):
	            1a： 2-FSK, Data rate 50kbps, Modulation Index =0.5
	            1b： 2-FSK, 50kbps, m=1.0
	            2a： 2-FSK, 100kbps, m=0.5
	            2b： 2-FSK, 100kbps, m=1.0
	             3： 2-FSK, 150kbps, m=0.5
	            4a： 2-FSK, 200kbps, m=0.5
	            4b： 2-FSK, 200kbps, m=1.0
	            10a： 2-FSK, 10kbps, m=0.5
	            10b： 2-FSK, 10kbps, m=1.0
	            20a： 2-FSK, 20kbps, m=0.5
	            20b： 2-FSK, 20kbps, m=1.0
	phymode (phytype=OFDM):
	            MCS0 to MCS6 [m0 to m6] : MCS0 to MCS6
	ChanPlanID: (Cannot be specified when domain=UD)
	            1 to 5, 21 to 24, 32 to 37 (refer to Table 3.11)
	chspace: (Valid only when domain=UD)
	            Channel spacing frequency (unit: Hz)
	            10,000-10,000,000 (10K-10000KHz)
	chfreq0: (Valid only when domain=UD)
	             Center frequency of Channel0 (unit: Hz)
	            100,000,000-1,000,000,000 (100M-1000MHz)
	
	Argument is omitted: ERROR, Out-of-range value: ERROR

Function	This command sets the PHY Operation mode（Sub-GHz transceiver transmission and reception mode）. Set this option before data is transmitted and received. Each operation of FSK and OFDM can be set independently. However, since the channel plan, channel spacing frequency, and channel0 center frequency settings are shared by FSK and OFDM, the last specified contents are applied to both. When performing simultaneous standby for FSK and OFDM (when executing reception using the tforx command), set the FSK and OFDM channel spacing frequency and channel top frequency to be the same. Refer to Table 3.9, Table 3.10 and Table 3.12 for combination of each argument.
Notice	After executing this command, be sure to use the tch command to specify the channel to transmit and receive data.

Table 3.9 The argument combination of tope command (FSK, domain = EU/NA/BZ/JP)

Argument of tope command					Operating mode (Argument combination is based on Wi-SUN PHY Specification)			
modulation	domain	phytype	phymode	Chan PlanID	FSK Modulation	Data Rate	Modulation Index	ChanPlanName
FSK	EU (863-876MHz)	FSKwoFEC / FSKwFEC	1a	32	2-FSK	50Kbps	0.5	863_870_100
				34				870_876_100
				36				863_876_100
			2a	33	2-FSK	100Kbps	0.5	863_870_200
				35				870_876_200
				37				863_876_200
			3	33	2-FSK	150Kbps	0.5	863_870_200
				35				870_876_200
				37				863_876_200
	NA (902-928MHz)	FSKwoFEC / FSKwFEC	1b	1	2-FSK	50Kbps	1.0	902_928_200
			2a	1	2-FSK	100Kbps	0.5	902_928_200
			3	2	2-FSK	150Kbps	0.5	902_928_400
			4a	2	2-FSK	200Kbps	0.5	902_928_400
	BZ (902-907.5MHz, 915-928MHz)	FSKwoFEC / FSKwFEC	1b	1	2-FSK	50Kbps	1.0	902_928_200
			2a	1	2-FSK	100Kbps	0.5	902_928_200
			3	2	2-FSK	150Kbps	0.5	902_928_400
			4a	2	2-FSK	200Kbps	0.5	902_928_400
	JP (920-928MHz)	FSKwoFEC / FSKwFEC	1b	21	2-FSK	50Kbps	1.0	920_928_200
			2b	22	2-FSK	100Kbps	1.0	920_928_400
			3	22	2-FSK	150Kbps	0.5	920_928_400
			4b	23	2-FSK	200Kbps	1.0	920_928_600

Table 3.10 The argument combination of tope command (OFDM, domain = EU/NA/BZ/JP)

Argument of tope command					Operating mode (Argument combination is based on Wi-SUN PHY Specification)	
modulation	domain	phytype	phymode	Chan PlanID	OFDM Mode	ChanPlanName
OFDM	EU (863-876MHz)	OFDMOP4	MCS4 to MCS6	33	Option4, MCS4 to MCS6	863_870_200
				35		870_876_200
				37		863_876_200
	NA (902-928MHz)	OFDMOP4	MCS4 to MCS6	1	Option4, MCS4 to MCS6	902_928_200
		OFDMOP3	MCS4 to MCS6	2	Option3, MCS4 to MCS6	902_928_400
		OFDMOP2	MCS3 to MCS6	4	Option2, MCS3 to MCS6	902_928_800
		OFDMOP1	MCS2 to MCS6	5	Option1, MCS2 to MCS6	902_928_1200
	BZ (902-907.5MHz, 915-928MHz)	OFDMOP4	MCS4 to MCS6	1	Option4, MCS4 to MCS6	902_928_200
		OFDMOP3	MCS4 to MCS6	2	Option3, MCS4 to MCS6	902_928_400
		OFDMOP2	MCS3 to MCS6	4	Option2, MCS3 to MCS6	902_928_800
		OFDMOP1	MCS2 to MCS6	5	Option1, MCS2 to MCS6	902_928_1200
	JP (920-928MHz)	OFDMOP4	MCS4 to MCS6	21	Option4, MCS4 to MCS6	920_928_200
		OFDMOP3	MCS4 to MCS6	22	Option3, MCS4 to MCS6	920_928_400
		OFDMOP2	MCS3 to MCS6	24	Option2, MCS3 to MCS6	920_928_800

Table 3.11 The supported frequencies and channels by ChanPlanID
(Defined in Wi-SUN PHY TPS)

Regulatory Domain	Chan PlanID	ChanPlanName	Chan Spacing (MHz)	Chan Center Freq0 (MHz)	Total Num Chan	Channel Mask [1]	usable channel
EU (863-876MHz)	32	863_870_100	0.1	863.1	69	00:00:00:00:00:00:80:E1:E6	ch0-54, 57-60, 64, 67-68 (ch0-68)[2]
	33	863_870_200	0.2	863.1	35	00:00:00:D8:FB	ch0-26, 29, 34 (ch0-34)[2]
	34	870_876_100	0.1	870.1	55	00:00:00:00:00:00:80	ch0-54
	35	870_876_200	0.2	870.2	27	00:00:00:F8	ch0-26
	36	863_876_100	0.1	863.1	125	00:00:00:00:00:00:80:E1:06 :00:00:00:00:00:00:E0	ch0-54, 57-60, 64, 67-124 (ch0-124)[2]
	37	863_876_200	0.2	863.1	62	00:00:00:D8:03:00:00:C0	ch0-26, 29, 34-61 (ch0-61)[2]
NA (902-928MHz)	1	902_928_200	0.2	902.2	129	00:00:00:00:00:00:00:00:00: 00:00:00:00:00:00:00:FE	ch0-128
	2	902_928_400	0.4	902.4	64	00:00:00:00:00:00:00:00	ch0-63
	4	902_928_800	0.8	902.8	32	00:00:00:00	ch0-31
	5	902_928_1200	1.2	903.2	21	00:00:E0	ch0-20
BZ (902-907.5MHz, 915-928MHz)	1	902_928_200	0.2	902.2	90	00:00:00:FC:FF:FF:FF:FF:01: 00:00:00:00:00:00:00:FE	ch0-25, 65-128 (ch0-128)[2]
	2	902_928_400	0.4	902.4	43	00:F0:FF:FF:01:00:00:00	ch0-11, 33-63 (ch0-63)[2]
	4	902_928_800	0.8	902.8	22	C0:FF:00:00	ch0-5, 16-31 (ch0-31)[2]
	5	902_928_1200	1.2	903.2	13	F8:07:E0	ch0-2, 11-20 (ch0-20)[2]
JP (920-928MHz)	21	920_928_200	0.2	920.6	29	FF:01:00:00:C0	ch9-37 (ch0-37)[2]
	22	920_928_400	0.4	920.9	14	0F:00:FC	ch4-17 (ch0-17)[2]
	23	920_928_600	0.6	920.8	9	07:F0	ch3-11 (ch0-11)[2]
	24	920_928_800	0.8	921.1	7	03:FE	ch2-8 (ch0-8)[2]

*1: Refer to Figure 3-6 Channel Mask Example

*2: This application allows using all channels.

Table 3.12 The argument combination of tope command (FSK/OFDM, domain = UD)

tope command argument					
modulation	domain	phytype	phymode	chspace (Hz)	chfreq0 (Hz)
FSK	UD	FSKwoFEC / FSKwFEC	any	10,000 to 10,000,000	100,000,000 to 1000,000,000
OFDM		OFDMOP1 to OFDMOP4	MCS0 to MCS6		

3.3.4   Channel Number Setting

Table 3.13 Description of the tch command

Command	tch (compatible name: t2)

Argument	Channel Number
	
	Range: Depending on the argument (domain) of the tope command, the specified range
	          is as follows.
	          The tope command (domain=EU/NA/BZ/JP) is specified:
	              Refer to "usable channel" in Table 3.11. and 3.4 Channel number setting list.
	          The tope command (domain=UD) is specified:
	              0 to 254 (0x00 to 0xFE) (ch0 to ch254)
	Default: 9 (0x09) (ch9)
	Argument is omitted: ERROR, Out-of-range value: Setting prohibited

Function	This command sets the channel number. Set this option before data is transmitted and received.
Notice	Before setting this command, it's necessary to set the command of 3.3.3 PHY Operation Mode Setting.

3.3.5   FSK and OFDM transmission Output Power Setting

Table 3.14 Description of the ttxpow command

Command	ttxpow (compatible name: t4)

Argument	FSK and OFDM transmission output level
	Range (FSK) : -41 to -35 (0xD7 to 0xDD) (Fixed at -17.0 [dBm])
	                      -34 to +32 (0xDE to 0x20) (-17.0 to +16.0 [dBm], Unit: 0.5dBm)
	                      +33 to +35 (0x21 to 0x23) (Fixed at +16.0 [dBm])
	Range (OFDM): -41 to +35 (0xD7 to 0x23) (-20.5 to +17.5 [dBm] , Unit: 0.5dBm)
	Default: FSK:-26 (0xE6) (-13.0 [dBm]), OFDM:-24 (0xE8) (-12.0 [dBm])
	Argument is omitted: ERROR, Out-of-range value: Setting prohibited

Function	This command sets the FSK and OFDM transmission output level. Set this option before data is transmitted and received.
Notice	-

3.3.6   FSK and OFDM transmission Output Power Setting in dBm

Table 3.15 Description of the ttxpowd command

Command	ttxpowd

Argument	FSK and OFDM transmission output level in dBm value
	Range (FSK) : -17.0 to +16.0 [dBm] (Unit: 0.5dBm)
	                             (If specified value is less than -17.0, the set value is fixed at -17.0.
	                              If more than +16.0, the set value is fixed at +16.0.)
	Range (OFDM): -20.5 to +17.5 [dBm] (Unit: 0.5dBm)
	Default: FSK: -13.0 [dBm], OFDM: -12.0 [dBm]
	Argument is omitted: ERROR, Out-of-range value: Setting prohibited

Function	This command sets the FSK and OFDM transmission output level in dBm value. Set this option before data is transmitted and received.
Notice	-

3.3.7   FSK transmission Output Power Setting in dBm

Table 3.16 Description of the tftxpowd command

Command	Tftxpowd
Argument	FSK transmission output level in dBm value Range: -17.0 to +16.0 [dBm] (Unit: 0.5dBm) Default: -13.0 [dBm] Argument is omitted: ERROR, Out-of-range value: Setting prohibited
Function	This command sets only FSK transmission output level in dBm value. Set this option before data is transmitted and received.
Notice	-

3.3.8   OFDM transmission Output Power Setting in dBm

Table 3.17 Description of the totxpowd command

Command	Totxpowd
Argument	OFDM transmission output level in dBm value Range: -20.5 to +17.5 [dBm] (Unit: 0.5dBm) Default: -12.0 [dBm] Argument is omitted: ERROR, Out-of-range value: Setting prohibited
Function	This command sets only OFDM transmission output level in dBm value. Set this option before data is transmitted and received.
Notice	-

3.3.9   External Gain of Received Signal setting

Table 3.18 Description of the trxgain command

Command	trxgain
Argument	External gain value for RF input signal of Sub-GHz transceiver. Range: -256 to 255 (0xFF00 to 0x00FF) (-32.000 to +31.875 [dB], Unit: 0.125dB) Default: According to the RF driver specifications (corresponds to the specified value of RP_USR_RF_RX_EXTERNAL_GAIN defined in RF driver r_phy_config.h) Argument is omitted: ERROR, Out-of-range value: Setting prohibited
Function	When inserting an external FEM, etc. between the receiving antenna and the RF input of the Sub-GHz transceiver, the RSSI value shown in the frame reception result and ED result are corrected according to the inserted total gain value specified by this command. In addition, each FSK and OFDM CCA is performed for the received signal level after correction with the specified value of this command.
Notice	-

3.3.10 External gain of received signal setting in dB

Table 3.19 Description of the trxgaind command

Command	trxgaind
Argument	External gain value in dB for RF input signal of Sub-GHz transceiver. Range: -32.000 to +31.875 [dB] (Unit: 0.125dB) Default: According to the RF driver specifications (corresponds to the specified value of RP_USR_RF_RX_EXTERNAL_GAIN defined in RF driver r_phy_config.h) Argument is omitted: ERROR, Out-of-range value: Setting prohibited
Function	When inserting an external FEM, etc. between the receiving antenna and the RF input of the Sub-GHz transceiver, the RSSI value shown in the frame reception result and ED result are corrected according to the inserted total gain value specified by this command. In addition, each FSK and OFDM CCA is performed for the received signal level after correction with the specified value of this command.
Notice	-

3.3.11 FSK Rx Wait Gain Offset setting

Table 3.20 Description of the twgain command

Command	twgain
Argument	FSK RX waiting gain adjustment when using external LNA. Range: 0 to 31 (0x00 to 0x1F) [dB] Default: According to the RF driver specifications (corresponds to the specified value of RP_USR_AGC_WAIT_GAIN_OFFSET defined in RF driver r_phy_config.h) Argument is omitted: ERROR, Out-of-range value: Setting prohibited
Function	FSK RX waiting gain adjustment when using external LNA. If no LNA is used, this value should be set to zero.
Notice	- Specify the setting value as necessary according to the external hardware specifications of the Sub-GHz transceiver such as the hardware configuration of the evaluation board. For details on the setting values, refer to the evaluation board specifications.

