CMOSTEK

AN166

CMT2219B RSSI User Guide

Overview

This document discusses RSSI related registers and their usage as well as the calibration methods of the CMT2219B.

The product models covered in this document are shown in the below table.

Table 1. Product Models Covered in the Document

Product Model	Frequency Range	Modulation Type	Main Function	Configuration Mode	Packaging
CMT2219B	127 - 1020 MHz	(G)FSK/OOK	Receiver	Register	QFN16

Before reading this document, it is recommended to read the *AN161-CMT2219B Quick Start Guide* to understand the basic information of the CMT2219B.

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1 RSSI Measurement and Comparison

The purpose of RSSI measurement is to help users get the accurate value of the currently received signal strength. The measurement value of the RSSI of a received signal can be regarded to some extent as the equivalence of the communication distance at a constant transmission power.

In the procedure of RSSI comparison, it compares the current real-time RSSI value to a threshold to generate a signal indicating whether the RSSI is valid. This indication signal can be mapped to the RSSI_VLD interrupt for application usage or sent to the chip to implement super-low power (SLP) receiver.

1.1 RSSI Measurement Related Registers

The corresponding RFPDK UI screen and parameters are shown in the below figure.

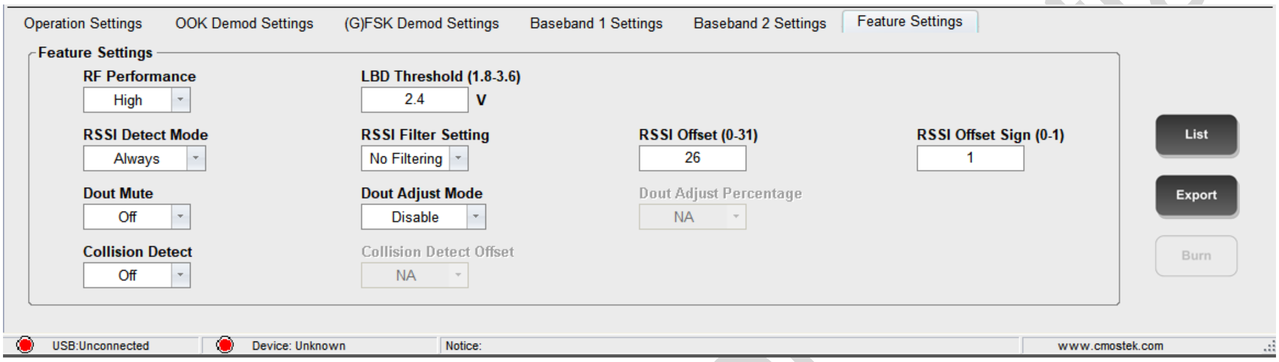

Figure 1. RFPDK UI Screen and Parameters for RSSI

Table 2. RSSI Related Bit Flags

Register Bit Flag for RFPDK	Register Bits
RSSI offset sign	RSSI_OFFSET_SIGN
RSSI offset	RSSI_OFFSET<4:0>
RSSI detection mode	RSSI_DET_SEL<1:0>
RSSI filter setting	RSSI_AVG_MODE<2:0>

See the below table for the register descriptions.

Table 3. Registers in Configuration Area

Name	Bits	R/W	Bit Flag	Description
CUS_CMT9 (0x08)	7	RW	RSSI_OFFSET_SIGN	The sign bit of the error compensation value for RSSI measurement.
CUS_RSSI (0x0B)	7:3	RW	RSSI_OFFSET<4:0>	Error compensation value for RSSI measurement.
CUS_SYS11 (0x16)	4:3	RW	RSSI_DET_SEL<1:0>	RSSI measurement time. 0: measure continuously 1: measure when PREAM_OK is active 2: measure when SYNC_OK is active

Name	Bits	R/W	Bit Flag	Description
				3: measure when PKT_OK is active
	2:0	RW	RSSI_AVG_MODE<2:0>	Average filtering order of RSSI measurement. 0: no filtering 1: 4th-order 2: 8th-order 3: 16th -order 4: 32nd order

Table 4. Registers in Control Area 2

Name	Bits	R/W	Bit Flag	Description
CUS_RSSI_CODE (0x6F)	7:0	RW	RSSI_CODE<7:0>	The read value of RSSI is an 8-bit code without unit, which is the filtering output of the SAR ADC.
CUS_RSSI_DBM (0x70)	7:0	RW	RSSI_DBM<7:0>	The read value of RSSI subtracted 128, with a unit of dBm, is equivalent to the signal power value at the input end of the antenna, which is the output value of the SAR ADC after filtering and unit conversion to dBm.

