# CC13xx wM-Bus S-Mode

**ABSTRACT**

This application report describes a wM-Bus S-mode patch for the CC13xx SimpleLink™ Sub-1 GHz ultra-low power wireless microcontroller (MCU). Measurements show that CC13xx meets EN13757-4:2012 [2] specifications with margin.

Recommended register settings discussed in this application report can be downloaded from http://www.ti.com/lit/zip/SWRA512.

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## Trademarks

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# 1 wM-Bus S-Mode

The wireless meter bus (wM-Bus) is an open standard for systems using radio to read remote meters and is supported by all major metering companies in Europe.

wM-Bus stationary mode (S-mode) is intended for unidirectional (S1) or bidirectional (S2) communications between a meter and a stationary or mobile device (see [2]).

**NOTE:** T2-mode uses the same physical layer (PHY) parameters as S-mode when transmitting from the “other device” to the meter.

Table 1 lists the S-mode requirements.

**Table 1. S-Mode Requirements**

| Parameter | Value |
|---|---|
| Chip rate | 32.768 (typical), 32.1113 (minimum), 33.423 (maximum) |
| Deviation | 50 (typical), 40 kHz (minimum), 80 kHz (maximum) |
| Data coding | Manchester |
| Sensitivity | –105 dBm (typical), –100 dBm (minimum) |
| RF carrier frequency | 868.3 MHz |
| Frequency tolerance | ±25 ppm in S2-mode |
| | ±60 ppm in S1-mode |
| Blocking @ 2 MHz offset for Class $H_R$ receivers | ≥ 35 dB – 10 log ($BW_{kHz}$ / 16 kHz)<br>where BW is the RX filter bandwidth<br>196 kHz BW: ≥ 24.1 dB<br>311 kHz BW: ≥ 22.1 dB |
| Blocking @ 10 MHz offset for Class $H_R$ receivers | ≥ 60 dB – 10 log ($BW_{kHz}$ / 16 kHz)<br>where BW is the RX filter bandwidth<br>196 kHz BW: ≥ 49.1 dB<br>311 kHz BW: ≥ 47.1 dB |
| Adjacent band selectivity for Class $H_R$ receivers | ≥ 40 dB |

For S2-mode, the RX filter bandwidth is set wide enough to receive packets for all combinations of data rate, deviation, and frequency offset (±25 ppm). A 196-kHz RX filter bandwidth is used for S2-mode.

S1-mode is transmit only, but RX measurements (where CC1310 is configured to receive from an S1-mode transmitter) are included in this application report. Table 1 shows that S1-mode has a higher frequency tolerance than S2-mode. The RX filter bandwidth is increased to 311 kHz in S2-mode to allow for the ±60 ppm frequency offset.

Performance figures (when using the patch with CC1310) are included in Section 4 and Section 5 for S2-mode and S1-mode, respectively.

All measurements were performed on CC13xxEM-7793_4L reference design [1]. A 3-byte preamble was used in all the measurements.

Measurements show that the CC13xx device meets EN13757-4:2012 [2] specifications with margin.

# 2 wM-Bus S-Mode Patch

The wM-Bus PHY S-mode is not available in radio ROM code, and a wM-Bus patch is required to support this physical layer. The wM-Bus stack uses Proprietary API commands together with wM-Bus related overrides. The patch is part of the SimpleLink™ CC13x0 Software Development Kit [5] and recommended settings and overrides are covered in Section 2.1.

## *2.1 Recommended Operating Limits*

The patch is designed only for wM-Bus S-mode. The user must set the following to make the patch work properly:

- Set the data rate to 32.768 kcps.
- Set the sync word to 0x547696. The sync word is made up of the S-mode sync word 000111011010010110 preceded by 3 × (01) preamble bits.
- Set the number of sync word bits to 24.
- Enable the MSB first.
- Set the RF to 868.3 MHz.

[3] contains a smartrf_settings.c file that has the complete override list and all the required API settings to be used with the patch.

### 2.1.1 API Configuration

Table 2 lists the required changes to the recommended 50 kbps, 2-GFSK radio operation commands from SmartRF™ Studio [4] to be compliant with recommended operation limits listed in Section 2.1.