3.3.12 Frequency Offset setting (TBD)

Table 3.21 Description of the tfreqo command

Command	tfreqo
Argument	Correction value for channel frequency. Range: -131072 to +131071 (0xFFFE0000 to 0x0001FFFF) [Hz] Default: 0 Argument is omitted: ERROR, Out-of-range value: Setting prohibited
Function	The set value is used to correct the channel frequency during transmission and reception. Set 0 when not correcting.
Notice	-

3.3.13 Transmission Packet Length Setting

Table 3.22 Description of the tfrlen command

Command	tfrlen (compatible name: t5)
Argument	Transmission packet length Range: 3 to 2047 (0x05 to 0x7FF) (unit: byte) (When FCS size is 2byte) 5 to 2047 (0x05 to 0x7FF) (unit: byte) (When FCS size is 4byte) Default: 20 (0x14) Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the transmission packet length. Set this option before data is transmitted and received. Set the length including the FCS (2 or 4 bytes).
Notice	Please note that the minimum number of available setting is depend on the FCS size. If set the minimum value equal to 3 and send a packet with FCS size = 4, the frame length of the transmission packet will be forced to change to 5 bytes.

3.3.14 Continuous Transmission Interval Time Setting

Table 3.23 Description of the ti command

Command	ti
Argument	Continuous transmission interval time setting Range: 0 to 60,000,000 (0x0 to 0x3938700) (unit: µsec) Default: 2,000 (0x07D0) Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets a transmission interval time. It is used when a packet is transmitted multiple times. Set this option before data is transmitted and received.
Notice	Please note that if the specified time is set to 0 or near the minimum value, the processing time of the RF driver by the MCU will be added from the transmission request to the actual transmission start, so the specified time will not be the transmission interval.

3.3.15 Transmission Option Setting

Table 3.24 Description of the ttxopt command

Command	ttxopt
Argument	Transmission option 0: When the packet transmitted, CCA is NOT executed. 1: When the packet transmitted, CCA is executed. Default: 0 Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets transmission option. Set this option before data is transmitted and received.
Notice	-

3.3.16 FSK SFD Mode Setting

Table 3.25 Description of the tfsfd command

Command	tfsfd (compatible name: tsfd)
Argument	FSK SFD Mode setting 0: SFD mode 0 1: SFD mode 1 Default: 0 Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the SFD mode. Set this option before FSK data is transmitted and received.
Notice	-

Table 3.26 Arguments set of tsfd command

SFD mode	Modulation method	FEC	SFD value
0 (0x00)	2GFSK	Disable	0x7209
		Enable	0x72F6
1 (0x01)	2GFSK	Disable	0x705E
		Enable	0xB4C6

3.3.17 FSK Preamble Length Setting

Table 3.27 Description of the tfpl command

Command	tfpl (compatible name: tpl)
Argument	FSK Preamble length Range: 4 to 1000 (0x0004 to 0x03E8) (unit: byte) Default: 15 (0x000F) Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command set the preamble length. Set this option before FSK data is transmitted and received.
Notice	-

3.3.18 FSK Data Whitening Option

Table 3.28 Description of the tdw command

Command	tdw
Argument	FSK Data whitening option 0: Data whitening disabled 1: Data whitening enabled Default: 1 Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the data whitening option. Set this option before FSK data is transmitted and received.
Notice	-

3.3.19 FSK FCS Length Setting

Table 3.29 Description of the tffcs command

Command	tffcs (compatible name: tffcs)
Argument	FSK FCS length Range: 2, 4 (unit: byte) Default: 2 Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the FSK FCS length. Set this option before FSK data is transmitted.
Notice	-

3.3.20 FSK FEC Scheme Setting

Table 3.30 Description of the tfscheme command

Command	tfscheme
Argument	FSK FEC Scheme setting 0: NRNSC 1: RSC Default: 0 Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets FEC scheme option. Set this option before FSK data is transmitted and received.
Notice	-

3.3.21 Reception Packet FEC Setting

Table 3.31 Description of the tffecrx command

Command	tffecrx (compatible name: tfecrx)
Argument	FEC setting when FSK reception 0: Disable the automatic discrimination of FEC packet 1: Enable the automatic discrimination of FEC packet Default: 0 Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets enable or disable of the automatic discrimination of FEC packet when FSK with FEC enabled is specified in the tope command. When is the enable of the automatic discrimination, hardware automatically determines whether FEC is applied or not of the received packet, so it can receive both packets. Set this option before FSK data is transmitted and received.
Notice	-

3.3.22 OFDM FCS Length Setting

Table 3.32 Description of the tofcs command

Command	tofcs
Argument	OFDM FCS length Range: 2, 4 (unit: byte) Default: 2 Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the OFDM FCS length. Set this option before OFDM data is transmitted and received.
Notice	-

3.3.23 OFDM Interleaving Mode Setting

Table 3.33 Description of the tointl command

Command	tointl
Argument	OFDM Interleaving mode 0: The interleaving depth is one symbol 1: The interleaving depth of the number of symbols equal to the frequency domain spreading factor Default: 0 Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the OFDM Interleaving mode. Set this option before OFDM data is transmitted and received.
Notice	-

3.3.24 OFDM Scrambler Value Setting

Table 3.34 Description of the toscr command

Command	toscr
Argument	OFDM Scrambler value Range: 0 to 3 (0x00 to 0x03) Default: 0 Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the Scrambler value of the OFDM frame. Specified value is set to the Scrambler field (2bit) in the PHR of the OFDM frame. Set this option before OFDM data is transmitted and received.
Notice	-

3.3.25 OFDM STF Length Setting

Table 3.35 Description of the tostf command

Command	tostf
Argument	OFDM STF length Range: 4 to 259 (0x0004 to 0x0103) (Option1,2,3 case) 4 to 258 (0x0004 to 0x0102) (Option4 case, even number only) Default: 4 (0x0004) Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the OFDM STF length (STF Symbols), and the STF length assumed to be included in the received frame when receiving OFDM. Set this option before OFDM data is transmitted and received.
Notice	- For Option4, set an even value (odd values are prohibited). - Normally use the default setting (4). Change the setting with this command when changing the STF length for a specific purpose.

3.3.26 CCA Mode Setting

Table 3.36 Description of the tccam command

Command	tccam
Argument	CCA Mode 0: Mode1 (Energy above CCA level threshold) 1: Mode2 (Carrier sense only) 2: Mode1 or Mode2 (Carrier sense or energy above CCA level threshold) 3: Mode1 & Mode2 (Carrier sense with energy above CCA level threshold) Default: 0 (Mode 1) Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the CCA Mode. Set this option before data is transmitted and received.
Notice	-

3.3.27 FSK ED/CCA Duration Setting

Table 3.37 Description of the tfcdr command

Command	tfcdr (compatible name: tcdr)

Argument	FSK ED/CCA duration
	
	Range: 100 to 20,000 (0x0064 to 0x4E20) (unit: µsec, In 10usec increments) or 0xFFFF
	
	  When 0xFFFF is specified, the CCA and ED operating periods are automatically set by
	  RF driver based on the following conditions:
	  CCA:
	   – The CCA duration is set based on ARIB if any of under the following conditions:
	    -- tope command option (modulation=FSK and domain=JP) is specified.
	    -- tope command option (modulation=FSK and domain=UD),
	      tttl command option (regulatory_mode=JP), and the center frequency is
	      920.5MHz or more and less than 928.1MHz are all specified.
	   - For conditions other than above, the CCA duration which a 160 µsec signal can be
	    detected is set.
	  ED:
	   - For the ED, the ED duration is set according to the operating conditions.
	
	Default: 0xFFFF
	Argument is omitted: ERROR, Out-of-range value: ERROR

Function	- This command sets the CCA duration for FSK condition. Set this option before FSK data
	  transmission with CCA, ED and CCA.
	- See Table 3.38 for recommended settings. Regarding the ED value shown here, it is the
	  minimum value. Please specify the value greater than or equal to this value.
	- When 0xFFFF is specified, the settings in Table 3.38 are applied according to the
	  operating conditions.

Notice	The specified value can be specified in increments of 10usec. Fraction values less than 10 is rounded down.

Table 3.38 Recommended settings of tfcdr command

tope phytype (FSK)	datarate, modulation index	Recommended setting of tfcdr command for CCA			Recommended setting of tfcdr command for ED (minimum value)
		Target CCA period = 128[us]	Target CCA period = 160[us]	Target CCA period = 5000[us]	
10a	10kbps,m=0.5	1420	1450	6290	1750
10b	10kbps,m=1.0	1420	1450	6290	1750
20a	20kbps,m=0.5	810	840	5680	930
10b	20kbps,m=1.0	810	840	5680	930
1a	50kbps,m=0.5	440	470	5310	440
1b	50kbps,m=1.0	440	470	5310	440
2a	100kbps,m=0.5	400	430	5270	300
2b	100kbps,m=1.0	400	430	5270	300
3	150kbps,m=0.5	340	370	5210	190
4a	200kbps,m=0.5	290	320	5160	170
4b	200kbps,m=1.0	290	320	5160	170

3.3.28 FSK CCA Level Threshold Setting

Table 3.39 Description of the tfccavt command

Command	tfccavt (compatible name: tccavt)
Argument	FSK CCA Level Threshold Range: -512 to 0 (0xFE00 to 0x0000) (-256.0 to 0.0 [dBm]) (unit: 0.5dBm) Default: -166 (0xFF5A) (-83.0 [dBm]) Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the CCA level threshold for FSK condition. Set this option before FSK data is transmitted and received.
Notice	-

3.3.29 FSK CCA Level Threshold Setting in dBm

Table 3.40 Description of the tfccavtd command

Command	tfccavtd
Argument	FSK CCA Level Threshold in dBm value Range: -256.0 to 0.0 [dBm] (unit: 0.5dBm) Default: -83.0 [dBm] Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the CCA level threshold in dBm value for FSK condition. Set this option before FSK data is transmitted and received.
Notice	-

3.3.30 OFDM ED/CCA Duration Setting

Table 3.41 Description of the tocdr command

Command	tocdr

Argument	OFDM ED/CCA duration
	Range: 100 to 20,000 (0x0064 to 0x4E20) (unit: μsec, In 10usec increments) or 0xFFFF
	   When 0xFFFF is specified, the CCA and ED operating periods are automatically set by
	   RF driver based on the following conditions:
	   CCA:
	     – The CCA duration is set based on ARIB if any of under the following conditions:
	       -- tope command option (modulation=OFDM and domain=JP) is specified.
	       -- tope command option (modulation=OFDM and domain=UD),
	         tttl command option (regulatory_mode=JP), and the center frequency is
	         920.5MHz or more and less than 928.1MHz are all specified.
	     - For conditions other than above, the CCA duration which a 160 μsec signal can be
	      detected is set.
	   ED:
	     - For the ED, the ED duration is set according to the operating conditions.
	
	   Default: 0xFFFF
	   Argument is omitted: ERROR, Out-of-range value: ERROR

Function	- This command sets the CCA duration for OFDM condition. Set this option before OFDM
	  data transmission with CCA, ED and CCA.
	- See Table 3.42 for recommended settings. Regarding the ED value shown here, it is the
	  minimum value. Please specify the value greater than or equal to this value.
	- When 0xFFFF is specified, the settings in Table 3.42 are applied according to the
	  operating conditions.

Notice	The specified value can be specified in increments of 10usec. Fraction values less than 10 is rounded down.

