R9A06G062GNP, RX65W-A

Transmit Power Adjustment Procedure for Using an External Amplifier

Introduction

This document describes the procedure for adjusting the transmit power on a board equipped with an RF transceiver and an external transmit amplifier. Two adjustments to the transmit power are required: temperature compensation and factory calibration. Adjustment procedures for each are described below.
This document describes an example of a board equipped with an RX65W-A (MCU+RF transceiver) and a SKY66122-11 (external transmit amplifier), but the same method can also be used with the R9A06G062GNP (RF transceiver) to correct fluctuations in transmit power due to temperature. The same method can also be used with boards equipped with external transmit amplifiers other than the SKY66122-11.

Note: Descriptions in this application note are examples for reference. Following the guidelines does not guarantee the quality of characteristic signals. In attempting to use this device in your actual system, extensively consider and evaluate the system as a whole. Choosing to use the device in your system is at your own responsibility.

Target Device

R9A06G062GNP, RX65W-A

Contents

1. Overview

1.1 Temperature compensation

Our R9A06G062GNP (RF transceiver) and RX65W-A (MCU + RF transceiver) have a temperature compensation function for transmit power, and when used in combination with our firmware, these devices are controlled to minimize fluctuations in transmit power when the temperature changes.

When using an RF transceiver in combination with an external transmit amplifier, the transmit gain of the external amplifier varies with temperature, so if the temperature changes, it may not be possible to output the desired antenna transmit power. Therefore, when combining an RF transceiver with an external transmit amplifier, it is necessary to control the RF transceiver's transmit power to an appropriate power value so that the desired antenna transmit power can be output even when the temperature changes.

The adjustment procedure for temperature compensation is explained in Chapters 3 and 4.

This adjustment only needs to be performed once for one product; there is no need to adjust it for each board.

1.2 Factory calibration

Our R9A06G062GNP (RF transceiver) and RX65W-A (MCU + RF transceiver) have a process calibration function for transmit power, and when used in combination with our firmware, these devices are controlled to minimize fluctuations in transmit power due to process variations.

When using an RF transceiver in combination with an external transmit amplifier, the transmit gain of the external amplifier fluctuates for each sample, so if the transmit gain changes, it may not be possible to output the desired antenna transmit power. Therefore, it is necessary to perform factory calibration to adjust the RF transceiver transmit power for each board.

The adjustment procedure for factory calibration is explained in Chapter 5.

This adjustment must be performed for each board.

1.3 Related documents

We have released design guidelines for using an external transmit amplifier. For details, please refer to the following application note.

Also refer to the following document related to this application note.

R01UH0993 : RX65W-A Group User’s Manual: Hardware

R02UH0006 : R9A06G062GNP Sub-GHz Transceiver User’s Manual: Hardware

R01AN8165 : Design guidelines for circuit boards with the external front-end module (RX65W-A)

R01AN8154 : Design guidelines for circuit boards with the external front-end module (R9A06G062GNP)

R01AN8237 : Design guidelines for circuit boards with the external power amplifier (RX65W-A)

R01AN8236 : Design guidelines for circuit boards with the external power amplifier (R9A06G062GNP)

2. Reference kit

This document explains the example using the reference kit (RTK0EE0016D11004BJ) equipped with the RX65W-A (MCU + RF transceiver) and SKY66122-11 (external transmit amplifier).

2.1 System Configuration

Figure 2-1 shows the system configuration of the reference kit.