1.2 RSSI Measurement and Comparison in FSK mode

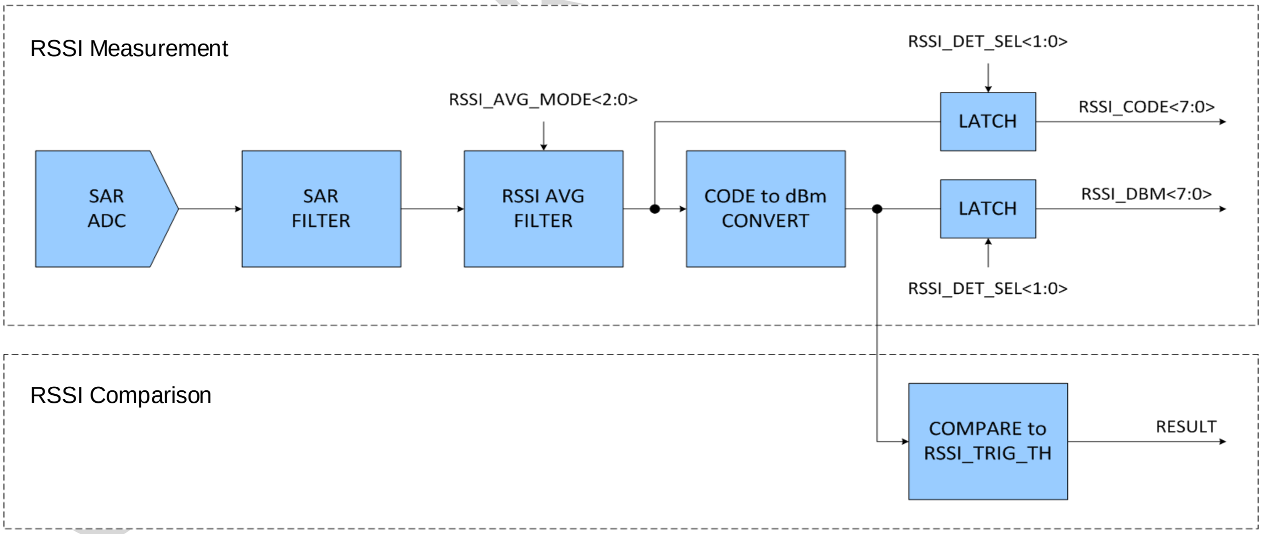

Figure 2. Structure Diagram of RSSI Measurement and Comparison in FSK mode

The RSSI measurement consists of following steps. First, through the SAR ADC, the real-time RSSI signal is converted to output an 8-bit code value. Then first-order filtering is performed by SAR FILTER to obtain a relatively smooth RSSI code value. Then, further smoothing is performed by the second-order RSSI AVG FILTER, with the order of the filtering set via RSSI_AVG_MODE<2:0> by users. After the smoothing filtering, the code value is converted to a value in dBm. At last, the values before and after the unit conversion are sent to the register for conditional latching with the latch condition configured by setting

RSSI_DET_SEL<1:0>. Users can read the register directly to obtain the final RSSI value.

In RSSI comparison procedure, the real-time RSSI value measured is compared to the threshold in dBm set by users in RSSI_TRIG_TH<7:0>-128 and it outputs *1* when it is greater than the threshold and outputs 0 when it is less. This output is used as one of the RSSI_VLD signal sources.

- **The method of selecting smoothing filter order**

The filtering order is equivalent to how many symbols passing through to obtained one correct RSSI value. The higher the order, the longer the filtering time, and the more smooth the result is. However, the order is limited by the measurement condition as well. For example, when RX_PREAM_SIZE is set as the length of 16 symbols, and RSSI_DET_SEL<1:0> is set to 1 (other words, active PREAM_OK is set as the RSSI measurement condition), it can output a correct RSSI value only if the filtering order is set not greater than 16. That is because, it receives PREAM_OK after receiving 16 symbols in a preamble, if the filtering order is set as 16, it can exactly obtain one correct average value based on the 16 symbols received. Surely, a more stable measurement result can be obtained if the order is set smaller than RX_PREAM_SIZE. Similarly, when the measurement condition is SYNC_OK or PKT_OK, it needs to ensure the number of symbols received before the two interrupts occurring is greater than the filtering order.

To accommodate different using habits of users, the CMT2219B provides both RSSI values in dBm and simple 8-bit code values. RSSI values in dBm is recommended in general.