Table 3.42 Recommended settings of tocdr command

tope phytype (OFDM)	OFDM Option	Recommended setting of tocdr command for CCA			Recommended setting of tocdr command for ED (minimum value)
		Target CCA period =128[us]	Target CCA period =160[us]	Target CCA period =5000[us]	
OFDMOP1	Option 1	520	550	5390	450
OFDMOP2	Option 2	450	480	5320	360
OFDMOP3	Option 3	470	500	5340	450
OFDMOP4	Option 4	480	510	5350	650

3.3.31 OFDM CCA Level Threshold Setting

Table 3.43 Description of the toccavt command

Command	toccavt
Argument	OFDM CCA Level Threshold Range: -512 to 0 (0xFE00 to 0x0000) (-256.0 to 0.0 [dBm]) (unit: 0.5dBm) Default: -166 (0xFF5A) (-83.0 [dBm]) Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the CCA level threshold for OFDM condition. Set this option before OFDM data is transmitted and received.
Notice	-

3.3.32 OFDM CCA Level Threshold Setting in dBm

Table 3.44 Description of the toccavtd command

Command	toccavtd
Argument	OFDM CCA Level Threshold in dBm value Range: -256.0 to 0.0 [dBm] (unit: 0.5dBm) Default: -83.0 [dBm] Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the CCA level threshold in dBm value for OFDM condition. Set this option before FSK data is transmitted and received.
Notice	-

3.3.33 GPIO Function Setting

Table 3.45 Description of the tgpios command

Command	tgpios
Argument	GPIO function mode of the Sub-GHz transceiver ① tgpios [port] [mode (gpio)] [dir (in)] [pull] ② tgpios [port] [mode (gpio)] [dir (out)] [drv] ([level]) port: GPIO terminal of this configuration target 　　　0 to 12 : GPIO0 to GPIO12 mode: Function Mode 　　　gpio: GPIO Port dir: GPIO Port Direction (mode: gpio only) 　　　in: Input 　　　out: Output pull: GPIO Port (IN) Register Pull-Up/ Down (mode: gpio & dir: in only) 　　　pdn: Pull-Down 　　　pup: Pull-Up 　　　nop: No Pull-Up/Down drv: GPIO Port (OUT) Drive Current Level (mode: gpio & dir: out only) 　　　drvlo: Low Current driving 　　　drvhi: High Current driving Level: GPIO Port (OUT) Output Signal Level (Voltage) 　　　(mode: gpio & dir: out only, optional) 　　　0: Low 　　　1: High Default: 　　　GPIO0: Reserved (cannot change) 　　　GPIO1: Reserved (cannot change) 　　　GPIO2: Reserved (cannot change) 　　　GPIO3: GPIO Input Port (with internal pull-up register) 　　　GPIO4: GPIO Input Port (with internal pull-up register) 　　　GPIO5: GPIO Input Port (with internal pull-up register) 　　　GPIO6: Reserved (cannot change) 　　　GPIO7: Reserved (cannot change) 　　　GPIO8: Reserved (cannot change) 　　　GPIO9: GPIO Input Port (with internal pull-up register) 　　　GPIO10: GPIO Input Port (with internal pull-up register) 　　　GPIO11: GPIO Input Port (with internal pull-up register) 　　　GPIO12: GPIO Input Port (with internal pull-up register) Argument is omitted: ERROR, Out-of-range value: ERROR

Function	This command sets the GPIO Terminal Function mode of the Sub-GHz transceiver.
	Setting examples:
	tgpios 1 gpio in pup : GPIO1 is input port with Register Pull-Up
	tgpios 2 gpio out drvhi 1 : GPIO2 is output port with Driving current high and
	output signal voltage level high
Notice	This command sets the GPIO function of the Sub-GHz transceiver. Set the function according to the hardware configuration and purpose of use of the evaluation board. If the GPIO terminal does not be used, set it to the GPIO port input and Register Pull-Up or Pull-Down. For detailed Hardware specifications, refer to the user's manual of the evaluation board.

3.3.34 GPIO Setting Status

Table 3.46 Description of the tgpio command

Command	tgpio
Argument	None
Function	This command gets the current setting status about the GPIO function of the Sub-GHz transceiver.
Notice	-

3.3.35 GPIO Port Output Signal Level Setting

Table 3.47 Description of the tgpioo command

Command	tgpioo
Argument	GPIO Port Output Level
	tgpioo [port][level]
	port: GPIO Port of configuration target
	3 to 5, 9 to 12 (GPIO0 to 3, GPIO9 to 12) (0 to 2, 6 to 8 are reserved)
	level: Output Level (Voltage)
	0: Low
	1: High
	Default:
	0: Low
	Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the Output level of the specified GPIO Output Port of the Sub-GHz transceiver.
Notice	Set the function according to the hardware configuration and purpose of use of the evaluation board. For detailed Hardware specifications, refer to the user's manual of the evaluation board.

3.3.36 GPIO Port Input Signal Level Status

Table 3.48 Description of the tgpioi command

Command	tgpioi
Argument	Target GPIO Port which get the input level Range: 3 to 5, 9 to 12 (GPIO0 to 3, GPIO9 to 12) (0 to 2, 6 to 8 are reserved) Default: - Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command gets the input level of the specified GPIO Input Port of the Sub-GHz transceiver. If it is not set in the input port, it shows an indefinite value.
Notice	For detailed Hardware specifications, refer to the user's manual of the evaluation board.

3.3.37 Frame Length for RX BER Setting

Table 3.49 Description of the tberlen command

Command	tberlen
Argument	Frame length for RX BER Range: 5 to 2047 (0x0005 to 0x07FF) (unit: byte) Default: 20 (0x0014) Argument is omitted: ERROR, Out-of-range value: ERROR
Function	- This command sets the frame length for RX BER. Set this option before data is transmitted and received. - Set the length including the FCS (2 or 4 bytes).
Notice	-

3.3.38 PN9 Mode for BER Setting

Table 3.50 Description of the tberpn9 command

Command	tberpn9

Argument	PN9 mode for BER
	0: The content of the transmission frame and the expected reception data value is the
	   data stored in the RAM area from 0x000 to 0x7FC.
	1: The content of the transmission frame and the expected reception data value is the
	   PN9 data (Same data for each transmission frame).
	2: Change the PN9 data of the transmission packet contents for each transmission frame
	   (Change the start bit position of PN9 data (511bit) for each transmission frame).
	Default: 0
	Argument is omitted: ERROR, Out-of-range value: ERROR

Function	- This command is used to select the PN9 data to be used as the content of the
	  transmission frame. Set this option before data is transmitted and received.
	- When measuring the BER, set the option "1" for both the transmitting side and
	  receiving.
	- See 3.2.10 for details of PN9 data.

Notice	-

3.3.39 Frequency Hopping Transmission (FSK)

Table 3.51 Description of the tffh command

Command	tffh
Argument	① tffh -r [Starting ch number] [End ch number] 　　-r: Frame is sent by random channel number. Starting ch number and End ch number 　　　are designated. ② tffh -f [Starting ch number] [End ch number] 　　-f: Frame is sent to channel numerical order (small-> large). Starting ch number and 　　　End ch number are designated. ③ tffh -x [Starting ch number] [End ch number] ④ tffh -x 255 　　-x: The range of the transmission prohibited channel number is designated. Starting 　　　ch number and End ch number are designated. Default is un-designating. 　　　The designated prohibited ch can be released by setting the start ch number to 　　　0xFF. ⑤ tffh -s [channel intervals] 　　-s: The number of intervals with the next channel is designated. The transmission 　　　starting ch number is the base. 　　　　1: 1 channel (default) 　　　　2: 2 channels
Function	FSK frame is sent while changing the channel number successively. The following is the example of settings when sending at random using channel number " 1, 3, 11, 13". - Transmission in the range of ch5 to ch9 is prohibited. 　　tffh -x 5 9 - The number of intervals in the next channel is set as 2ch. 　　tffh -s 2 - A frame is sent at random at the range of ch1 to ch13. 　　tffh -r 1 13
Notice	- Please use the channel number supported by the band plan set in advance with the top 　command. - If the end channel number specified by the tffh command exceeds the upper limit 　channel of the currently set band plan, the end channel is set to the upper limit channel. - If necessary, use the option "-x" and "-s" before a transmission. - The prohibited starting ch number can't be set below the transmission starting ch 　number. - If the opt 2 command is specified before executing the tffh command, the channel 　number to be sent is displayed and sent. Please use it for operation checking.

3.3.40 Frequency Hopping Transmission (OFDM)

Table 3.52 Description of the tofh command

Command	tofh

Argument	① tofh -r [Starting ch number] [End ch number]
	
	   -r: Frame is sent by random channel number. Starting ch number and End ch number are designated.
	
	② tofh -f [Starting ch number] [End ch number]
	
	   -f: Frame is sent to channel numerical order (small-> large). Starting ch number and End ch number are designated.
	
	③ tofh -x [Starting ch number] [End ch number]
	④ tofh -x 255
	
	   -x: The range of the transmission prohibited channel number is designated. Starting ch number and End ch number are designated. Default is un-designating.
	   The designated prohibited ch can be released by setting the start ch number to 0xFF.
	
	⑤ tofh -s [channel intervals]
	
	   -s: The number of intervals with the next channel is designated. The transmission starting ch number is the base.
	     1: 1 channel (default)
	     2: 2 channel

Function	OFDM frame is sent while changing the channel number successively.
	The following is the example of settings when sending at random using channel number " 1, 3, 11, 13".
	- Transmission in the range of ch5 to ch9 is prohibited.
	  tofh -x 5 9
	- The number of intervals in the next channel is set as 2ch.
	  tofh -s 2
	- A frame is sent at random at the range of ch1 to ch13.
	  tofh -r 1 13

Notice	- Please use the channel number supported by the band plan set in advance with the top command. - If the end channel number specified by the tofh command exceeds the upper limit channel of the currently set band plan, the end channel is set to the upper limit channel. - If necessary, use the option "-x" and "-s" before a transmission. - The prohibited starting ch number can't be set below the transmission starting ch number. - If the opt 2 command is specified before executing the tofh command, the channel number to be sent is displayed and sent. Please use it for operation checking.

3.3.41 RAM Read and Write Mode

Table 3.53 Description of the ram command

Command	ram

Argument	RAM read and write mode
	① ram –[r][B|S|L] [address] ([n])
	    Read the specified range (size * n) from the specified address.
	    (When n is omitted, the operation is equivalent to n=1)
	
	② ram –[w][B|S|L] [address] [data0] ([data1] ⋯ [data31])
	    Write specified data from the specified address.
	    (When multiple data are specified, the data is written in the specified size
	     in order from the specified address)
	
	③ ram –[a][B|S|L]
	    Read the entire RAM area with the specified data size.
	
	r: Read designation(Default)
	w: Write designation(When multiple data are specified, the data is written in order from the specified address)
	a: Read designation of all RAM area
	B: Access data size 1byte designation(Default)
	S: Access data size 2byte designation
	L: Access data size 4byte designation
	address: 0x000 to 0x7FC
	data0-31: Write data (data1 to data31 can be omitted)
	n: Specify the number of read addresses at the time of reading (1 if omitted).
	   If 2 or more is specified, the read address is updated, and the specified range is read.

Function	Reads and writes the RAM of RX65x Microcontroller that stores the expected value of transmitted data and received data. This RAM area is reserved by the RF characteristics evaluation program, and the logical addresses are 0x000 to 0x7FC.
	
	3 formats are defined.
	① Read the specified range (size * n) from the specified address.(when n is omitted, the operation is equivalent to n=1)
	② Write specified data from the specified address. One or more write data can be specified (up to 32 data). When multiple data are specified, the data is written in the specified size in order from the specified address. When the write destination address reaches the upper limit of the RAM area, writing ends at that point. After writing the data, the value read from the same address is displayed.
	③ Read the entire RAM area with the specified data size.
	
	- When the value of address 0x123 is read.
	   ram -rB 0x123
	- When 0x45 is written in address 0x123.
	   ram -wB 0x123 0x45

	- When 0x45 is written in address 0x123, and when 0x67 is written in address 0x124.
	    ram -wS 0x123 0x6745
	- When 6byte data (0xAA 0xBB 0xCC 0xDD 0xEE 0xFF) is written from address 0x123.
	    ram -wB 0x0123 0xAA 0xBB 0xCC 0xDD 0xEE 0xFF

Notice	- When designating neither of "r", "w" and "a", designation will be "r". - When designating neither of "B", "S" and "L", designation will be "B". - About setting address, lower rank 11bit is effective.

3.3.42 Register Read and Write Mode

Table 3.54 Description of the reg command

Command	reg
Argument	Register read and write mode
	① reg –[r][B|S|L] [address] ([n])
	Read the specified range (size * n) from the specified address.
	(When n is omitted, the operation is equivalent to n=1)
	② reg –[w][B|S|L] [address] [data0] ([data1] ⋯ [data31])
	Write specified data from the specified address.
	(When multiple data are specified, the data is written in the specified size
	in order from the specified address)
	③ reg –[wf][B|S|L] [address] [data0] ([data1] ⋯ [data31])
	Write specified data from the specified address.
	(When multiple data are specified, the data is written in the specified size
	to the specified same address)
	④ reg –[a0|a1|a][B|S|L]
	Read all register and RAM area of the specified Bank with the specified data size.
	r: Read designation(Default)
	w: Write designation(When multiple data are specified, the data is written in order from the specified address)
	wf: Write designation(When multiple data are specified, the data is written to the specified same address)
	a0: Read all Bank0 register
	a1: Read all Bank1 register
	a: Read all Bank0 and Bank1 register
	address: 0x0000 to 0x0FFF (Bank0), 0x8000 to 0x8FFF (Bank1)
	data0-31: Write data (data1 to data31 can be omitted)
	n: 0x0000 to 0x0FFF Specify the number of read addresses at the time of reading (1 if omitted). If 2 or more is specified, the read address is updated, and the specified range is read.
	B: Access data size 1byte designation(Default)
	S: Access data size 2byte designation
	L: Access data size 4byte designation
	The specified value of Address is interpreted as follows.
	- address = 0x0000 to 0x0FFF (Address bit15=0):
	Access the address 0x0000-0x0FFF of Sub-GHz transceiver with condition of
	the Transmit/Receive Data RAM access area switching bit=0.
	- address = 0x8000 to 0x8FFF (Address bit15=1):
	Access the address 0x0000-0x0FFF of Sub-GHz transceiver with condition of
	the Transmit/Receive Data RAM access area switching bit=1.
	- address = other value than the above: Setting prohibited

Function	Reads and writes the register and the Transmit/Receive Data RAM of the Sub-GHz transceiver.
	4 types format are defined.
	① Read the specified range (size * n) from the specified address.
	  (when n is omitted, the operation is equivalent to n=1)
	② Write specified data from the specified address. One or more write data can be specified (up to 32 data). When multiple data are specified, the data is written in the specified size in order from the specified address. When the write destination address reaches the upper limit of each Bank area, writing ends at that point. After writing the data, the value read from the same address is displayed.
	③ Write specified data from the specified address. One or more write data can be specified (up to 32 data). When multiple data are specified, the data is written in the specified size to the specified same address. This mode does not read data after the writing.
	④ Read all register and RAM area of the specified Bank with the specified data size.
	
