CC110x/CC111x OOK/ASK Register Settings

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Keywords

- *OOK*
- *ASK*
- *PER (Packet Error Rate)*
- *CC1100*
- *CC1100E*

- *CC1101*
- *CC1110*
- *CC1111*
- *CC430*

1   Introduction

This design note provides guidelines for finding optimum register settings for OOK/ASK operation. The starting point for the optimization is the preferred settings given by the SmartRF® Studio SW. The user needs to measure the sensitivity (PER) over the full input dynamic range to determine the optimum settings.

This design note uses CC1101 as an example on how to find optimum register settings, but it is also applicable for CC1100, CC1100E, CC1110, CC1111, and CC430.

Table of Contents

2   Abbreviations

AGC	Automatic Gain Control
ASK	Amplitude Shift Keying
EM	Evaluation Module
2-FSK	Frequency Shift Keying
GFSK	Gaussian shaped Frequency Shift Keying
IF	Intermediate Frequency
MSK	Minimum Shift Keying
OOK	On-Off Keying
PER	Packet Error Rate
SW	Software

3 OOK/ASK Register Settings

3.1 AGC Settings

The register settings provided by SmartRF® Studio have been optimized for 2-FSK/GFSK/MSK modulation and when using one of the preferred settings and only changing the modulation format to OOK/ASK, the AGC settings might result in unstable or non-optimum reception (i.e. degraded sensitivity). This is pictured in Figure 1.
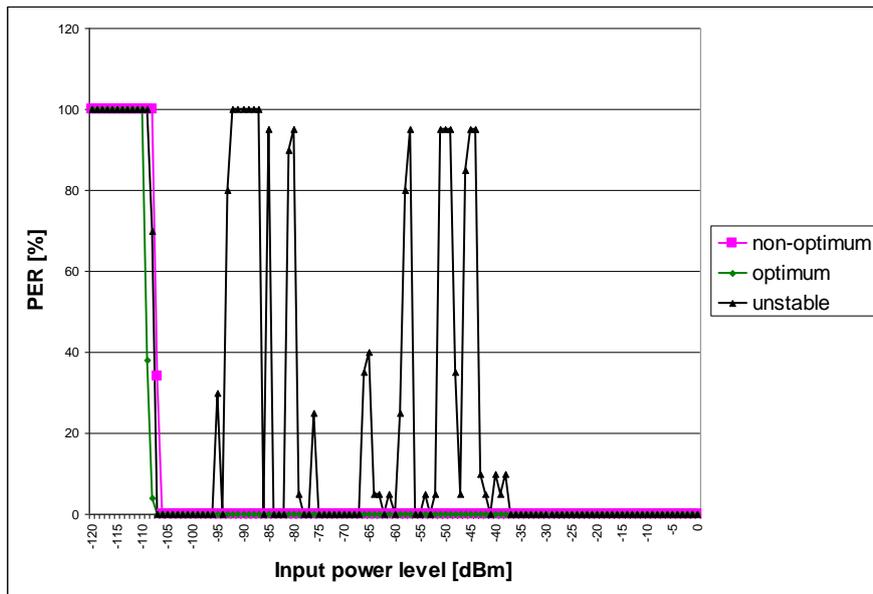

Figure 1. Example of Unstable, Non-Optimum, and Optimum Reception

The optimum AGC settings change with RX filter bandwidth and data rate, but for OOK/ASK the following has been found to give good results:

AGCCTRL2 = 0x03 to 0x07
AGCCTRL1 = 0x00
AGCCTRL0 = 0x91 or 0x92

In the example shown in Figure 2, the best sensitivity is achieved with AGCCTRL2 = 0x04, AGCCTRL1 = 0x00, and AGCCTRL0 = 0x92. Please note that optimum register settings change with data rate so it is important to measure sensitivity for different combinations of AGCCTRL2 and AGCCTRL0. Furthermore, as shown in Figure 1, some combinations of AGC settings results in unstable reception. That is, for some input power levels above the sensitivity limit there will be degraded packet error rate (PER). It is therefore important to check the PER for the entire dynamic range and not only at the sensitivity limit. One option is to check the PER for every 2 dB increase in input power level.

AGCCTRL2.MAGN_TARGET[2:0] is used to set an on-chip target value for the peak signal amplitude. MAGN_TARGET is used by the AGC loop to set the correct gain.