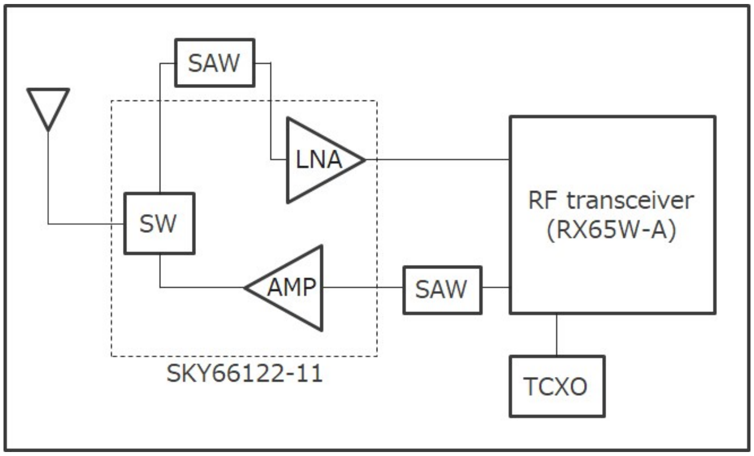

Figure 2-1 : System Configuration

2.2 Appearance of the evaluation kit

The appearance of the evaluation kit is shown in Figure 2-2.

Figure 2-2 : Appearance of the evaluation kit

2.3 Appearance of the RTK0EE0016D11004BJ (Daughter board)

The appearance of the RTK0EE0016D11004BJ is shown in Figure 2-3.

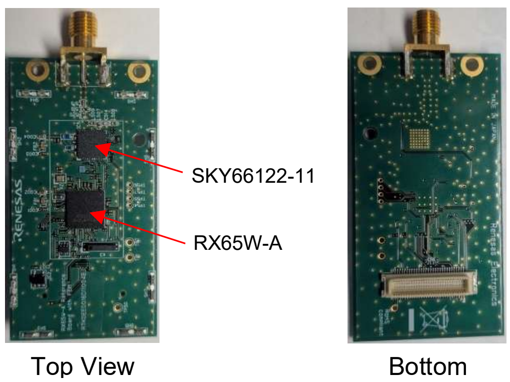

Figure 2-3 : Appearance of the RTK0EE0016D11004BJ (Daughter board)

2.4 Appearance of the RTK0EE0013D12002BJ (Mother board)

The appearance of the RTK0EE0013D12002BJ is shown in Figure 2-4.

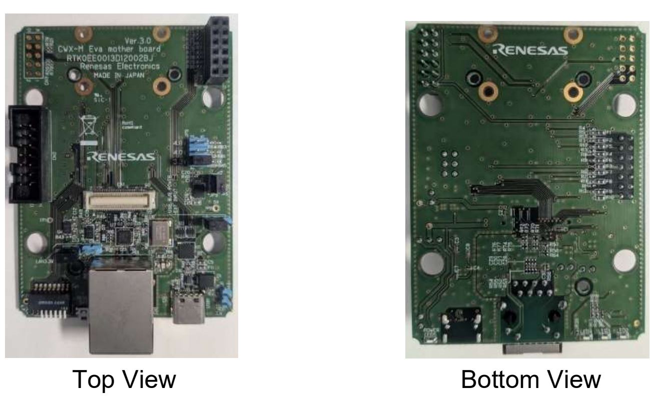

Figure 2-4 : Appearance of the RTK0EE0013D12002BJ (Mother board)

3. Adjusting the temperature compensation parameter

This chapter explains how to adjust the parameters used for temperature compensation of the transmit power. Use a temperature chamber to change the ambient temperature of the board and adjust the parameters. Finally, we create a temperature compensation table for the RF transceiver's transmit power setting values.

Considering variations in board characteristics, we recommend calculating temperature compensation values for multiple boards and using the average temperature compensation table.

3.1 Measurement system

An example of a measurement system for parameter adjustment is shown in Figure 3-1.