1.3 RSSI Measurement and Comparison in OOK Mode

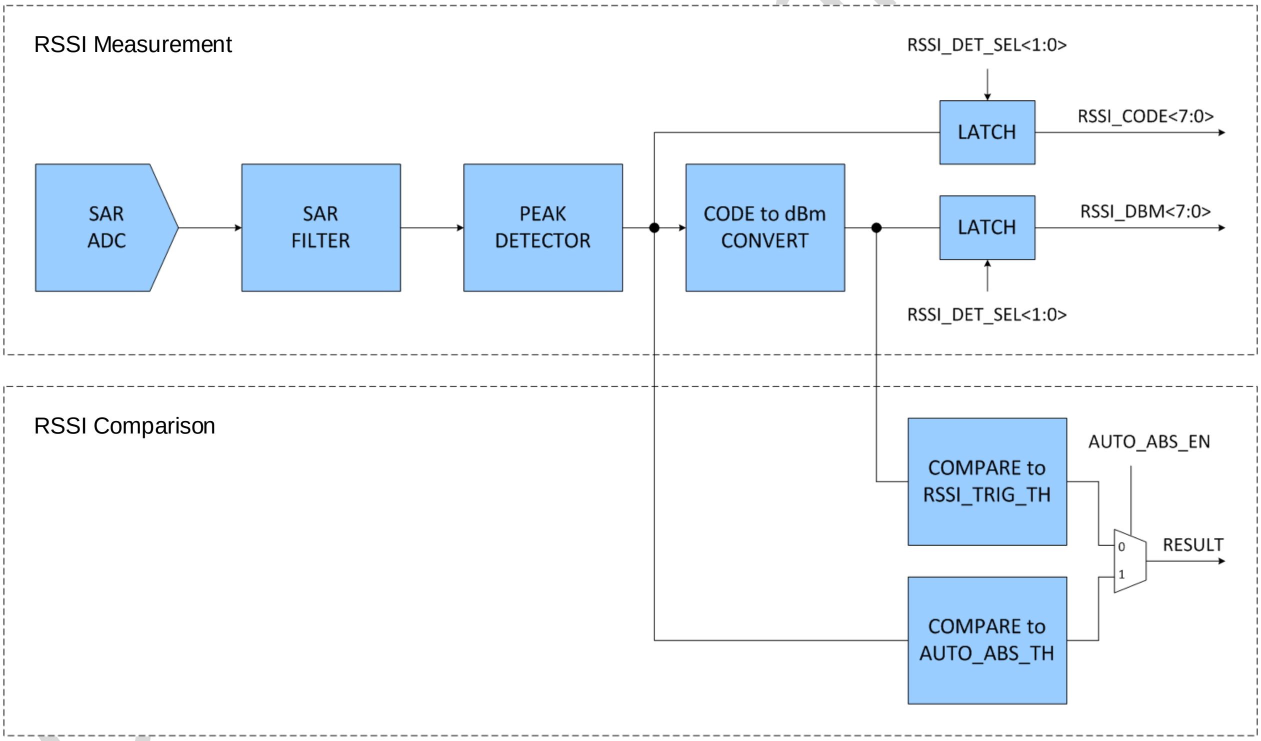

Figure 3. Structure Diagram of RSSI Measurement and Comparison in OOK Mode

Since OOK is based on amplitude modulation, RSSI will show high and low transitions. However, users need a constant RSSI value representing signal *1*, therefore the PEAK DETECTOR is used in the circuit to pick up peak values (the RSSI value representing *1*) in the signal and output them to register.

Moreover, 2 RSSI comparison methods are available in OOK mode. One is the same as that of FSK mode, the other is called automatic absolute threshold which is enabled by setting AUTO_ABS_EN. When it is enabled, the chip will generate a threshold automatically for noise shielding and compared it to the output of PEAK DETECTOR with support of comparison result output.

The automatic absolute threshold has the advantage in automatic noise shielding, saying that, when there is no signal the demodulation output is zero, with no noise impact. Moreover, the comparison results can also be used to help implement super-low power (SLP) receiver, no need for users' manual measuring or debug to obtain appropriate thresholds. However, the disadvantage is the loss of 12 dB of receiving sensitivity when automatic absolute threshold is used.

1.4 RSSI Measurement Result Compensation

The read value of RSSI_DBM minus 128 is the RSSI measurement result. Users can get the RSSI measurement result value this way in general,

$$\text{RSSI @ RF\_Input} = \text{RSSI\_dBm}\langle 7{:}0\rangle - 128$$

If a relatively high accurate measurement is required, it needs to perform further calibration after chip production or even after chip being applied in user solutions.

These calibrations involve the use of the three registers mentioned above, RSSI_OFFSET<4:0>, RSSI_OFFSET_SIGN and RSSI_CODE<7:0>. The calibration method is as follows: 1) let the chip enter the RX state with the configuration satisfying application requirements. 2) set RSSI_OFFSET and RSSI_OFFSET_SIGN to *0*. 3) add the sine wave RF signal with a in-band signal strength of - 90 dBm to the RFIN end. 4) read the RSSI_CODE<7:0> value, calculate based on the following formula and update the calculation result to the RSSI_OFFSET and RSSI_OFFSET_SIGN registers.

$$\text{RSSI\_OFFSET}\langle 4{:}0\rangle = |\,\text{RSSI\_CODE}\langle 7{:}0\rangle - 91|$$

$$\text{RSSI\_OFFSET\_SIGN} = \begin{cases} 1, \text{ When RSSI\_CODE}\langle 7{:}0\rangle - 91 > 0 \\ 0, \text{ When RSSI\_CODE}\langle 7{:}0\rangle - 91 < 0 \end{cases}$$

After calibration, the RSSI measurement value is increasing monotonically from -128 dBm to 20 dBm. It shows fine linearity from -100 to -50 dBm, reaching an accuracy of ± 3dB.

2 Revise History

Table 2. Revise History Records

Version No.	Chapter	Description	Date
0.7	All	Initial version	2018-10-10

3 Contacts

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