AGCCTRL0.FILTER_LENGTH[1:0] is used to configure the ASK decision boundary. If the ASK decision boundary is set to 8 dB, the "low" bit must be at least 16 dB below the "high" bit.
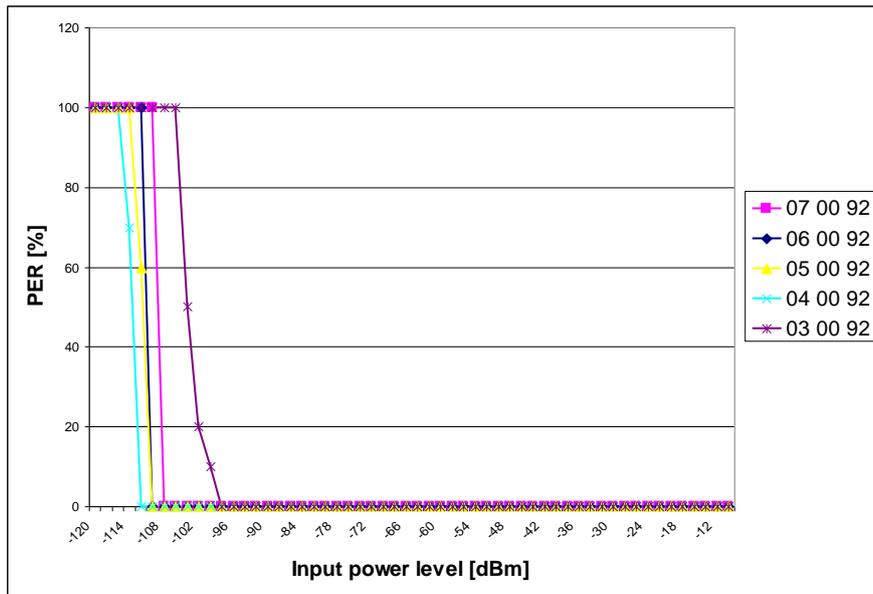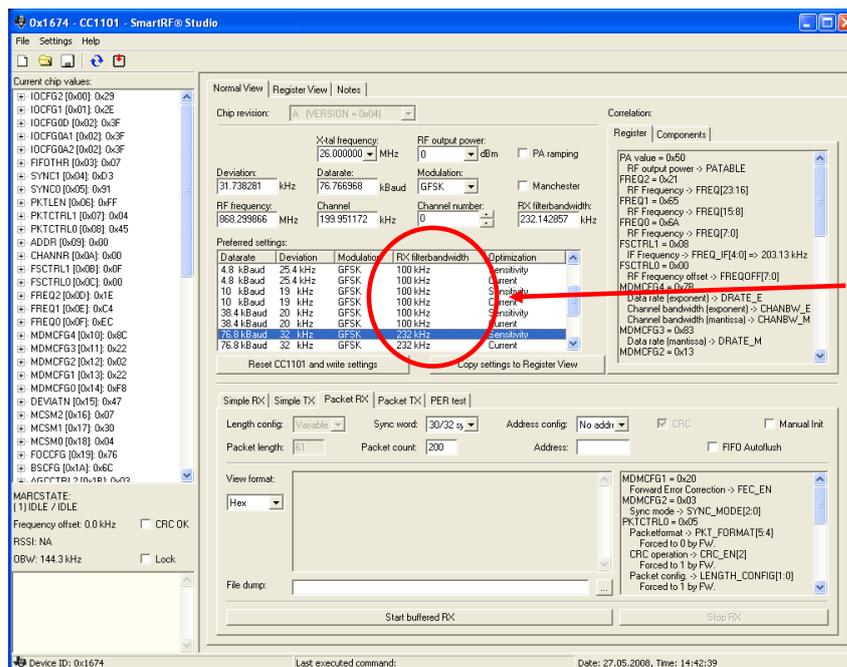
Figure 2. PER versus Input Power Level for Different AGC Register Settings (3.8 kBaud, 100 kHz RX Filter Bandwidth)

3.2 IF Frequency

Register FSCTRL1 sets the IF frequency and the optimum value is different for different RX filter bandwidths. It is therefore recommended to find the FSCTRL1 setting using one of the preferred RX filter bandwidth settings in SmartRF® Studio (see Figure 3). If the wanted RX filter bandwidth is not given by one of the preferred settings, choose the FSCTRL1 setting for the first RX filter bandwidth that is wider than the wanted RX filter bandwidth.

As an example, for a wanted 150 kHz RX filter bandwidth use the FSCTRL1 setting given for 232 kHz RX filter bandwidth.

RX filter bandwidths used by preferred settings: 58 kHz, 100 kHz, 232 kHz, 325 kHz, 540 kHz, 812 kHz

Figure 3. Available RX Filter Bandwidths Given by the Preferred Settings in SmartRF® Studio

Note that the FREND1, FIFOTHR, TEST2, and TEST1 register settings change for different RX filter bandwidths.

FREND1:
- RX filter bandwidth > 101 kHz, FREND1 = 0xB6
- RX filter bandwidth ≤ 101 kHz, FREND1 = 0x56

TEST2:
- RX filter bandwidth > 325 kHz, TEST2 = 0x88
- RX filter bandwidth ≤ 325 kHz, TEST2 = 0x81

TEST1:
- RX filter bandwidth > 325 kHz, TEST1 = 0x31
- RX filter bandwidth ≤ 325 kHz, TEST1 = 0x35

FIFOTHR:
- RX filter bandwidth > 325 kHz, FIFOTHR = 0x07
- RX filter bandwidth ≤ 325 kHz, FIFOTHR = 0x47