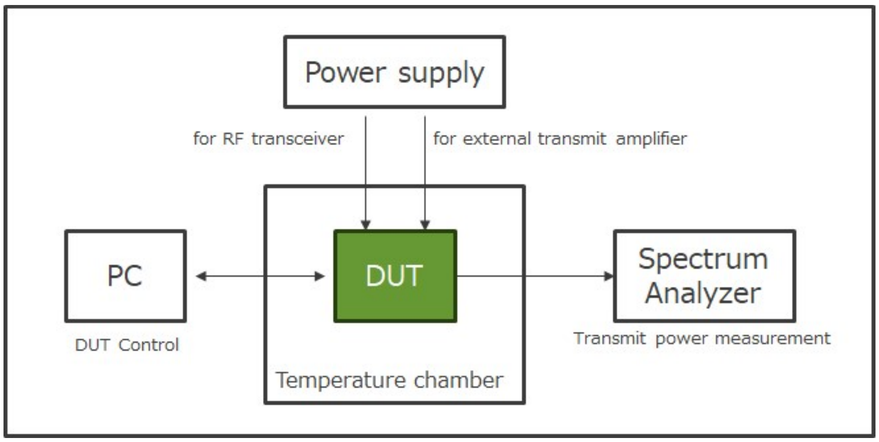

Figure 3-1 : Measurement system

3.2 Parameter adjustment flow

Figure 3-2 shows the parameter adjustment flow.

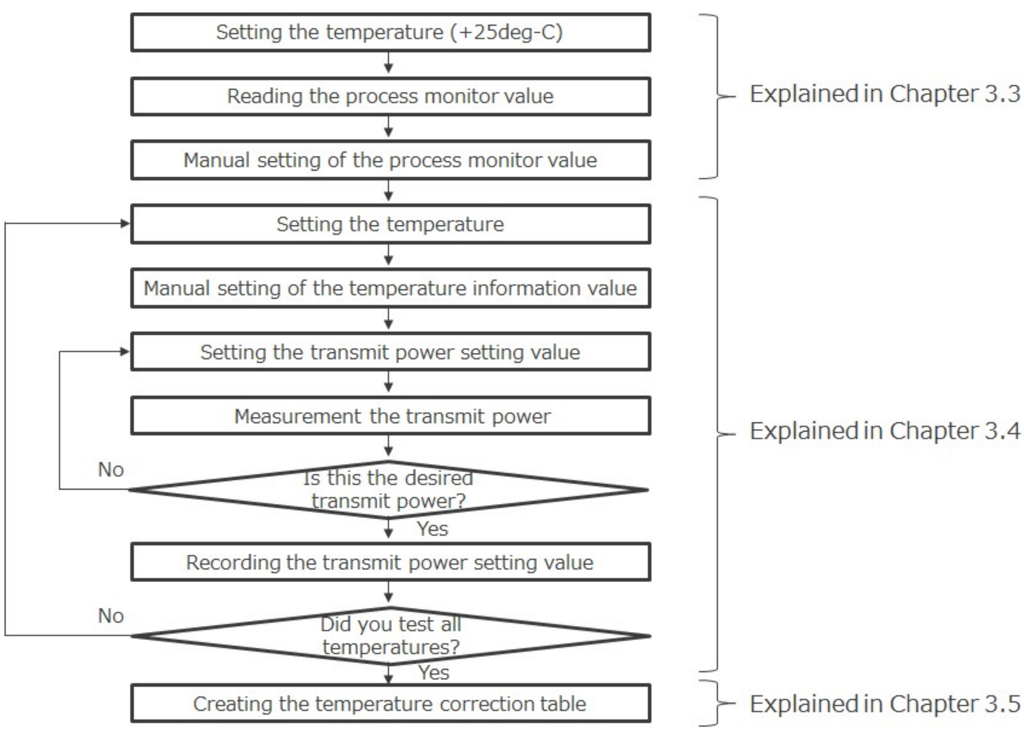

Figure 3-2 : Parameter adjustment flow

3.3 Manual setting of the process monitor value

Check the process monitor value of the RF transceiver at room temperature (+25deg-C) and manually set the process monitor value.

The RF transceiver performs process calibration at startup and reflects the results in the process monitor value. The process monitor value is read by firmware and the register settings are adjusted according to the process monitor value to compensate for individual IC variations. If the ambient temperature at startup is different, the process monitor value may change.

In this adjustment, a fixed process monitor value is used to improve the accuracy of temperature compensation. The fixed value is the process monitor value confirmed at room temperature, and is manually set to be used at all temperatures.