**Table 2. API Settings Required for the Patch**

| Radio Operation Command | Field | Value |
|---|---|---|
| CMD_PROP_RADIO_DIV_SETUP | modulation.modType | 0 |
| | modulation.deviation | 0xC8 |
| | symbolRate.preScale | 0xF |
| | symbolRate.rateWord | 0x53E3 |
| | rxBw | 0x27 (S2-mode), 0x29 (S1-mode) |
| | preamConf.nPreamBytes | 0x3 |
| | preamConf.preamMode | 0 |
| | formatConf.nSwBits | 0x18 |
| | formatConf.bMsbFirst | 0x1 |
| | centerFreq | 0x0364 |
| | intFreq | 0x8000 |
| | loDivider | 0x05 |
| CMD_FS | Frequency | 0x0364 |
| | fractFreq | 0x4CCC |
| CMD_PROP_TX | syncWord | 0x547696 |
| CMD_PROP_RX | syncWord | 0x547696 |

### 2.1.2 Register Overrides

Table 3 lists the overrides needed in addition to the recommended 50 kbps, 2-GFSK overrides from SmartRF Studio [4] to be compliant with recommended operation limits in Section 2.1.

**Table 3. Additional Register Overrides Required for the Patch**

| Override | Comment |
|---|---|
| HW_REG_OVERRIDE(0x6064,0x1306) | AGC win size 7 samples |
| HW32_ARRAY_OVERRIDE(0x405C,1) | Set divider bias to disabled |
| (uint32_t)0x1800 0200 | Divider 5 |

Four of the 50 kbps, 2-GFSK overrides from SmartRF Studio must be changed (see [3] and Table 4).

**Table 4. Register Overrides to be Changed from 50 kbps, 2-GFSK Radio Register Settings**

| Override | Comment |
|---|---|
| MCE_RFE_OVERRIDE(1, 0, 0, 1, 0, 0) | Run the MCE and RFE patches |
| (uint32_t)0x00F988A3 | Set RSSI offset to adjust reported RSSI by +7 dB |
| HW_REG_OVERRIDE(0x6088,0x611F) | PA ramping and AGC reference level |
| HW_REG_OVERRIDE(0x608C,0x8112) | PA ramping and AGC settle wait = 21 samples |

## 3 Building a Software Example

To test the RF performance of the patch, the user can refer to the rfPacketRX and rfPacketTX examples available when downloading the SimpleLink™ CC13x0 Software Development Kit [5]. See the Proprietary RF Quick Start Guide for more information. A local link to this guide can also be found in the documentation_overview_simplelink_cc13x0_sdk.html found here:

C:\ti\simplelink_cc13x0_sdk_x_xx_xx_xx\docs (assuming that installation has been to the default location)

The smartrf_settings.c file must be replaced with the one included with this document (see [3]).

**NOTE:** When using the rfPacketRX/TX examples, the correct packet format will not be transmitted (with respect to CRC and length information).

# 4 S2-Mode Measurement Summary

## 4.1 S2-Mode Sensitivity

Table 5 lists the measurement results for S2-mode sensitivity.

**Table 5. S2-Mode Typical 1% BER Sensitivity vs Frequency Deviation (80% PER, 20-Byte Payload)**

| Typical Sensitivity [dBm] | Deviation [kHz] | Chip Rate [kcps] |
|---|---|---|
| –110.5 | 40 | 32.1113 |
| –111.1 | 50 (nominal) | 32.768 (nominal) |
| –108.8 | 80 | 33.423 |

## 4.2 S2-Mode Blocking

Table 6 lists the measurement results for S2-mode blocking.

**Table 6. S2-Mode Blocking**

| Frequency Offset [MHz] | Blocking [dB] |
|---|---|
| ±20 | 76 / 76 |
| ±10 | 72 / 68 |
| ±2 | 55 / 52 |
| ±1 | 52 / 43 |
| ±0.4 | 47 / 41 |
| ±0.2 | 43 / 42 |

### 4.3 S2-Mode PER vs Input Power Level vs Frequency Offset

The frequency offset can be up to ±25 ppm in S2-mode. Figure 1, Figure 2, and Figure 3 show the packet error rate (PER) versus input power level and frequency offset. An 80% PER corresponds to a 1% bit error rate (BER). During the measurements, 100 packets were transmitted at each power level.