3.3 Procedure for Finding OOK/ASK Settings using SmartRF® Studio

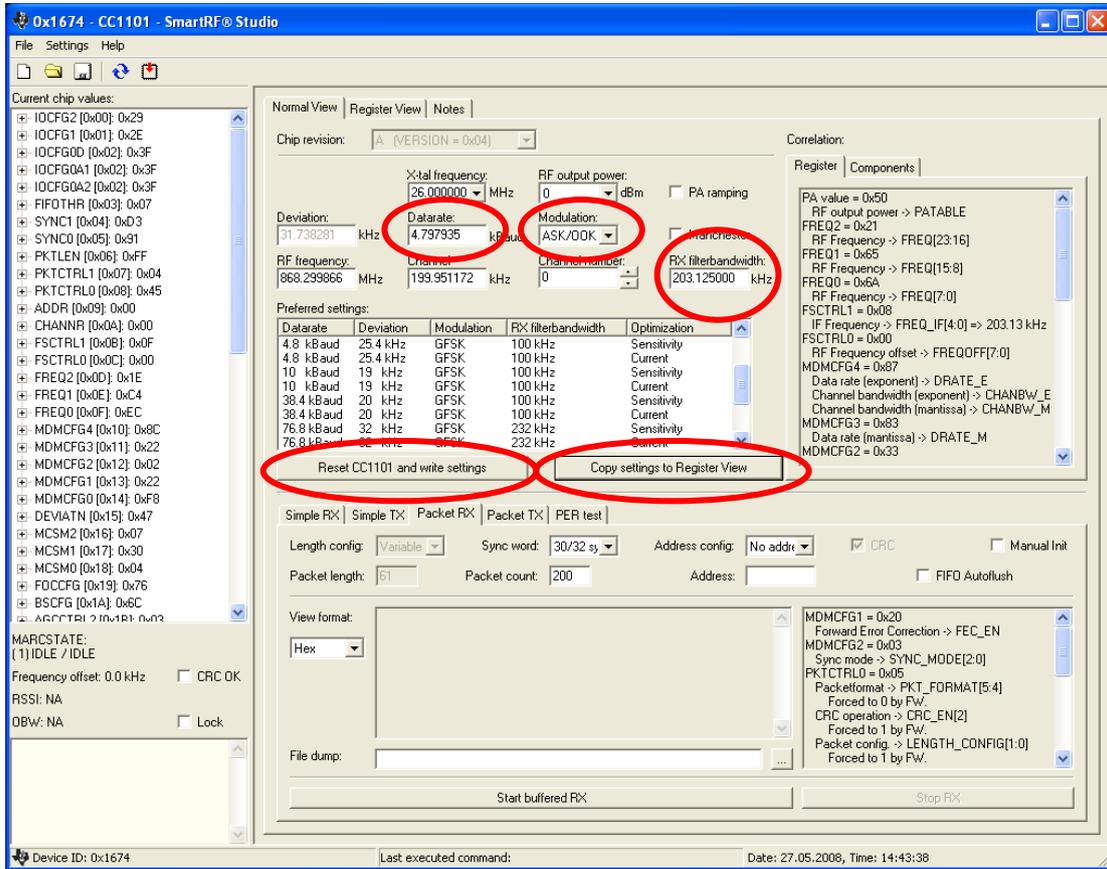As an example, assume 4.8 kBaud data rate and 203 kHz RX filter bandwidth.

1) Use SmartRF® Studio to find the optimum IF frequency. Select the preferred setting that has an RX filter bandwidth equal to the wanted bandwidth. If the wanted RX filter bandwidth is not given by one of the preferred settings, chose the first RX filter bandwidth that is wider than the wanted bandwidth. For a 203 kHz wanted RX filter bandwidth, select the 232 kHz RX filter bandwidth for optimum IF frequency.

2) Change the data rate and the RX filter bandwidth to the wanted values. Change the modulation format to ASK/OOK. Press "Reset CC1101 and write settings" (if SmartRF® Studio is being used to control a CC1101EM) and then "Copy settings to Register View"

3) In Register View, change the AGCCTRL2, AGCCTRL1, and AGCCTRL0 settings as explained in Section 3.1. Make sure the FSCTRL1, FIFOTHR, FREND1, TEST2, and TEST1 registers are set as explained in Section 3.2. It is possible to print the register settings to a file using "Export CC1101 Registers" under "File". Press the "Write" button for the register to be updated if SmartRF® Studio is being used to control a CC1101EM.

4) If SmartRF® Studio is being used to perform the test, go back to Normal View. Check the Manual Init box for the changes done in Register View to take effect.

4 General Information

4.1 Document History

Revision	Date	Description/Changes
SWRA215E	2012-03-08	Changed document name from "CC11xx OOK/ASK Register Settings" to "CC110x/CC111x OOK/ASK Register Settings"
SWRA215D	2012-02-10	Corrected error in RX BW on page 5
SWRA215C	2012-02-09	Added FIFOTHR to the list of registers on page 5
SWRA215B	2009-11-11	Added CC430 to list of devices
SWRA215A	2009-03-15	Added CC1100E. Added info about TEST2, TEST1, and FREND1 register settings for wide RX filter bandwidths.
SWRA215	2008-06-09	Initial release

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