1. Set the temperature to room temperature (+25deg-C).

2. After the RF transceiver starts up, execute the "pmonadj on" command to read the process monitor values and manually set the values. In the example below, the process monitor value for room temperature is set to 0x09. Even if the temperature changes, the fixed value of 0x09 will be used.

```
command (and SetData[Dec])? >pmonadj on
   APL ---> STACK  set Process Monitor value adjustment
   Process Monitor value adjustment: ON (value: 9)
```

(#) If the board power is turned off or reset during the adjustment procedure in Chapter 3, the manually set process monitor value will be reset, so please set the process monitor value confirmed at room temperature again. In the example below, the "pmonadj XX" command is used to set the value (value: 9) that was confirmed in step 2.

```
command (and SetData[Dec])? >pmonadj 0x09
   APL ---> STACK  set Process Monitor value adjustment
   Process Monitor value adjustment: ON (value: 9)
```

3.4 Adjusting the transmit power setting value

Adjust the transmit power setting value(ttxpow) to output the desired transmit power. The transmit power setting value must be adjusted under specific temperature conditions. Use a temperature chamber to change the temperature conditions.

Adjust the transmit power setting value according to the procedures in sections 3.4.1 to 3.4.3 under each temperature condition. Adjustment of the transmit power setting value must be performed separately for the FSK signal and the OFDM signal.

3.4.1 Transmit power setting value (ttxpow)

The transmit power setting value is the RF transceiver transmit power setting value. This can be set using the "ttxpow" command.

Table 3-1 shows the possible setting ranges for the transmit power setting value.

Table 3-1 : ttxpow setting range

Mode	Setting range	note
FSK	-34～32 (#)	The set value divided by 2 indicates the absolute power value (dBm).
OFDM	-41～35 (#)	

(#)The maximum level that can be set may be limited to meet the input rating of the external transmit amplifier. If a limit is set, use a transmit power setting value within that range.

3.4.2 Setting the temperature

Use a temperature chamber to set the temperature (Ta) around the board. There are 10 types of temperature settings as shown in Table 3-2.

Start at +25deg-C.

Table 3-2 : Temperature settings

Temp [deg-C]	-40	-35	-20	-5	+10	+25	+40	+55	+70	+85
Temperature Info value (temp index)	0	1	2	3	4	5	6	7	8	9

3.4.3 Manual setting of the temperature Info value (temp index)

Manually set the temperature information value according to your temperature settings.

The RF transceiver stores temperature information internally, and before transmission begins, the firmware reads this information and sets registers according to the temperature information to compensate for fluctuations in transmission power due to temperature. It has temperature information ranging from 0 to 9 depending on the ambient temperature. If there is variation in IC characteristics, different temperature information may be output between ICs even at the same temperature.

In this adjustment, a fixed temperature information value according to the temperature setting is used to improve the accuracy of temperature compensation. For fixed values, refer to Table 3-2 and set them manually.

1. Use the "tmonadj" command to manually set the temperature info value. In the example below, set "5" as a setting example for +25deg-C.

```
command (and SetData[Dec])? >tmonadj 5
   APL ---> STACK  set Temperature Monitor value adjustment
   Temperature Monitor value adjustment: ON (value: 5)
```

3.4.4 Searching the transmit power setting value

Connect the board's antenna output terminal to a measuring device that can measure transmission power (such as a spectrum analyzer or power meter) and search for the desired transmit power setting value.

1. Use the "ttxpow" command to set the desired transmit power value. In the example below, set is "7".

```
command (and SetData[Dec])? >ttxpow 7
   APL ---> STACK  set Transmit Power Setvalue =  FSK: 7 (3.5 [dBm]), OFDM: 7 (3.5 [dBm])
```

2. Start transmission. The example below shows the transmission commands for FSK and OFDM signals.

(FSK example)

```
command (and SetData[Dec])? >tfpn9
   APL ---> STACK  FSK ConTxModu for PN9     Freq = 915000000 [Hz]
```

(OFDM example)

```
command (and SetData[Dec])? >topn9
   APL ---> STACK  OFDM ConTxModu for PN9     Freq = 915000000 [Hz]
```

3. Check the transmission power. Check the transmission power using a spectrum analyzer or similar.

4. Stop transmission. (Pressing the return key will stop transmission.)

```
command (and SetData[Dec])? >tfpn9
   APL ---> STACK  FSK ConTxModu for PN9     Freq = 915000000 [Hz]

   APL ---> STACK  ConTxStop
```

5. If the desired transmission power is not achieved in step 3, change the transmit power setting value and repeat steps 1 to 4.