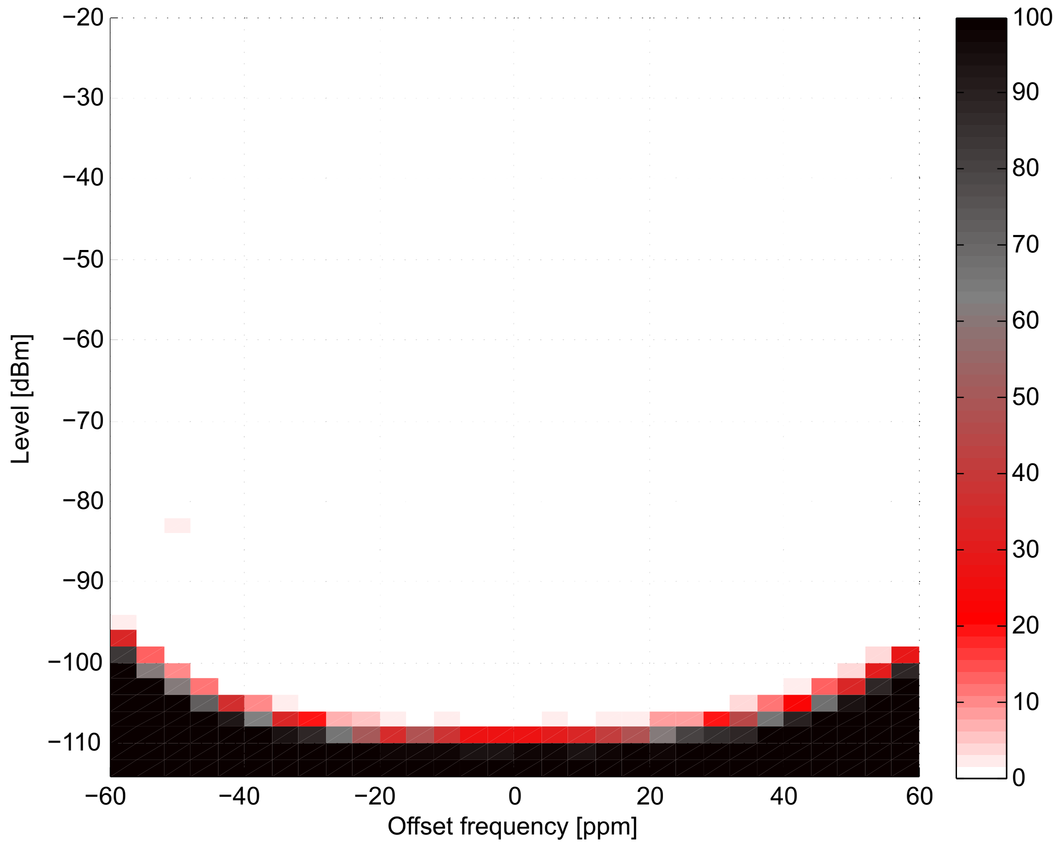


**Figure 1. 32.768 kcps, ±50 kHz, 20-Byte Payload**

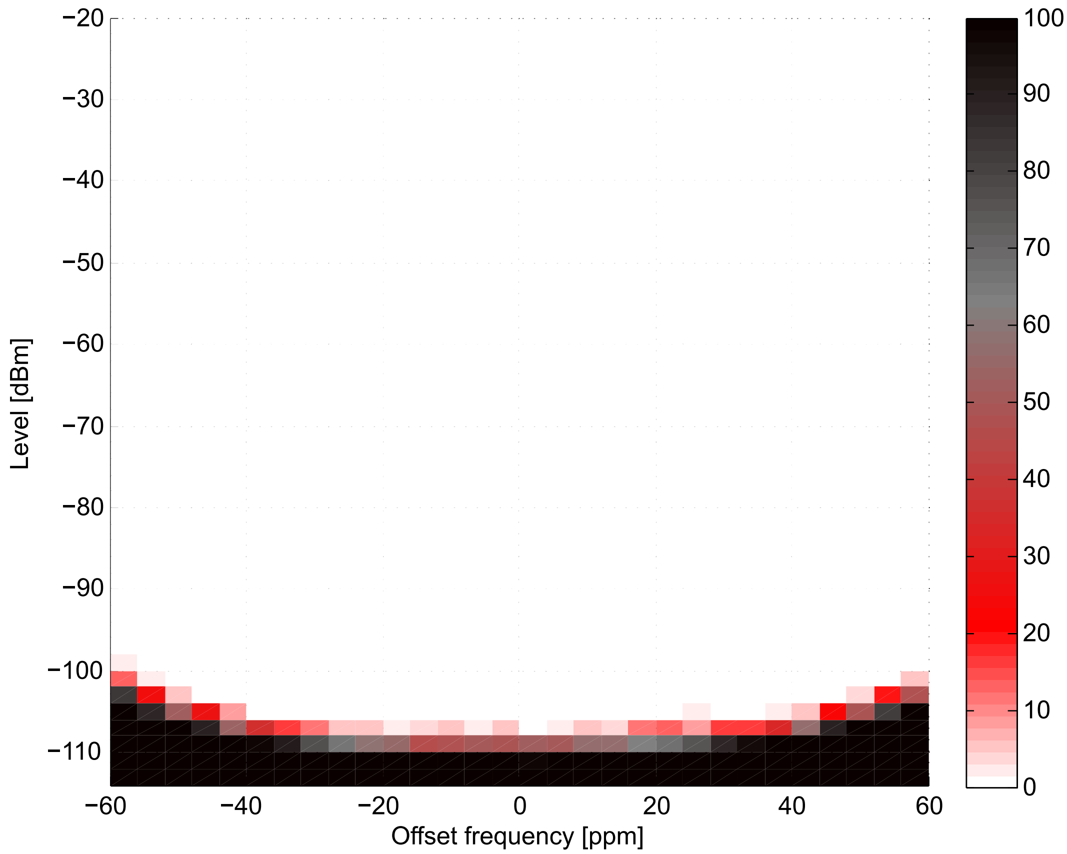


**Figure 2. 32.113 kcps, ±40 kHz, 20-Byte Payload**