	Specified address range and access target
	  0x0000 to 0x0FFF: Bank0 Register
	  0x8000 to 0x87FF: Bank1 Register
	  0x8800 to 0x8FFF: Bank1 Transmit/Receive Data RAM
	
	- When the value of address 0x123 is read at Bank0 register.
	  reg -rB 0x0123
	- When the value of address 0x123 is read at Bank1 register.
	  reg -rB 0x8123
	- When 0x45 is written in address 0x123 of Bank0 register.
	  reg -wB 0x0123 0x45
	- When 0x45 is written in address 0x123 of Bank0 register, and when 0x67 is written in address 0x124 of Bank0 register.
	  reg -wS 0x0123 0x6745
	- When 0x45 is written in address 0x900 of Bank1 (+0x100 from start address of RAM).
	  reg -wB 0x8900 0x45
	- When 6byte data (0xAA 0xBB 0xCC 0xDD 0xEE 0xFF) is written from address 0x123 of Bank0 register.
	  reg -wB 0x0123 0xAA 0xBB 0xCC 0xDD 0xEE 0xFF

Notice	- When designating neither of "r", "w", "a", "a0" and "a1", designation will be "r". - When designating neither of "B", "S" and "L", designation will be "B".

3.3.43 FSK Packet Transmission

Table 3.55 Description of the tftx command

Command	tftx (compatible name: t6)
Argument	Number of transmissions Range: 1 to 65535 (0x0001 to 0xFFFF) Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command is used to transmit FSK packets. When the number of transmissions is set to "65535 (0xFFFF)", the transmission continues until the return key is pressed. The content of the transmission data is either the data stored in 0x000 to 0x7FC specified by the ram command if the PN9 mode for BER is set to 0 or the PN9 data if the PN9 mode for BER is set to 1 or 2. Press Enter to stop sending and enter the command input state.
Notice	Set the transmission settings using the tope command, tch command and other related command before executing this command.

3.3.44 OFDM Packet Transmission

Table 3.56 Description of the totx command

Command	totx
Argument	Number of transmissions Range: 1 to 65535 (0x0001 to 0xFFFF) Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command is used to transmit OFDM packets. When the number of transmissions is set to "65535 (0xFFFF)", the transmission continues until the return key is pressed. The content of the transmission data is either the data stored in 0x000 to 0x7FC specified when the ram command is executed if the PN9 mode for BER is set to 0 or the PN9 data if the PN9 mode for BER is set to 1 or 2. Press Enter to stop sending and enter the command input state.
Notice	Set the transmission settings using the tope command, tch command and other related command before executing this command.

3.3.45 Continuous FSK Modulated PN9 data Transmission

Table 3.57 Description of the tfpn9 command

Command	tfpn9 (compatible name: tpn)
Argument	None
Function	This command initiates the continuous FSK modulated transmission of the PN9 data. Press Enter to stop sending and enter the command input state.
Notice	Set the transmission settings using the tope command, tch command and other related command before executing this command.

3.3.46 Continuous OFDM Modulated PN9 data Transmission

Table 3.58 Description of the topn9 command

Command	topn9
Argument	None
Function	This command initiates the continuous OFDM modulated transmission of the PN9 data. Press Enter to stop sending and enter the command input state.
Notice	Set the transmission settings using the tope command, tch command and other related command before executing this command.

3.3.47 Continuous Unmodulated Transmission

Table 3.59 Description of the tnmtx command

Command	tnmtx (compatible name: t9)
Argument	None
Function	This command initiates the continuous transmission of an unmodulated wave. The channel center frequency of the transmission is set based on the FSK setting of the top command and the tch command. Press Enter to stop sending and enter the command input state.
Notice	- Set the transmission settings using the tope command, tch command and other related command before executing this command.

3.3.48 FSK Packet Reception

Table 3.60 Description of the tfrx command

Command	tfrx (compatible name: t7)
Argument	Reception option (See Table 3.61) Range: 0x00, 0x11, 0x12 Argument is omitted: 0x00, Out-of-range value: ERROR
Function	This command is used to receive FSK packets. It will be reception waiting after command execution. Press Enter to stop reception waiting and enter the command input state.
Notice	- Set the receiving settings using the tope command, tch command and other related command before executing this command. - At option is "0x00", when packet transmission interval is short, any packets may be discarded and not be displayed.

Table 3.61 Reception option

Reception option	Reception operation
0 (0x00)	The content of the frame is displayed for each packet received.
17 (0x11)	Bit errors are counted, and the result is displayed after the reception stops.
18 (0x12)	Packet errors are counted, and the result is displayed after the reception stops.

3.3.49 OFDM Packet Reception

Table 3.62 Description of the torx command

Command	torx
Argument	Reception option (See Table 3.61) Range: 0x00, 0x11, 0x12 Argument is omitted: 0x00, Out-of-range value: ERROR
Function	This command is used to receive OFDM packets. It will be reception waiting after command execution. Press Enter to stop reception waiting and enter the command input state.
Notice	- Set the receiving settings using the tope command, tch command and other related command before executing this command. - At option is "0x00", when packet transmission interval is short, any packets may be discarded and not be displayed.

3.3.50 FSK & OFDM Packet Reception

Table 3.63 Description of the tforx command

Command	tforx
Argument	Reception option (See Table 3.61) Range: 0x00, 0x11, 0x12 Argument is omitted: 0x00, Out-of-range value: ERROR
Function	This command is used to receive FSK and OFDM packets. It will be reception waiting after command execution. In this mode, it waits for both FSK and OFDM packet to be received and starts receiving the first detected packet in either FSK or OFDM. When reception is complete, it returns to both FSK and OFDM packet reception standby states. Press Enter to stop reception waiting and enter the command input state.
Notice	- Set the FSK and OFDM receiving settings using the tope command, tch command and other related command before executing this command. In this case, make sure that the settings related to the reception channel and frequency are the same for both. - At option is "0x00", when packet transmission interval is short, any packets may be discarded and not be displayed.

3.3.51 ED Measurement

Table 3.64 Description of the te command

Command	te

Argument	te [type] ([num])
	type: execution type
	        0: FSK
	        1: OFDM
	num: number of execution times (optional, equivalent to 1 when num is omitted)
	        Range: 1 to 65535 (0x0001 to 0xFFFF)
	Argument is omitted: Error, Out-of-range value: ERROR

Function	This command measures the ED. "ed" (LQI value) and "rssi" (RSSI value) are displayed as measurement results.
Notice	- Set the FSK or OFDM settings using the tope command before executing this command. - If necessary, set the related setting for ED (tfcdr, tocdr) before executing this command.

3.3.52 CCA Execution

Table 3.65 Description of the tcca command

Command	tcca

Argument	tcca [type] ([num])
	type: execution type
	        0: FSK
	        1: OFDM
	num: number of execution times (optional, equivalent to 1 when num is omitted)
	        Range: 1 to 65535 (0x0001 to 0xFFFF)
	Argument is omitted: Error, Out-of-range value: ERROR

Function	This command executes CCA and view the results ("CHANNEL CLEAR" or "CHANNEL BUSY").

Notice	- Set the FSK and/or OFDM settings using the tope command before executing this
	  command.
	- If necessary, set the related setting for CCA (tfcdr, tfccavt, tfccavtd or tocdr, toccavt,
	  toccavtd) before executing this command.

3.3.53　Mode Switch & New Mode Frame Transmission Setting

Table 3.66　Description of the tmstxs command

Command	tmstxs
Argument	FSK　: Current FSK Tx settings are reflected to the next New Mode frame transmission OFDM: Current OFDM Tx settings are reflected to the next New Mode frame transmission ccaon: Both of Mode Switch and New Mode Frame are transmitted after CCA ccaoff: Both of Mode Switch and New Mode Frame are transmitted without CCA (default) Argument is omitted: ERROR
Function	This command is used to set New Mode frame transmission settings. When FSK or OFDM is specified as an argument, the current transmit settings for the specified modulation are taken in as the transmit settings for the New Mode frame. When the argument is specified as ccaon or ccaoff, it specifies whether to execute CCA before transmission of Mode Switch and New Mode frame. The PHR of the Mode Switch frame (Wi-SUN standard compliant) sent before the New Mode frame is generated based on this setting information. Please refer to Figure 3-4 for how to use this command.
Notice	Set the transmission settings using the tope command, tch and other commands which are related transmission setting before executing this command (refer to Figure 3-4).

3.3.54　Mode Switch & New Mode Frame Transmission

Table 3.67　Description of the tmstx command

Command	tmstx
Argument	Number of transmissions Range: 1 to 65535 (0x0001 to 0xFFFF) Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command is used to transmit a set of Mode Switch frame and New Mode frame (one frame each) is transmitted repeatedly for the specified number of times. Mode Switch frame (FSK) transmission conditions must be set in advance using related commands. When the number of transmissions is set to "65535 (0xFFFF)", the transmission continues until the return key is pressed. The content of the New Mode Frame transmission data is either the data stored in 0x000 to 0x7FC specified by the ram command if the PN9 mode for BER is set to 0 or the PN9 data if the PN9 mode for BER is set to 1 or 2. The tberpn9 command supports specifying the PN9 mode. Press Enter to stop transmission and enter the command input state. After the transmission stops, it will be in Base Mode. Please refer to Figure 3-4 for how to use this command.
Notice	Set the transmission settings of the Mode Switch frame using the tope command, tch command and other related command before executing this command (refer to Figure 3-4).

Settings for New Mode frame transmission using the following related commands:

Common settings: **tope, tch** command

Settings if New Mode frame is FSK: **tsfd, tdw, tffcs, tfscheme, tfpl** command

Settings if New Mode frame is OFDM: **tofcs, tointl, foscr, tostf** command

If execute CCA before New Mode frame transmission:

   tfcca, tfccavt (**tfccavtd**) or **tocca, toccavt** (**toccavtd**) command

Execute **tmstxs** command

Settings for Mode Switch frame (FSK) using the following related commands:

FSK settings: **tope, tch, tsfd, tfpl** command
If execute CCA before FSK frame transmission: **tfcca, tfccavt** (**tfccavtd**) command

Setting the transmission length of the New Mode frame using **tfrlen** command.

Setting the interval time between completion of the New Mode frame transmission and start the next Mode Switch frame transmission using **ti** command.

Execute **tmstx** command to start transmission Mode Switch and New Mode frame.

After the Mode Switch and the New Mode frame have been transmitted, if necessary, set the transmission settings for the FSK and OFDM normal frames (Base Mode frames) using the following related commands:

FSK settings   : **tope, tch, tsfd, tdw, tffcs, tfscheme** command
If execute CCA before FSK frame transmission: **tfcca, tfccavt** (**tfccavtd**) command

OFDM settings: **tope, tch, tofcs, tointl, foscr** command
If execute CCA before OFDM frame transmission: **tocca, toccavt** (**toccavtd**) command

Figure 3-4 Procedure of the transmission settings for Mode Switch and New Mode frame

3.3.55 Mode Switch & New Mode Frame Reception Setting

Table 3.68 Description of the tmsrxs command

Command	tmsrxs
Argument	tmsrxs [modulation] [bank] modulation: Modulation for New Mode frame reception settings 　　FSK　: Current FSK Rx settings are reflected to the next New Mode frame 　　　　　　transmission. 　　OFDM: Current OFDM Rx settings are reflected to the next New Mode frame 　　　　　　transmission. bank: bank number that to be stored the specified New Mode Frame reception settings 　　Range: 0 to 11 Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command is used to set New Mode frame reception settings. The current reception settings of the modulation specified by this command is imported as the reception settings of the New Mode frame with the same modulation. This setting information is the expected PHR included in the Mode Switch frame (compliant with Wi-SUN) which has been received before New Mode Frame reception. Please refer to Figure 3-5 for how to use this command.
Notice	Set the reception settings using the tope command, tch and other commands which are related reception setting before executing this command (refer to Figure 3-5).