6. When the desired transmit power is achieved, record the transmit power setting value used.

Once you have recorded the transmit power setting value at the current temperature, return to Section 3.4.2 and record the transmit power setting value at a different temperature. Record the transmit power setting values for 10 types of temperatures.

3.5 Creating the temperature compensation table

Create a temperature compensation table using the transmit power setting value recorded in section 3.4.

3.5.1 Calculating the temperature compensation value

Calculate the difference between the transmit power setting values at each temperature and the transmit power setting value at +25deg-C.

An example of a reference kit is shown and explained. This is an example when the antenna transmit power is +30dBm for FSK and +23dBm for OFDM.

1. Table 3-3 shows the transmit power setting values recorded at each temperature.

Table 3-3 : transmit power setting values

Temp [deg-C]	-40	-35	-20	-5	+10	+25	+40	+55	+70	+85
ttxpow (FSK)	2	2	3	4	5	7	8	9	10	10
ttxpow (OFDM)	0	1	2	2	2	3	3	4	5	6

2. Calculate the difference from +25deg-C. The difference is shown in Table 3-4. This is the temperature compensation table.

Table 3-4 : temperature compensation table

Temp [deg-C]	-40	-35	-20	-5	+10	+25	+40	+55	+70	+85
ttxpow compensation amount (FSK)	-5	-5	-4	-3	-2	0	1	2	3	3
ttxpow compensation amount (OFDM)	-3	-2	-1	-1	-1	0	0	1	2	3

3.5.2 Setting the temperature compensation table

This section explains the procedure for setting the temperature compensation table using the test program command.

1. Use the "tftxcorr" command to set the FSK temperature compensation table. In the example below, the values in Table 3-4 are set.

```
command (and SetData[Dec])? >tftxcorr -5 -5 -4 -3 -2 0 1 2 3 3
   APL ---> STACK
   FSK tx temprature correction table
   temp index:   0   1   2   3   4   5   6   7   8   9
        value:  -5  -5  -4  -3  -2   0   1   2   3   3
```

2. Use the "totxcorr" command to set the OFDM temperature compensation table. In the example below, the values in Table 3-4 are set.

```
command (and SetData[Dec])? >totxcorr -3 -2 -1 -1 -1 0 0 1 2 3
   APL ---> STACK
   OFDM tx temprature correction table
   temp index:   0   1   2   3   4   5   6   7   8   9
        value:  -3  -2  -1  -1  -1   0   0   1   2   3
```

Note1 : If you do not want to use temperature compensation, use the above command to set all values to "0".

Note2 : If a limit is set for the ttxpow value, and the ttxpow value after temperature compensation exceeds the limit, the ttxpow value of the limit value will be output. Set the limit value considering the increase due to temperature compensation.

4. Checking characteristics when using temperature compensation

This chapter shows how to evaluate the transmit power characteristics when using the temperature compensation table calculated in Chapter 3.

4.1 Test commands used in the evaluation

The test commands used in this evaluation are shown in Table 4-1 and Table 4-2.

Table 4-1 : Test commands (FSK)

? >rst	- Hardware reset
? >tboot 11	- Boot mode setting(e.g. 11)
? >pmonadj 0x09	- Process monitor setting (e.g. 9)
? >tftxcorr -5 -5 -4 -3 -2 0 1 2 3 3	- Temperature correction table setting (FSK)
? >tope FSK NA f 1b 1	- Operation mode setting(e.g. NA band / FSK 50kbps_m=1)
? >tch 64	- Channel setting(e.g. 915MHz)
? >ttxpow 7	- TX power setting(e.g. +3.5dBm@RX65W-A output)
? >tfpn9	- TX start

Table 4-2 : Test commands (OFDM)