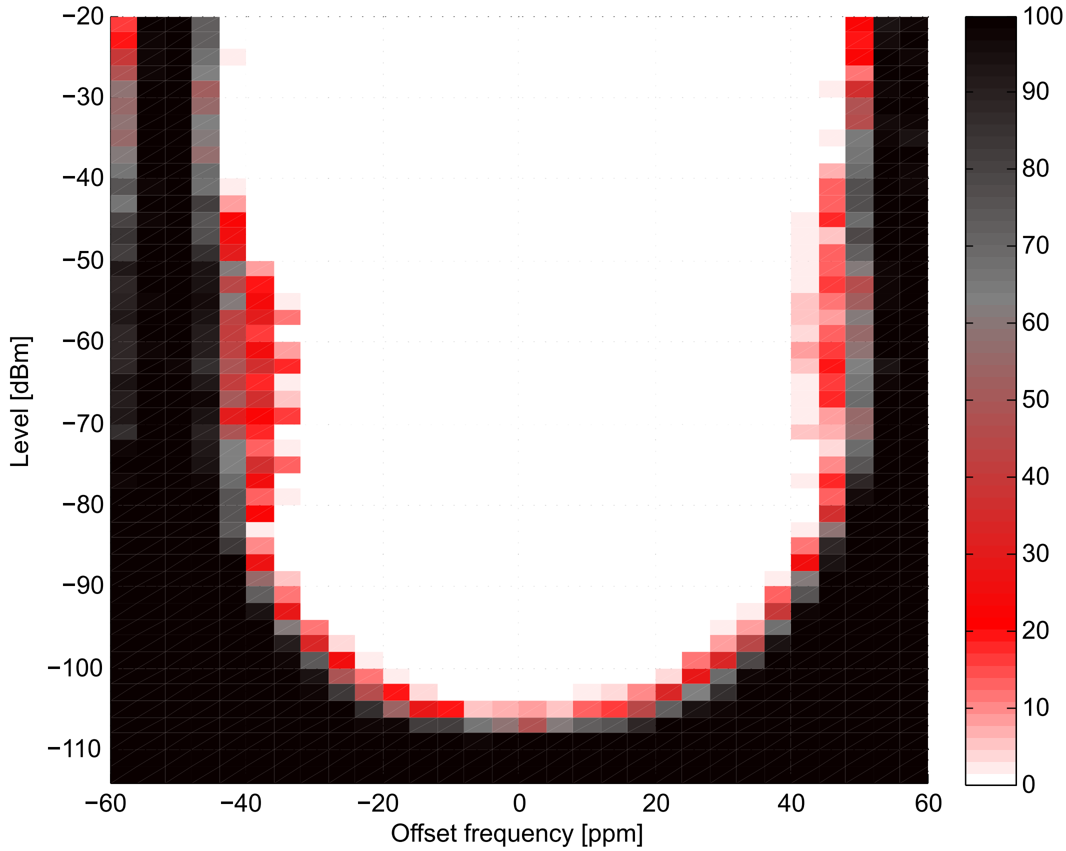


**Figure 3. 33.423 kcps, ±80 kHz, 20-Byte Payload**

# 5 S1-Mode Measurement Summary

## 5.1 S1-Mode Sensitivity

Table 7 lists the measurement results for S1-mode.