3.3.56 Mode Switch & New Mode Frame Reception

Table 3.69 Description of the tmsrx command

Command	tmsrx
Argument	tmsrx [timeout] ([option]) timeout: New Mode frame reception start timeout 　　Range: 0 to 268435456 (0x00000000 to 0x10000000) (unit: μsec) 　　　　Time-out time from the completion of the Mode Switch frame reception to 　　　　the start of New Mode frame reception. option: Reception option (See Table 3.61) 　　Range: 0x00, 0x11, 0x12 Argument is omitted: option=0x00, Out-of-range value: ERROR
Function	This command is used to receive Mode Switch and New Mode Frame. Mode Switch frame (FSK) reception conditions must be set in advance using related commands. It will be reception waiting for Mode Switch frame after command execution. When received the Mode Switch which has identical expected PHR, proceed New Mode frame reception automatically. After receiving a New Mode frame successfully, it returns to Base Mode and waiting for the next Mode Switch reception. When received the Mode Switch which contains an unexpected PHR, or the expected Mode Switch frame to be received but could not receive the New Mode frame in the timeout time, it returns to Base Mode and waiting for the next Mode Switch reception. Press the enter key to stop the reception. After the reception stops, it will be in Base Mode. Please refer to Figure 3-5 for how to use this command.

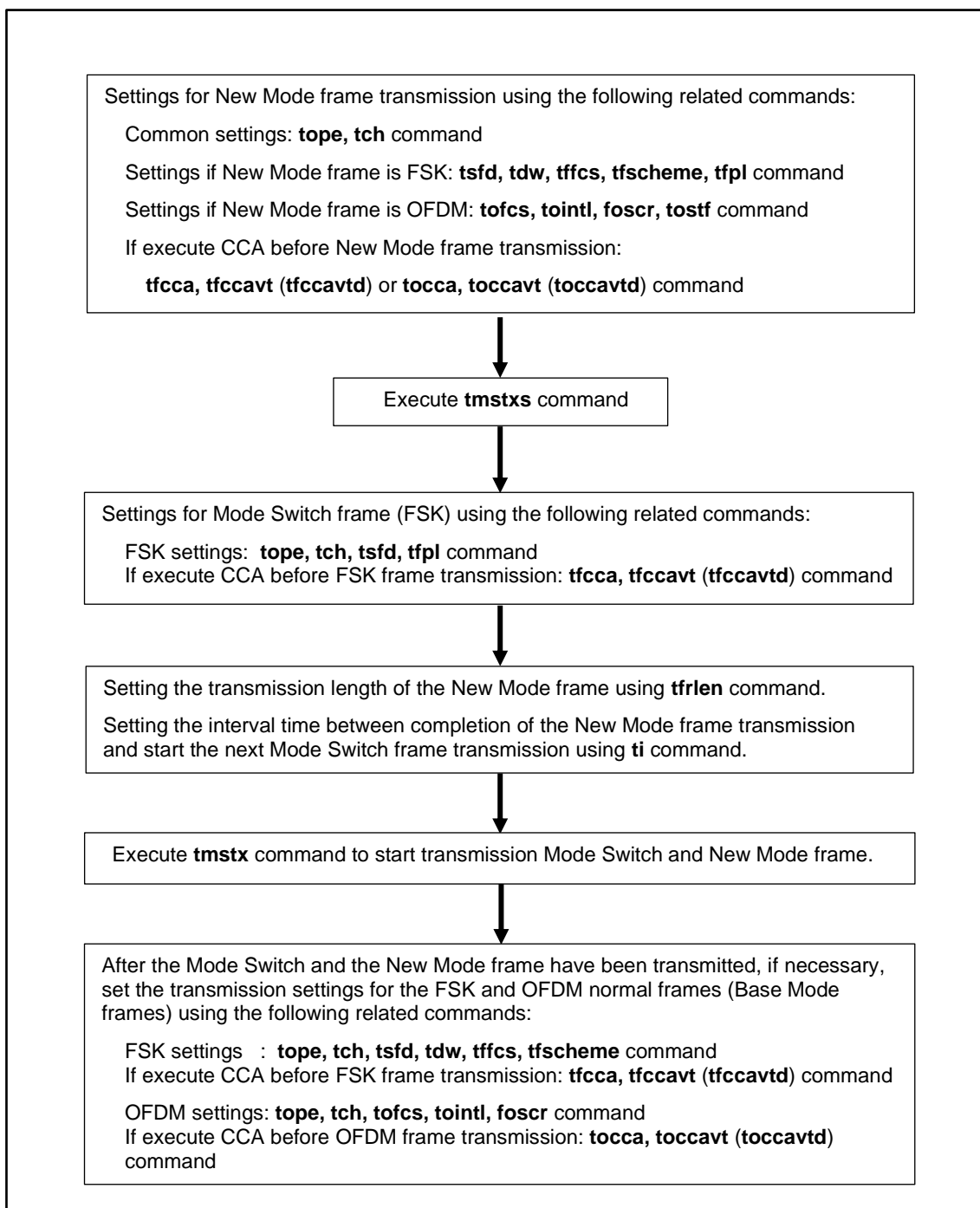| Notice | - Set the receiving settings using the tope command, tch command and other related command before executing this command (refer to Figure 3-5). |
| | - At option is "0x00", when packet transmission interval is short, any packets may not be displayed. |
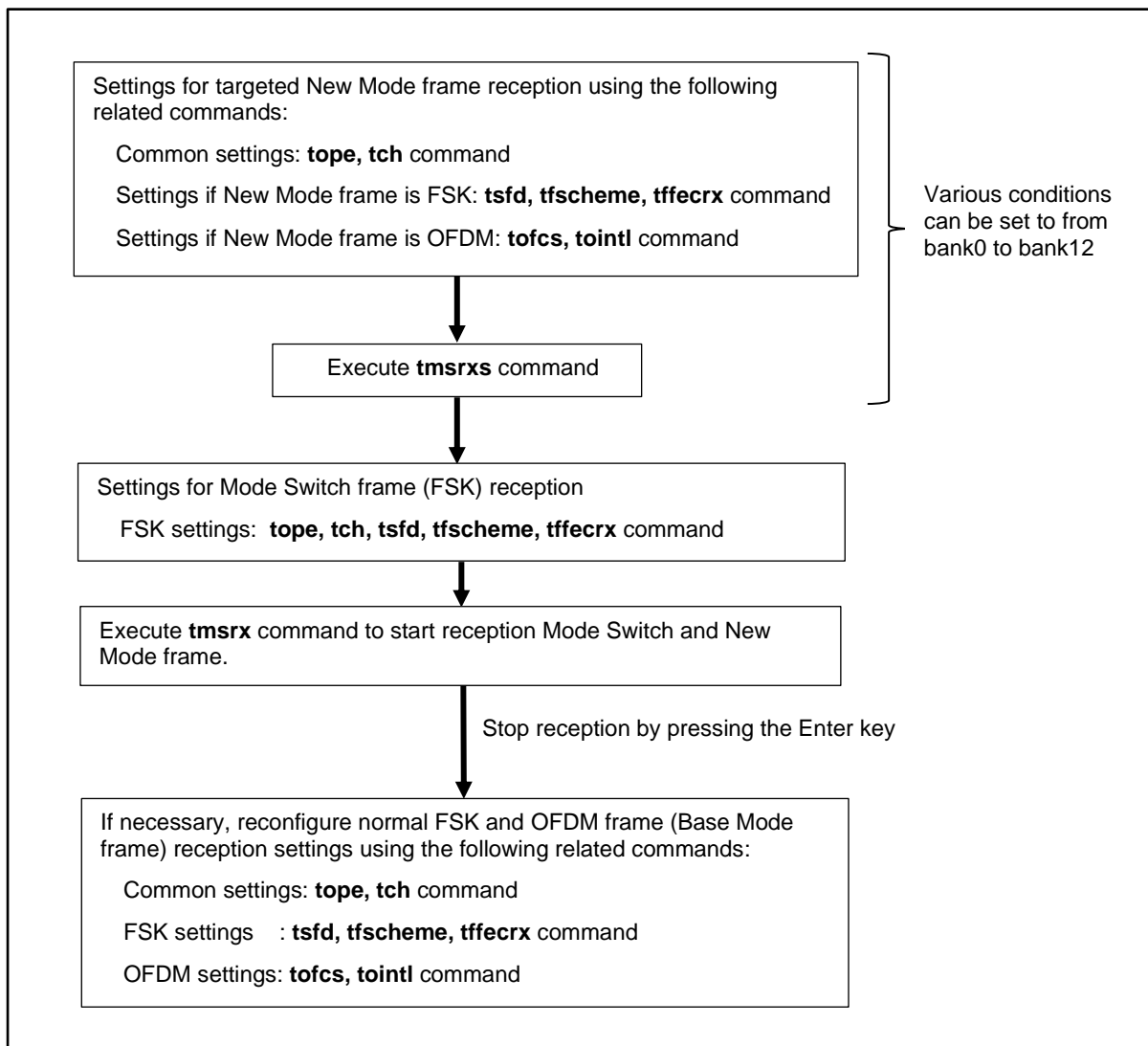
Figure 3-5 Procedure of the reception settings for Mode Switch and New Mode frame

3.3.57 Regulatory Mode Setting

Table 3.70 Description of the tttl command

Command	tttl
Argument	tttl [regulatory_mode(OFF/JP/UD)] [tcum_period] [tcum_limit] [ton_max] [toff_min] ① tttl OFF 　　Regulatory mode is disabled. ② tttl JP ([tcum_period]) 　　Regulatory mode is "JP mode" (comply with ARIB STD-T108). 　　tcum_period: Observation period 　　　　　　　1 to 60 (unit: min) (Optional, default 60) ③ tttl UD ([tcum_period] [tcum_limit] [ton_max] [toff_min]) 　　Regulatory mode is "UD mode" (operating according to User Defined conditions) 　　tcum_period: Observation period 　　　　　　　1 to 1092 (unit: min) (Optional, default 60) 　　tcum_limit: Cumulative transmission time limit 　　　　　　　0 to 65520000 (unit: msec) (Optional, default 0) 　　ton_max: Maximum transmission time limit 　　　　　　　0 to 10000 (unit: msec) (Optional, default 0) 　　toff_min: Minimum pause duration (inter-transmission interval) limit 　　　　　　　0 to 1000 (unit: msec) (Optional, default 1000) ④ tttl TH [threshold_time] 　threshold_time: The available transmission time threshold in the total transmission 　　　　　　　time limit of Regulatory Mode. 　　　　　　　0 to 65520000 (unit: msec) (default 1000) ⑤ tttl 　　Shows the current mode and status.
Function	This command provides a regulatory mode which is to limit maximum transmission time, minimum pause duration, and cumulative transmission time per observation period. **JP mode** This application supports the limit based on ARIB STD-T108, the Japanese regulation. This regulatory control applies only when operating with the parameter domain in tope command is "JP" or "UD", where the center frequency of the Tx / Rx channel is the Japanese frequency band. This mode operates according to argument tcum_period. This parameter is observation period for calculate cumulative transmission time. In this mode, transmission is restricted so that the cumulative transmission time is within 10% in the observation period. This parameter can be omitted, and the default value is 60 (min). When this mode is enabled, the current status is displayed by executing this command without specifying any options. (Display example)

```
command (and SetData[Dec])? >tttl
  Tx Total Time Limit mode
  Regulatory mode     :       JP
  Cumulative tx time  :      700 [msec]   (0.0194444 [%])
  tcum_period         :       60 [min]    (3600000 [msec])
  threshold to release :    1000 [msec]
  time left to release :       0 [sec]
```

UD mode

This application operates according to the limits for Regulatory Mode parameters specified in this command arguments.

This mode operates according to following parameters:

tcum_period: Observation period for calculate cumulative transmission time. This parameter can be omitted, and the default value is 60 (min).

tcum_limit: Cumulative transmission time in the observation period. When transmitting a frame, if the cumulative transmission time in the observation period exceeds tcum_limit, then transmission of that frame is cancelled. If UD mode is enabled with the initial value, no frame can be sent. Therefore it is recommended to set the appropriate value.

ton_max: Maximum transmission time limit. If the transmission time of a frame exceeds ton_max, the transmission of that frame is cancelled. If this mode is enabled with the initial value, no frame can be sent. Therefore it is recommended to set the appropriate value.

toff_min: Minimum pause duration (inter-transmission interval) limit. If the pause duration is shorter than toff_min, this application defers backward frame transmission so that the interval is greater than toff_min. The initial value is a very severe limit. Therefore it is recommended to set the appropriate value.

When this mode is enabled, the current status is displayed by executing this command without specifying any options.

(Display example)

```
command (and SetData[Dec])? >tttl
  Tx Total Time Limit mode
  Regulatory mode     :       UD
  Cumulative tx time  :      700 [msec]   (0.0194444 [%])
  tcum_period         :       60 [min]    (3600000 [msec])
  tcum_limit          :   100000 [msec]
  ton_max             :     1000 [msec]
  toff_min            :      100 [msec]
  threshold to release :    1000 [msec]
  time left to release :       0 [sec]
```

tttl command execution without any options will show the current mode and parameter settings, Cumulative transmission time in the observation period (Cumulative tx time) and the time it takes for the available transmission time in the total transmission time limit of Regulatory Mode to be greater than or equal to the threshold (time left to release).

When JP or UD mode is enabled once, Cumulative transmission time cannot be cleared even if this command changed to turn off or tinit command executing. To initialize this state, restart the system using the rst command or turn off the power and on again.