? >rst	- Hardware reset
? >tboot 11	- Boot mode setting(e.g. 11)
? >pmonadj 0x09	- Process monitor setting (e.g. 9)
? >totxcorr -3 -2 -1 -1 -1 0 0 1 2 3	- Temperature correction table setting (OFDM)
? >tope OFDM NA op4 m6 1	- Operation mode setting(e.g. NA band / OFDM Option4-MCS6)
? >tch 64	- Channel setting(e.g. 915MHz)
? >ttxpow -7	- TX power setting(e.g. -3.5dBm@RX65W-A output)
? >topn9	- TX start

4.2 Example of characteristics with and without temperature compensation

Figure 4-1 shows an example of FSK characteristics with and without correction, and Figure 4-2 shows an example of OFDM characteristics with and without correction. The left figure shows the absolute power value, and the right figure shows the power difference from +25deg-C.
It can be seen that using temperature compensation improved the transmit power fluctuation due to temperature. Tables 4-1 and 4-2 show the evaluation conditions.

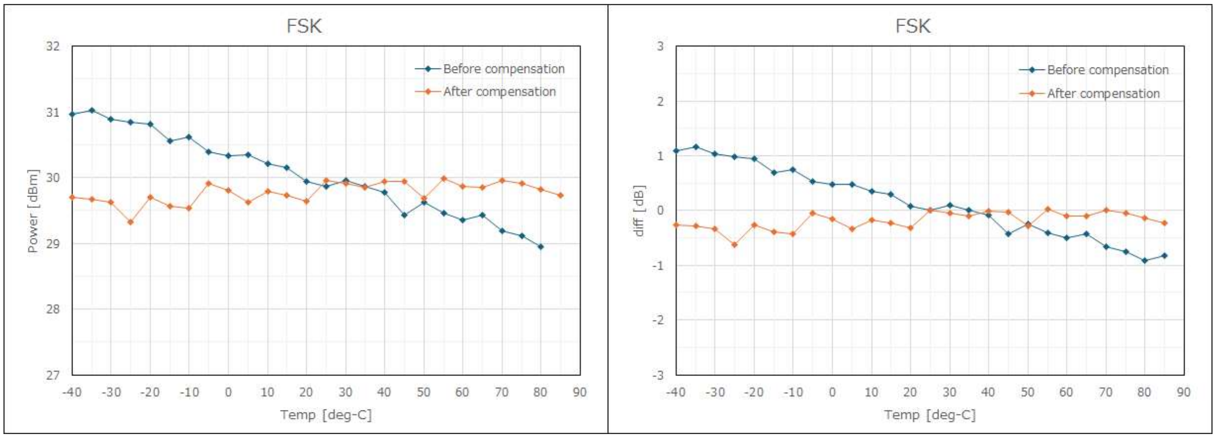

Figure 4-1 : Example of transmission power characteristics (FSK)

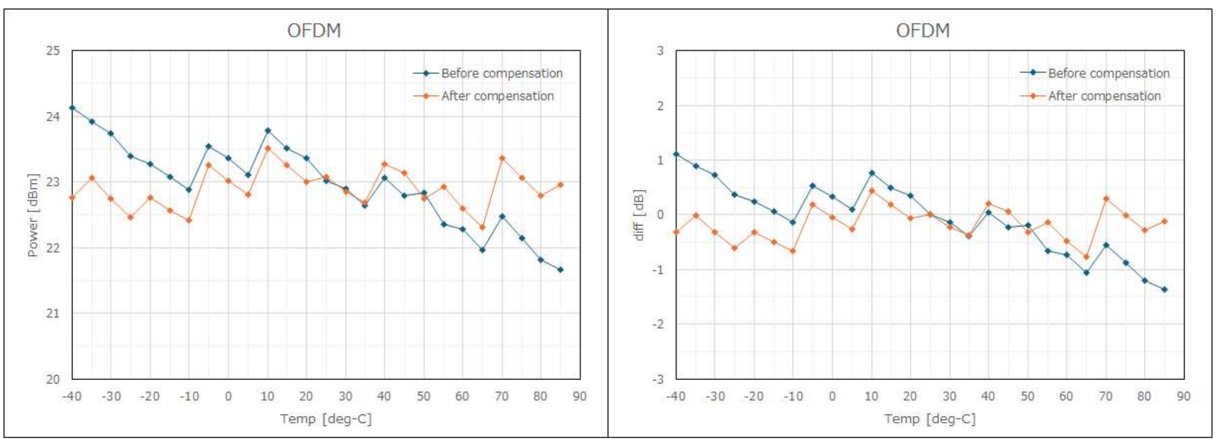

Figure 4-2 : Example of transmission power characteristics (OFDM)

Table 4-1 : Measurement conditions

	Frequency	Modulation	Target Power	ttxpow setting
FSK	915 MHz	50kbps_m=1	+30 dBm	7
OFDM	915 MHz	Option4 - MCS6	+23 dBm	-7

Table 4-2 : Temperature compensation table used

temp index	0	1	2	3	4	5	6	7	8	9
ttxpow compensation amount (FSK)	-5	-5	-4	-3	-2	0	1	2	3	3
ttxpow compensation amount (OFDM)	-3	-2	-1	-1	-1	0	0	1	2	3

The process monitor value (pmonadj) is fixed at 0x09 for evaluation.

5. Factory Calibration

Parameters related to transmission power (transmit power setting value and process monitor value) may vary for each board due to variations in gain of the RF transceiver and external transmit amplifier.

Therefore, we recommend that you perform factory calibration for each board and store the adjustment values in the flash ROM in the MCU.

Table 5-1 shows the parameters that require factory calibration.

Table 5-1 : Factory Calibration

Item	Detail
Process monitor value	Process monitor values at room temperature (+25deg-C)
Transmit power setting value (FSK)	FSK transmit power setting value that can output the target antenna power at room temperature (+25deg-C)
Transmit power setting value (OFDM)	OFDM transmit power setting value that can output the target antenna power at room temperature (+25deg-C)

5.1 Factory Calibration flow

Figure 5-1 shows the factory calibration flow.

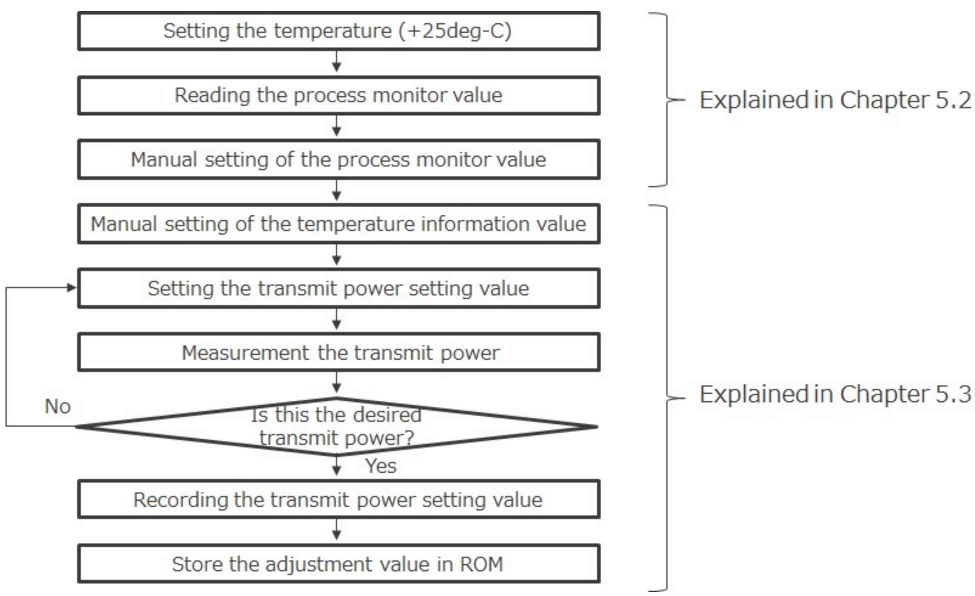

Figure 5-1 : Factory calibration flow

5.2 Manual setting and recording of the process monitor value

Check the process monitor value of the RF transceiver at room temperature (+25deg-C) and manually set the process monitor value. Also, record the value to store it in flash ROM.