Notice	-

3.3.58 Antenna diversity Setting

Table 3.71 Description of the tantdv command

Command	tantdv
Argument	Antenna diversity option 0: Antenna diversity disable 1: Antenna diversity enable Default: 0 Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the antenna diversity option. Set this option before data is transmitted and received.
Notice	- Before enabling Antenna diversity by this command, it is required to set 2 or more antennas to be used in the tantnum command. Antenna diversity cannot be enabled when the number of antennas used is 1. - To establish frame reception by antenna diversity, the received frame must have the following FSK preamble length and OFDM / STF symbol length (see Table 3.72 and Table 3.73).

Table 3.72 FSK Preamble length for Antenna diversity (TBD)

Data Rate	Preamble length	
	2 antenna	4 antenna
FSK 50kbps, m=0.5	12	14
FSK 100kbps, m=0.5	12	14
FSK 150kbps, m=0.5	TBD	TBD
FSK 200kbps, m=0.5	16	18
FSK 10kbps, m=0.5	TBD	TBD
FSK 20kbps, m=0.5	TBD	TBD
FSK 50kbps, m=1	12	14
FSK 100kbps, m=1	12	14
FSK 200kbps, m=1	16	18
FSK 10kbps, m=1	10	14
FSK 20kbps, m=1	TBD	TBD

Table 3.73 OFDM STF symbol length for Antenna diversity (TBD)

Modulation	STF Simbol length	
	2 antenna	4 antenna
OFDM Option 1	8	12
OFDM Option 2	10	12
OFDM Option 3	10	14
OFDM Option 4	10	16

3.3.59 Number of Antenna Setting

Table 3.74 Description of the tantnum command

Command	tantnum
Argument	Number of antennas available setting Range: 1,2,4 (Max number is equal to RP_USR_ANTENNA_NUM_MAX in r_phy_config_board_*.h) Default: 1 (It is specified as RP_USR_ANTENNA_NUM_MAX in r_phy_config_board_*.h) Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the number of antennas available.

Notice	- Before enabling Antenna diversity by tantdv command, it is required to set 2 or more
	  antennas to be used in this command.
	- When changing the number of antennas, an error will occur if the number of antennas
	  is less than the antenna number specified by tantsel command.

3.3.60 Antenna Selection Setting

Table 3.75 Description of the tantsel command

Command	tantsel
Argument	Antenna number to be used for Tx and Rx setting Range: 0 to 3 (Antenna 0 to Antenna 3) (The maximum value of the range depends on the tantnum command setting) Default: 0 (Antenna 0) Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the Antenna number to be used for Tx and Rx. Selected Antenna number is used for Tx regardless Antenna diversity enabled and disabled. Selected Antenna number is used for Rx only if Antenna diversity disabled.
Notice	The maximum value of the range depends on the tantnum command setting.

3.3.61 Sleep Setting

Table 3.76 Description of the tsleep command

Command	tsleep
Argument	None
Function	This command sets sleep mode for Sub-GHz transceiver. When returning from sleep, press the enter key. After the returning, settings of Sub-GHz transceiver have been restored to the same as before entering sleep mode.
Notice	If the clock output from CKOUT terminal of the Sub-GHz transceiver is enabled, the clock output will be stopped during the transition to sleep mode. When the operating clock of the RX65N MCU is using this clock output, the clock source of the MCU is switched to the built-in oscillator (HOCO) of the MCU while in the sleep state.

3.3.62 Reset

Table 3.77 Description of the rst command

Command	rst
Argument	None
Function	This command executes the hardware reset of the Sub-GHz transceiver and reset this application (reboot the RX65N MCU which working this application). The all setting and status of this application will be cleared and wait for start executing the tboot command. It can always be accepted only if the RX65N MCU is operating normally.
Notice	-

3.3.63 Option Setting

Table 3.78 Description of the opt command

Command	opt
Argument	Display mode setting 0: Mode 0 1: Mode 1 2: Mode 2 3: Reserved 4: Mode 4 5: Mode 5 <table><tr><th></th><th>NowSetVal display (Figure 3-1)</th><th>Tx/Rx progress display</th><th>Antenna number with CRC NG count in Reception result</th><th>Tx channel display in tffh and tofh command</th></tr><tr><td>Mode 0</td><td>OFF</td><td>Displayed "." every 100 frames of Tx/Rx</td><td>OFF</td><td>OFF</td></tr><tr><td>Mode 1</td><td>ON</td><td>Displayed "." every 100 frames of Tx/Rx</td><td>OFF</td><td>OFF</td></tr><tr><td>Mode 2</td><td>ON</td><td>Displayed "." every 100 frames of Tx/Rx</td><td>ON</td><td>ON</td></tr><tr><td>Mode 4</td><td>OFF</td><td>Displayed "." every 1 frame of Tx/Rx</td><td>OFF</td><td>OFF</td></tr><tr><td>Mode 5</td><td>ON</td><td>Displayed "." every 1 frame of Tx/Rx</td><td>OFF</td><td>OFF</td></tr></table> Default: 1 Argument is omitted: ERROR, Out-of-range value: ERROR
Function	This command sets the display mode of this application.
Notice	-

3.3.64 Setting Information Display

Table 3.79 Description of the val command

Command	val
Argument	None
Function	This command displays the application setting information (NowSetVal) (Figure 3-1).

3.3.65 Command List Display

Table 3.80 Description of the help command

Command	help
Argument	None
Function	This command displays the command list.

3.4　Channel number setting list

Indicating the channel number by region and frequency band based on Wi-SUN PHY Specification Amendment 1VA9.

Channel Mask in each channel setting is defined as follows in the Wi-SUN PHY Specification. Channel Mask represents the channels that are supported by the ChannelPlanID for each regional frequency bands. It is a bitfield, each bit referring to a different channel. If a channel is supported, it is represented as zero and if the channel is not supported, it is represented as one. Bit0 of Channel Mask corresponds to Channel0.

Figure 3-6　Channel Mask Example

3.4.1　Channel setting of the EU domain, ChanPlanID=32

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [1]		
EU	32 (863_870_100)	0.1	863.1	62	00:00:00:00:00:00:80:E1:E6		
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
0	863.1	1	863.2	2	863.3	3	863.4
4	863.5	5	863.6	6	863.7	7	863.8
8	863.9	9	864.0	10	864.1	11	864.2
12	864.3	13	864.4	14	864.5	15	864.6
16	864.7	17	864.8	18	864.9	19	865.0
20	865.1	21	865.2	22	865.3	23	865.4
24	865.5	25	865.6	26	865.7	27	865.8
28	865.9	29	866.0	30	866.1	31	866.2
32	866.3	33	866.4	34	866.5	35	866.6
36	866.7	37	866.8	38	866.9	39	867.0
40	867.1	41	867.2	42	867.3	43	867.4
44	867.5	45	867.6	46	867.7	47	867.8
48	867.9	49	868.0	50	868.1	51	868.2
52	868.3	53	868.4	54	868.5	55	868.6
56	868.7	57	868.8	58	868.9	59	869.0
60	869.1	61	869.2	62	869.3	63	869.4
64	869.5	65	869.6	66	869.7	67	869.8
68	869.9						

The gray areas are not used in Wi-SUN PHY Specification Amendment.
*1: Refer to Figure 3-6　Channel Mask Example

3.4.2 Channel setting of the EU domain, ChanPlanID=33

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [1]		
EU	33 (863_870_200)	0.2	863.1	29	00:00:00:D8:FB		
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
0	863.1	1	863.3	2	863.5	3	863.7
4	863.9	5	864.1	6	864.3	7	864.5
8	864.7	9	864.9	10	865.1	11	865.3
12	865.5	13	865.7	14	865.9	15	866.1
16	866.3	17	866.5	18	866.7	19	866.9
20	867.1	21	867.3	22	867.5	23	867.7
24	867.9	25	868.1	26	868.3	27	868.5
28	868.7	29	868.9	30	869.1	31	869.3
32	869.5	33	869.7	34	869.9		

The gray areas are not used in Wi-SUN PHY Specification Amendment.

3.4.3 Channel setting of the EU domain, ChanPlanID=34

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [1]		
EU	34 (870_876_100)	0.1	870.1	55	00:00:00:00:00:00:80		
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
0	870.1	1	870.2	2	870.3	3	870.4
4	870.5	5	870.6	6	870.7	7	870.8
8	870.9	9	871.0	10	871.1	11	871.2
12	871.3	13	871.4	14	871.5	15	871.6
16	871.7	17	871.8	18	871.9	19	872.0
20	872.1	21	872.2	22	872.3	23	872.4
24	872.5	25	872.6	26	872.7	27	872.8
28	872.9	29	873.0	30	873.1	31	873.2
32	873.3	33	873.4	34	873.5	35	873.6
36	873.7	37	873.8	38	873.9	39	874.0
40	874.1	41	874.2	42	874.3	43	874.4
44	874.5	45	874.6	46	874.7	47	874.8
48	874.9	49	875.0	50	875.1	51	875.2
52	875.3	53	875.4	54	875.5		

3.4.4　Channel setting of the EU domain, ChanPlanID=35

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [*1]				
EU	35 (870_876_200)	0.2	870.2	27	00:00:00:F8				
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]		
0	870.2	1	870.4	2	870.6	3	870.8		
4	871.0	5	871.2	6	871.4	7	871.6		
8	871.8	9	872.0	10	872.2	11	872.4		
12	872.6	13	872.8	14	873.0	15	873.2		
16	873.4	17	873.6	18	873.8	19	874.0		
20	874.2	21	874.4	22	874.6	23	874.8		
24	875.0	25	875.2	26	875.4				

3.4.5　Channel setting of the EU domain, ChanPlanID=36

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [*1]				
EU	36 (863_876_100)	0.1	863.1	118	00:00:00:00:00:00:80:E1:06:00:00:00:00:00:00:E0				
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]		
0	863.1	1	863.2	2	863.3	3	863.4		
4	863.5	5	863.6	6	863.7	7	863.8		
8	863.9	9	864.0	10	864.1	11	864.2		
12	864.3	13	864.4	14	864.5	15	864.6		
16	864.7	17	864.8	18	864.9	19	865.0		
20	865.1	21	865.2	22	865.3	23	865.4		
24	865.5	25	865.6	26	865.7	27	865.8		
28	865.9	29	866.0	30	866.1	31	866.2		
32	866.3	33	866.4	34	866.5	35	866.6		
36	866.7	37	866.8	38	866.9	39	867.0		
40	867.1	41	867.2	42	867.3	43	867.4		
44	867.5	45	867.6	46	867.7	47	867.8		
48	867.9	49	868.0	50	868.1	51	868.2		
52	868.3	53	868.4	54	868.5	55	868.6		
56	868.7	57	868.8	58	868.9	59	869.0		
60	869.1	61	869.2	62	869.3	63	869.4		
64	869.5	65	869.6	66	869.7	67	869.8		
68	869.9	69	870.0	70	870.1	71	870.2		
72	870.3	73	870.4	74	870.5	75	870.6		
76	870.7	77	870.8	78	870.9	79	871.0		
80	871.1	81	871.2	82	871.3	83	871.4		
84	871.5	85	871.6	86	871.7	87	871.8		
88	871.9	89	872.0	90	872.1	91	872.2		
92	872.3	93	872.4	94	872.5	95	872.6		
96	872.7	97	872.8	98	872.9	99	873.0		
100	873.1	101	873.2	102	873.3	103	873.4		

104	873.5	105	873.6	106	873.7	107	873.8
108	873.9	109	874.0	110	874.1	111	874.2
112	874.3	113	874.4	114	874.5	115	874.6
116	874.7	117	874.8	118	874.9	119	875.0
120	875.1	121	875.2	122	875.3	123	875.4
124	875.5						

The gray areas are not used in Wi-SUN PHY Specification Amendment.

3.4.6   Channel setting of the EU domain, ChanPlanID=37

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [1]		
EU	37 (863_876_200)	0.2	863.1	56	00:00:00:D8:03:00:00:C0		
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
0	863.1	1	863.3	2	863.5	3	863.7
4	863.9	5	864.1	6	864.3	7	864.5
8	864.7	9	864.9	10	865.1	11	865.3
12	865.5	13	865.7	14	865.9	15	866.1
16	866.3	17	866.5	18	866.7	19	866.9
20	867.1	21	867.3	22	867.5	23	867.7
24	867.9	25	868.1	26	868.3	27	868.5
28	868.7	29	868.9	30	869.1	31	869.3
32	869.5	33	869.7	34	869.9	35	870.1
36	870.3	37	870.5	38	870.7	39	870.9
40	871.1	41	871.3	42	871.5	43	871.7
44	871.9	45	872.1	46	872.3	47	872.5
48	872.7	49	872.9	50	873.1	51	873.3
52	873.5	53	873.7	54	873.9	55	874.1
56	874.3	57	874.5	58	874.7	59	874.9
60	875.1	61	875.3				

The gray areas are not used in Wi-SUN PHY Specification Amendment.