1. Set the temperature to room temperature (+25deg-C).

2. After the RF transceiver starts up, execute the "pmonadj on" command to read the process monitor values and manually set the values. In the example below, the process monitor value for room temperature is set to 0x09.

```
command (and SetData[Dec])? >pmonadj on
   APL ---> STACK  set Process Monitor value adjustment
   Process Monitor value adjustment: ON (value: 9)
```

3. Record the process monitor values obtained in step 2. The process monitor value in this example is 0x09.

5.3 Adjusting and recording of the transmit power setting value

Adjust the transmit power setting value(ttxpow) to output the desired transmit power. Also, record the value to store it in flash ROM.

5.3.1 Manual setting of the temperature Info value (temp index)

Manually set the temperature information value.

1. Use the "tmonadj" command to manually set the temperature info value. Since the factory calibration is performed at room temperature (+25deg-C), the temperature information value is set to a fixed value of "5".

```
command (and SetData[Dec])? >tmonadj 5
   APL ---> STACK  set Temperature Monitor value adjustment
   Temperature Monitor value adjustment: ON (value: 5)
```

5.3.2 Searching the transmit power setting value

Connect the board's antenna output terminal to a measuring device that can measure transmission power (such as a spectrum analyzer or power meter) and search for the desired transmit power setting value.

1. Use the "ttxpow" command to set the desired transmit power value. In the example below, set is "7".

```
command (and SetData[Dec])? >ttxpow 7
   APL ---> STACK  set Transmit Power Setvalue =  FSK: 7 (3.5 [dBm]), OFDM: 7 (3.5 [dBm])
```

2. Start transmission. The example below shows the transmission commands for FSK and OFDM signals.

(FSK example)

```
command (and SetData[Dec])? >tfpn9
   APL ---> STACK  FSK ConTxModu for PN9     Freq = 915000000 [Hz]
```

(OFDM example)

```
command (and SetData[Dec])? >topn9
   APL ---> STACK  OFDM ConTxModu for PN9     Freq = 915000000 [Hz]
```

3. Check the transmission power. Check the transmission power using a spectrum analyzer or similar.

4. Stop transmission. (Pressing the return key will stop transmission.)

```
command (and SetData[Dec])? >tfpn9
   APL ---> STACK  FSK ConTxModu for PN9     Freq = 915000000 [Hz]

   APL ---> STACK  ConTxStop
```

5. If the desired transmission power is not achieved in step 3, change the transmit power setting value and repeat steps 1 to 4.

6. When the desired transmit power is achieved, record the transmit power setting value used.

The process monitor value, transmit power setting value (FSK), and transmit power setting value (OFDM) recorded using the procedure in Chapter 5 are stored in the flash ROM.

When using in an actual system, read the value stored in firmware after starting the MCU and use it as the IB setting value. For IB settings, please refer to Chapter 6.

6. IB setting value

Table 6-1 shows the IB settings that reflect the temperature compensation table values and factory calibration values. In actual systems, please use the compensation values calculated in this document as the IB setting values.

Table 6-1 : IB settings

Item	IB name	Note
Temperature compensation table value (FSK)	phyFskTempCorrTable	Please set the temperature compensation table values calculated in Chapter 3.
Temperature compensation table value (OFDM)	phyOfdmTempCorrTable	Please set the temperature compensation table values calculated in Chapter 3.
Process monitor value	phyProcMonAdjEna	Please set it to 0x01.
	phyProcMonValue	Please set the factory calibration value calculated in Chapter 5. (Flash ROM stored value)
Transmit power setting value (FSK)	phyFskTransmitPower	Please set the factory calibration value calculated in Chapter 5. (Flash ROM stored value)
Transmit power setting value (OFDM)	phyOfdmTransmitPower	Please set the factory calibration value calculated in Chapter 5. (Flash ROM stored value)

For detailed information regarding IB settings, please refer to the following document:

R30UW0077: R9A06G062・RX65W-A Sub-GHz RF Driver API Specification

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Mar.27.2026	-	First edition issued

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.

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