3.4.7 Channel setting of the NA domain, ChanPlanID=1

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [1]	
NA	1 (902_928_200)	0.2	902.2	129	00:00:00:00:00:00:00:00:00: 00:00:00:00:00:00:00:00:FE	

Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
0	902.2	1	902.4	2	902.6	3	902.8
4	903.0	5	903.2	6	903.4	7	903.6
8	903.8	9	904.0	10	904.2	11	904.4
12	904.6	13	904.8	14	905.0	15	905.2
16	905.4	17	905.6	18	905.8	19	906.0
20	906.2	21	906.4	22	906.6	23	906.8
24	907.0	25	907.2	26	907.4	27	907.6
28	907.8	29	908.0	30	908.2	31	908.4
32	908.6	33	908.8	34	909.0	35	909.2
36	909.4	37	909.6	38	909.8	39	910.0
40	910.2	41	910.4	42	910.6	43	910.8
44	911.0	45	911.2	46	911.4	47	911.6
48	911.8	49	912.0	50	912.2	51	912.4
52	912.6	53	912.8	54	913.0	55	913.2
56	913.4	57	913.6	58	913.8	59	914.0
60	914.2	61	914.4	62	914.6	63	914.8
64	915.0	65	915.2	66	915.4	67	915.6
68	915.8	69	916.0	70	916.2	71	916.4
72	916.6	73	916.8	74	917.0	75	917.2
76	917.4	77	917.6	78	917.8	79	918.0
80	918.2	81	918.4	82	918.6	83	918.8
84	919.0	85	919.2	86	919.4	87	919.6
88	919.8	89	920.0	90	920.2	91	920.4
92	920.6	93	920.8	94	921.0	95	921.2
96	921.4	97	921.6	98	921.8	99	922.0
100	922.2	101	922.4	102	922.6	103	922.8
104	923.0	105	923.2	106	923.4	107	923.6
108	923.8	109	924.0	110	924.2	111	924.4
112	924.6	113	924.8	114	925.0	115	925.2
116	925.4	117	925.6	118	925.8	119	926.0
120	926.2	121	926.4	122	926.6	123	926.8
124	927.0	125	927.2	126	927.4	127	927.6
128	927.8						

3.4.8   Channel setting of the NA domain, ChanPlanID=2

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [1]			
NA	2 (902_928_400)	0.4	902.4	64	00:00:00:00:00:00:00:00			
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	
0	902.4	1	902.8	2	903.2	3	903.6	
4	904.0	5	904.4	6	904.8	7	905.2	
8	905.6	9	906.0	10	906.4	11	906.8	
12	907.2	13	907.6	14	908.0	15	908.4	
16	908.8	17	909.2	18	909.6	19	910.0	
20	910.4	21	910.8	22	911.2	23	911.6	
24	912.0	25	912.4	26	912.8	27	913.2	
28	913.6	29	914.0	30	914.4	31	914.8	
32	915.2	33	915.6	34	916.0	35	916.4	
36	916.8	37	917.2	38	917.6	39	918.0	
40	918.4	41	918.8	42	919.2	43	919.6	
44	920.0	45	920.4	46	920.8	47	921.2	
48	921.6	49	922.0	50	922.4	51	922.8	
52	923.2	53	923.6	54	924.0	55	924.4	
56	924.8	57	925.2	58	925.6	59	926.0	
60	926.4	61	926.8	62	927.2	63	927.6	

3.4.9   Channel setting of the NA domain, ChanPlanID=3

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [1]			
NA	3 (902_928_600)	0.6	902.6	42	00:00:00:00:00:FC			
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	
0	902.6	1	903.2	2	903.8	3	904.4	
4	905.0	5	905.6	6	906.2	7	906.8	
8	907.4	9	908.0	10	908.6	11	909.2	
12	909.8	13	910.4	14	911.0	15	911.6	
16	912.2	17	912.8	18	913.4	19	914.0	
20	914.6	21	915.2	22	915.8	23	916.4	
24	917.0	25	917.6	26	918.2	27	918.8	
28	919.4	29	920.0	30	920.6	31	921.2	
32	921.8	33	922.4	34	923.0	35	923.6	
36	924.2	37	924.8	38	925.4	39	926.0	
40	926.6	41	927.2						

3.4.10 Channel setting of the NA domain, ChanPlanID=4

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [1]			
NA	4 (902_928_800)	0.8	902.8	32	00:00:00:00			
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
0	902.8	1	903.6	2	904.4	3	905.2
4	906.0	5	906.8	6	907.6	7	908.4
8	909.2	9	910.0	10	910.8	11	911.6
12	912.4	13	913.2	14	914.0	15	914.8
16	915.6	17	916.4	18	917.2	19	918.0
20	918.8	21	919.6	22	920.4	23	921.2
24	922.0	25	922.8	26	923.6	27	924.4
28	925.2	29	926.0	30	926.8	31	927.6

3.4.11 Channel setting of the NA domain, ChanPlanID=5

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [1]			
NA	5 (902_928_1200)	1.2	903.2	21	00:00:E0			
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
0	903.2	1	904.4	2	905.6	3	906.8
4	908.0	5	909.2	6	910.4	7	911.6
8	912.8	9	914.0	10	915.2	11	916.4
12	917.6	13	918.8	14	920.0	15	921.2
16	922.4	17	923.6	18	924.8	19	926.0
20	927.2						

3.4.12 Channel setting of the BZ domain, ChanPlanID=1

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [*1]			
BZ	1 (902_928_200)	0.2	902.2	90	00:00:00:FC:FF:FF:FF:FF: 01:00:00:00:00:00:00:00:FE			
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
---	---	---	---	---	---	---	---
0	902.2	1	902.4	2	902.6	3	902.8
4	903.0	5	903.2	6	903.4	7	903.6
8	903.8	9	904.0	10	904.2	11	904.4
12	904.6	13	904.8	14	905.0	15	905.2
16	905.4	17	905.6	18	905.8	19	906.0
20	906.2	21	906.4	22	906.6	23	906.8
24	907.0	25	907.2	26	907.4	27	907.6
28	907.8	29	908.0	30	908.2	31	908.4
32	908.6	33	908.8	34	909.0	35	909.2
36	909.4	37	909.6	38	909.8	39	910.0
40	910.2	41	910.4	42	910.6	43	910.8
44	911.0	45	911.2	46	911.4	47	911.6
48	911.8	49	912.0	50	912.2	51	912.4
52	912.6	53	912.8	54	913.0	55	913.2
56	913.4	57	913.6	58	913.8	59	914.0
60	914.2	61	914.4	62	914.6	63	914.8
64	915.0	65	915.2	66	915.4	67	915.6
68	915.8	69	916.0	70	916.2	71	916.4
72	916.6	73	916.8	74	917.0	75	917.2
76	917.4	77	917.6	78	917.8	79	918.0
80	918.2	81	918.4	82	918.6	83	918.8
84	919.0	85	919.2	86	919.4	87	919.6
88	919.8	89	920.0	90	920.2	91	920.4
92	920.6	93	920.8	94	921.0	95	921.2
96	921.4	97	921.6	98	921.8	99	922.0
100	922.2	101	922.4	102	922.6	103	922.8
104	923.0	105	923.2	106	923.4	107	923.6
108	923.8	109	924.0	110	924.2	111	924.4
112	924.6	113	924.8	114	925.0	115	925.2
116	925.4	117	925.6	118	925.8	119	926.0
120	926.2	121	926.4	122	926.6	123	926.8
124	927.0	125	927.2	126	927.4	127	927.6
128	927.8						

The gray areas are not used in Wi-SUN PHY Specification Amendment.

3.4.13 Channel setting of the BZ domain, ChanPlanID=2

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [1]		
BZ	2 (902_928_400)	0.4	902.4	43	00:F0:FF:FF:01:00:00:00		
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
0	902.4	1	902.8	2	903.2	3	903.6
4	904.0	5	904.4	6	904.8	7	905.2
8	905.6	9	906.0	10	906.4	11	906.8
12	907.2	13	907.6	14	908.0	15	908.4
16	908.8	17	909.2	18	909.6	19	910.0
20	910.4	21	910.8	22	911.2	23	911.6
24	912.0	25	912.4	26	912.8	27	913.2
28	913.6	29	914.0	30	914.4	31	914.8
32	915.2	33	915.6	34	916.0	35	916.4
36	916.8	37	917.2	38	917.6	39	918.0
40	918.4	41	918.8	42	919.2	43	919.6
44	920.0	45	920.4	46	920.8	47	921.2
48	921.6	49	922.0	50	922.4	51	922.8
52	923.2	53	923.6	54	924.0	55	924.4
56	924.8	57	925.2	58	925.6	59	926.0
60	926.4	61	926.8	62	927.2	63	927.6

The gray areas are not used in Wi-SUN PHY Specification Amendment.

3.4.14 Channel setting of the BZ domain, ChanPlanID=3

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [1]		
BZ	3 (902_928_600)	0.6	902.6	28	00:FF:3F:00:00:FC		
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
0	902.6	1	903.2	2	903.8	3	904.4
4	905.0	5	905.6	6	906.2	7	906.8
8	907.4	9	908.0	10	908.6	11	909.2
12	909.8	13	910.4	14	911.0	15	911.6
16	912.2	17	912.8	18	913.4	19	914.0
20	914.6	21	915.2	22	915.8	23	916.4
24	917.0	25	917.6	26	918.2	27	918.8
28	919.4	29	920.0	30	920.6	31	921.2
32	921.8	33	922.4	34	923.0	35	923.6
36	924.2	37	924.8	38	925.4	39	926.0
40	926.6	41	927.2				

The gray areas are not used in Wi-SUN PHY Specification Amendment.

3.4.15 Channel setting of the BZ domain, ChanPlanID=4

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [*1]			
BZ	4 (902_928_800)	0.8	902.8	22	C0:FF:00:00			
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	
0	902.8	1	903.6	2	904.4	3	905.2	
4	906.0	5	906.8	6	907.6	7	908.4	
8	909.2	9	910.0	10	910.8	11	911.6	
12	912.4	13	913.2	14	914.0	15	914.8	
16	915.6	17	916.4	18	917.2	19	918.0	
20	918.8	21	919.6	22	920.4	23	921.2	
24	922.0	25	922.8	26	923.6	27	924.4	
28	925.2	29	926.0	30	926.8	31	927.6	

The gray areas are not used in Wi-SUN PHY Specification Amendment.

3.4.16 Channel setting of the BZ domain, ChanPlanID=5

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [*1]			
BZ	5 (902_928_1200)	1.2	903.2	13	F8:07:E0			
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	
0	903.2	1	904.4	2	905.6	3	906.8	
4	908.0	5	909.2	6	910.4	7	911.6	
8	912.8	9	914.0	10	915.2	11	916.4	
12	917.6	13	918.8	14	920.0	15	921.2	
16	922.4	17	923.6	18	924.8	19	926.0	
20	927.2							

The gray areas are not used in Wi-SUN PHY Specification Amendment.

3.4.17 Channel setting of the JP domain, ChanPlanID=21

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask *1		
JP	21 (920_928_200)	0.2	920.6	29	FF:01:00:00:C0		
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
0	920.6	1	920.8	2	921.0	3	921.2
4	921.4	5	921.6	6	921.8	7	922.0
8	922.2	9	922.4	10	922.6	11	922.8
12	923.0	13	923.2	14	923.4	15	923.6
16	923.8	17	924.0	18	924.2	19	924.4
20	924.6	21	924.8	22	925.0	23	925.2
24	925.4	25	925.6	26	925.8	27	926.0
28	926.2	29	926.4	30	926.6	31	926.8
32	927.0	33	927.2	34	927.4	35	927.6
36	927.8	37	928.0				

The gray areas are not used in Wi-SUN PHY Specification Amendment.

3.4.18 Channel setting of the JP domain, ChanPlanID=22

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask *1		
JP	22 (920_928_400)	0.4	920.9	14	0F:00:FC		
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
0	920.9	1	921.3	2	921.7	3	922.1
4	922.5	5	922.9	6	923.3	7	923.7
8	924.1	9	924.5	10	924.9	11	925.3
12	925.7	13	926.1	14	926.5	15	926.9
16	927.3	17	927.7				

The gray areas are not used in Wi-SUN PHY Specification.

3.4.19 Channel setting of the JP domain, ChanPlanID=23

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask *1		
JP	23 (920_928_600)	0.6	920.8	9	07:F0		
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
0	920.8	1	921.4	2	922.0	3	922.6
4	923.2	5	923.8	6	924.4	7	925.0
8	925.6	9	926.2	10	926.8	11	927.4

The gray areas are not used in Wi-SUN PHY Specification Amendment.

3.4.20 Channel setting of the JP domain, ChanPlanID=24

Regulatory Domain	ChanPlanID (ChanPlan Name)	ChanSpacing (MHz)	ChanCenter Freq0 (MHz)	TotalNum Chan	Channel Mask [1]		
JP	24 (920_928_800)	0.8	921.1	7	03:FE		
Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]	Channel number	Frequency [MHz]
0	921.1	1	921.9	2	922.7	3	923.5
4	924.3	5	925.1	6	925.9	7	926.7
8	927.5						

The gray areas are not used in Wi-SUN PHY Specification Amendment.

Revision History

		Description	
Rev.	Date	Page	Summary
0.50	Dec.22.2020	-	First printing
0.51	Jan.25.2021	P.30	3.3.23 FSK CCA Level Threshold Offset Setting Correct the error. Range was changed to: 0x00 to 0xFF (0.0 to 127.5) (unit: [0.5dB]) (T.B.D.)
		P.31	3.3.26 OFDM CCA Level Threshold Offset Setting Correct the error. Range was changed to: 0x00 to 0xFF (0.0 to 127.5) (unit: [0.5dB]) (T.B.D.)
0.52	Feb.25.2021	P.7	Figure 2-2 has been updated (Added new commands (tmstxs. tmstx, tmsrxs, tmsrx)).
		P.11	Table 3.1 Added descriptions of new commands (tmstxs. tmstx, tmsrxs, tmsrx).
		P.23	Table 3.9 has been updated according to Wi-SUN PHY TPS latest draft (phymode of NA and BZ).
		P.24	Table 3.11 has been updated according to Wi-SUN PHY TPS latest draft (NumChan of JP).
		P.46-49	3.3.47 to 3.3.50 New commands are added as tmstxs, tmstx, tmsrxs and tmsrx to support Mode Switch and New Mode frame which compliant with Wi-SUN.
		P.62-63	3.4.17 to 3.4.20 Channel setting of the JP domain has been updated according to Wi-SUN PHY TPS latest draft.
0.53	Apl.9.2021	P.46	Figure 3-4 Added explanation of tfpl and tostf settings to NewMode frame transmission settings. Also corrected the description of the normal OFDM transmission setting procedure.
0.54	May.21.2021	P.45	Table 3.58 Added new option (ccaon/ccaoff) of tmstxs command.
0.55	July.28.2021	P.9, P.39	The argument of tnmtx command is removed.
		P.9, P.47	tsleep command has been supported.
		P.22	Table 3.11 Channel Mask and usable channel has been corrected according to defined in the latest Wi-SUN PHY Specification Amendment (1VA8).
		P.23	3.3.4 tch command Table 3.13 Fixed a typo. (0x00 to 0xFF --> 0x00 to 0xFE)
		P.23	3.3.5 ttxpow command Table 3.14 The range of the transmission output level is changed. Meaning of the argument value is also changed.
		P.49	Added description and Figure 3-6 of Channel Mask according to defined in the latest Wi-SUN PHY Specification Amendment (1VA8).
		P.49-60	The following has been corrected according to defined in the latest Wi-SUN PHY Specification Amendment (1VA8). - Changed the expression of the channel mask field in each ChanPlanID. - 3.4.12 to 3.4.16 TotalNunChan has been corrected. - 3.4.1, 3.4.2, 3.4.5, 3.4.6 TotalNunChan and Channel Mask has been corrected.
		P.56-60	3.4.12 to 3.4.20 Added a supplementary comment.
0.56	Aug.24.2021	P.19	3.3.3 PHY Operation Mode Setting Corrected the specifiable value of phymode (phytype = FSK)

Rev.	Date	Page	Description	
			Summary	
0.57	Sep.3.2021	P.5	2.1 Serial Terminal Settings Corrected the explanation about the terminal software setting as an example of Teraterm setting.	
		P.48-49	Added tttl command - 3.3.50 Regulatory Mode Setting	
0.58	Oct.20.2021	P.11-15	Improved the descriptions. 3.2 Examples of the Command Input Sequence	
		P.50	tttl command Changed description about the activate condition of JP mode.	
		P.9, P.35	Added tffh command 3.3.33　Frequency Hopping Transmission (FSK)	
		P.9, P.36	Added tofh command 3.3.34　Frequency Hopping Transmission (OFDM)	
0.59	Nov.1.2021	P.24	Changed the range of transmission output level 3.3.5 Transmission Output Power Setting	
0.60	Dec.1.2021	P.7	Figure 2-2　Added new commands (tantdv, tantnum, tantsel)	
		P.10	Table 3.1 Added new commands (tantdv, tantnum, tantsel), Cahged default setting of tgpios command.	
		P.11	figure 3-1　Added command setting statuses (tantdv, tantnum, tantsel) in NowSetVal list.	
		P.13, P.15	Table3.3, Table3.4　Change remark description about LQI and ANT0-3.	
		P.23	Table3.11　Corrected typo (usable channel of JP domain & ChanPlanID=24)	
		P.24	3.3.5 Transmission Output Power Setting - Changed range of the transmission output level of FSK and OFDM. - Removed "TBD"	
		P.25	3.3.6 Transmission Packet Length Setting Changed range of the frame length available. Minimum number of available setting is depend on the FCS size.	
		P.32	3.3.27 GPIO Function Setting Changed default setting of the GPIO terminals.	
		P.33, P.34	3.3.29 GPIO Port Output Signal Level Setting 3.3.30 GPIO Port Input Signal Level Status Changed range of the argument.	
		P.52	3.3.53 Antenna diversity Setting Added new command.	
		P.53	3.3.54 Number of Antenna Setting Added new command.	
		P.54	3.3.54 Number of Antenna Setting Added new command.	
0.61	Dec.22.2021	P.19	Table 3.6　The functional names have been changed.	
		P.44	3.3.46 ED Measurement Added explanation about display of measurement results.	
		P.45	3.3.47 CCA Execution Added explanation about display of measurement results.	
		P.10, P.44, P.45	Clarified that "FSK & OFDM" reception and ED by "FSK & OFDM" mode are currently being evaluated and are TBD and not supported.	

		Description	
Rev.	Date	Page	Summary
0.62	Mar.18.2022	P.7-8	Figure 2-2 Changed the commands
		P.8-9	Table 3.1 ttxpow: The default value has been changed. ttxpowd: The default value has been changed. tftxpowd: Added as new command. totxpowd: Added as new command. tomode: This command has been removed because the RF driver (version V072 or later) supports OFDM PHR transmission compliant with IEEE Std 802.15.4-2020. (Please refer to clause 20.2.4 PHR in the IEEE Std for the detailed information.) tfccavtd, toccavtd: Added as new command. tfccavto, toccavto: Removed because of the RF Driver's HW configuration considers similar offset compensation. tforx: This has been removed due to be not supported as a TBD feature.
		P.11	Figure 3-1 The display format of "NowSetVal" has been changed.
		P.24	Table 3.14 Default value for OFDM has been changed. Removed Notice description.
		P.25-26	3.3.6 FSK and OFDM transmission Output Power Setting in dBm, 3.3.7 FSK transmission Output Power Setting in dBm, 3.3.8 OFDM transmission Output Power Setting in dBm Added as new command.
		P.30-31	3.3.27 FSK ED/CCA Duration Setting, 0 OFDM ED/CCA Duration Setting Added the explanation that the specified value can be specified in increments of 10usec and fractional values less than 10 are rounded down.
		P.31-32	3.3.29 FSK CCA Level Threshold Setting in dBm, 3.3.32 OFDM CCA Level Threshold Setting in dBm Added as new command.
		P.43	3.3.47 Continuous Unmodulated Transmission Added function description that the channel center frequency of the transmission is set based on the FSK setting of the top command and the tch command.
		P.45	3.3.51 ED Measurement Supported the optional function of multiple execution.
		P.45	3.3.52 CCA Execution - Supported the optional function of multiple execution. - The function of "FSK&OFDM", which is TBD, is no longer supported.
		P.47	Figure 3-4 - Added explanation about CCA settings for Mode Switch and New Mode frame transmission. - tomode command was deleted in the explanation.
		P.49	Figure 3-5 tomode command was deleted in the explanation.
		P.59	3.3.61 Sleep Setting Added a description about sleep operation when CKOUT of RFIC is active.

Rev.	Date	Description	
		Page	Summary
0.63	May.31.2022	P.7	Figure 2-2 Start Window Added new commands (trxgain, trxgaind)
		P.8-9	Table 3.1 Command List Added new commands (trxgain, trxgaind), Changed default setting (tfcdr, tocdr)
		P.11	Figure 3-1 executing example of tboot command Changed the display format of "NowSetVal"
		P.13	Table 3.3 Added description that only received packets without CRC error are measured for RSSI and LQI statistics.
		P.15	Table 3.4 Added description that all received packets are measured for RSSI and LQI statistics regardless of CRC check result.
		P.26	3.3.9 External Gain of Received Signal setting 3.3.10 External gain of received signal setting in dB Added new commands.
		P.32 P.34	3.3.27 FSK ED/CCA Duration Setting 3.3.30 OFDM ED/CCA Duration Setting Title changed, added 0xFFFF (automatic setting option) to the argument, changed default value and added description of recommended settings.
		P.48	3.3.50 FSK & OFDM Packet Reception Added command.
0.64	July.12.2022	P.5	Table 2.1 Changed line feed code setting sent from terminal software to "LF" only.
		All	The tstp command is abolished due to the specification change. Deleted the description about this command.
		P.46	3.3.47 Continuous Unmodulated Transmission Regarding the method of stopping transmission, the explanation was changed to stop operation by pressing the Enter key instead of the tstp command execution.
		P.49	3.3.51 ED Measurement Updated the explanation of related settings described in the notice column.
0.65	Sep.14.2022	P.8-10	Table 3.1 Command List Added note to default values of commands related to setting transmit power, GPIO and number of antennas used.
		P.38	3.3.38 PN9 Mode for BER Setting Added a function and explanation for the tberpn9 command.
		P.54-55	3.3.57 Regulatory Mode Setting Added functions and explanations for the tttl command.

Rev.	Date	Description	
		Page	**Summary**
0.66	Nov.17.2022	P.7	Figure 2-2 - Added twgain command. - Changed display location of trxgain and txgaind command.
		P.9-10	Table 3.1 - Changed the initial setting value of each command to the setting for the R9A06G062 reference board (ttxpow, ttxpowd, tftxpowd, totxpowd, tgpios, tantnum) - Added twgain command. - Changed location of trxgain and txgaind command explanation.
		P.11	3.2.1 Bootstrapping of the Renesas Sub-GHz transceiver Changed description when using R9A06G062 reference board (tboot 9 -> tboot 11)
		P.11	Figure 3-1 - Added display of twgain settings - Changed to values displayed for R9A06G062 reference board (ttxpow, trxgain, tantnum)
		P.22	Table 3.10 Corrected typo in phymode specifiable range (OFDM MCS specifiable range) for each region.
		P.24-25	3.3.5 FSK and OFDM transmission Output Power Setting 3.3.6 FSK and OFDM transmission Output Power Setting in dBm 3.3.7 FSK transmission Output Power Setting in dBm 3.3.8 OFDM transmission Output Power Setting in dBm Changed the default setting value to the value when using the R9A06G062 reference board. (FSK: -13.0dBm, OFDM:-12.0dBm)
		P.26	3.3.11 FSK Rx Wait Gain Offset setting Added twgain command.
		P.56	Table 3.71 fixed typo in Argument explanation. (0:enable -> disable, 1:disable -> enable)
0.67	Dec.12.2022	P.5	2 Operation Overview Added the model name of the reference board targeted in this document.
		P.7	Figure 2-2 Added tfreqo command (Frequency Offset Setting)
		P.10	Table 3.1 Added tfreqo command (Frequency Offset Setting)
		P.11	3.2.1 Bootstrapping of the Renesas Sub-GHz transceiver Changed the description to the specified value of the boot mode corresponding to the reference board targeted in this document.
		P.11	Figure 3-1 Added display of tfreqo settings.
		P.19	3.3.1 Bootstrapping of the Renesas Sub-GHz transceiver Table 3.5 Added notes (Added an explanation that it is necessary to specify the boot mode supported by the target board)
		P.21	3.3.3 PHY Operation Mode Setting Added an explanation that the FSK and OFDM channel spacing frequency and channel center frequency must be set to have the same value when performing simultaneous standby for FSK and OFDM.
		P.23	Table 3.11 Corrected typo in EU ChanPlanID=36 usable channel (57-69 --> 57-60)
		P.27	3.3.12 Frequency Offset setting (TBD) Added tfreqo command. (TBD)
		P.31	3.3.25 OFDM STF Length Setting Added explanation that setting function of STF length assumed to be included in received frame when receiving OFDM is included.

		P.36	3.3.33 GPIO Function Setting
			Limited to GPIO functions. Changed description of default setting.
R30AN0376EJ0100		P.37	3.3.35 GPIO Port Output Signal Level Setting
			Changed the available GPIO port number.
		P.38	3.3.36 GPIO Port Input Signal Level Status
			Changed the available GPIO port number.
		P.48	3.3.50 FSK & OFDM Packet Reception
			Removed "**This command is currently being evaluated.**"
		P.50-51	3.3.54 Mode Switch & New Mode Frame Transmission
			Table 3.67
			- Added description of this command.
			Figure 3-4
			- Changed the description for better understanding.
		P.52-53	3.3.56 Mode Switch & New Mode Frame Reception
			Table 3.69
			- Added description of the specified range of timeout.
			- Added description of this command.
			Figure 3-5
			- Changed the description for better understanding.
		P.57	Table 3.74 Fixed a typo in the specified range (1 to 4 -> 1,2,4)
		P.59	3.3.63 Option Setting
			Added Mode 4 and Mode 5. Added explanation for each mode.
		P.60	3.4 Channel number setting list
			Added the name of the reference standard (Wi-SUN PHY Specification Amendment 1VA9).
1.00	Dec.16.2022	P.15	Table 3.4 Added explanation about BER display.

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on

   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

4. Handling of unused pins

   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).

7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.

2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.

3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.

4. You shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.

5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.

6. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

    "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.

    "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

    Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION ("Vulnerability Issues"). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.

8. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.

9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.

10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.

11. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.

12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.

13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.

14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.renesas.com/contact/.