**Table 7. S1-Mode Typical 1% BER Sensitivity vs Frequency Deviation (80% PER, 20-Byte Payload)**

| Typical Sensitivity [dBm] | Deviation [kHz] | Chip Rate [kcps] |
|---|---|---|
| –107.0 | 40 | 32.1113 |
| –108.2 | 50 (nominal) | 32.768 (nominal) |
| –108.7 | 80 | 33.423 |

## 5.2 S1-Mode Blocking

Table 8 lists the measurement results for S1-mode blocking.

**Table 8. S1-Mode Blocking**

| Frequency Offset [MHz] | Blocking [dB] |
|---|---|
| ±20 | 74 / 73 |
| ±10 | 67 / 66 |
| ±2 | 51 / 40 |
| ±1 | 52 / 47 |
| ±0.4 | 49 / 46 |

### 5.3 S1-Mode PER vs Input Power Level vs Frequency Offset

The frequency offset can be up to ±60 ppm in S1-mode. Figure 4, Figure 5, and Figure 6 show the packet error rate (PER) versus input power level and frequency offset. An 80% PER corresponds to a 1% bit error rate (BER). During the measurements, 100 packets were transmitted at each power level.

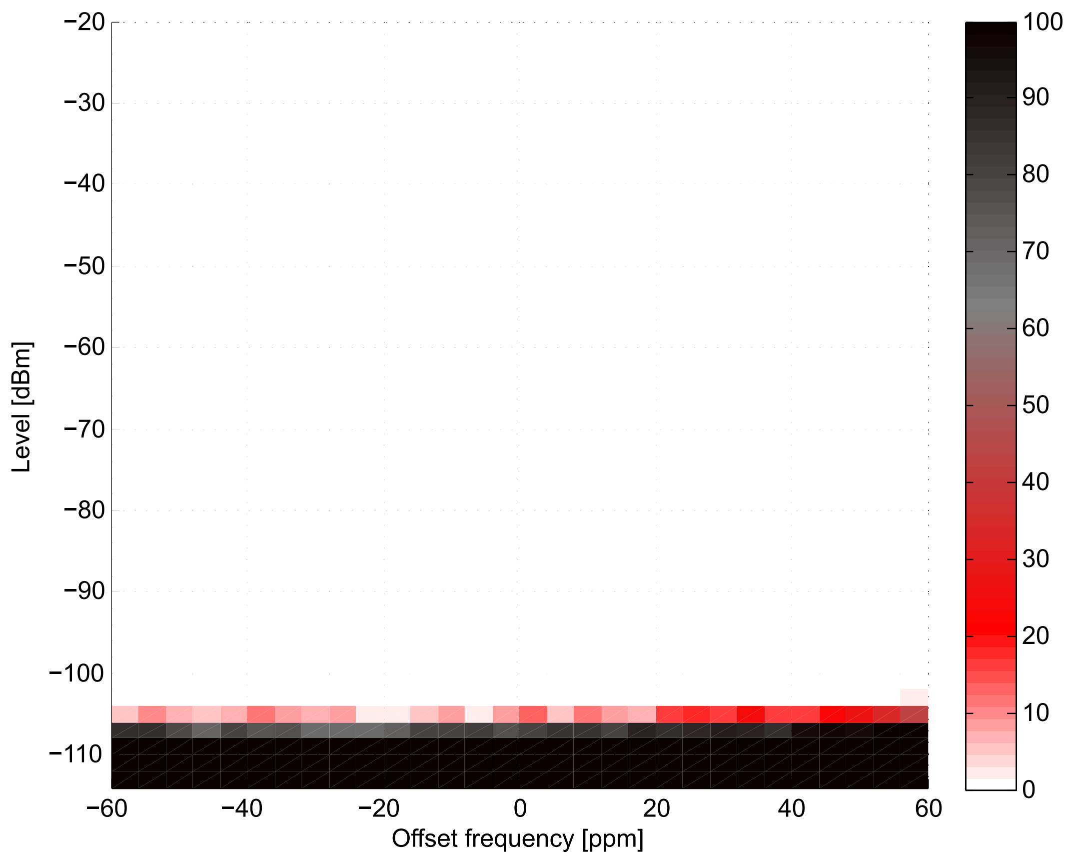


**Figure 4. 32.768 kcps, ±50 kHz, 20-Byte Payload**

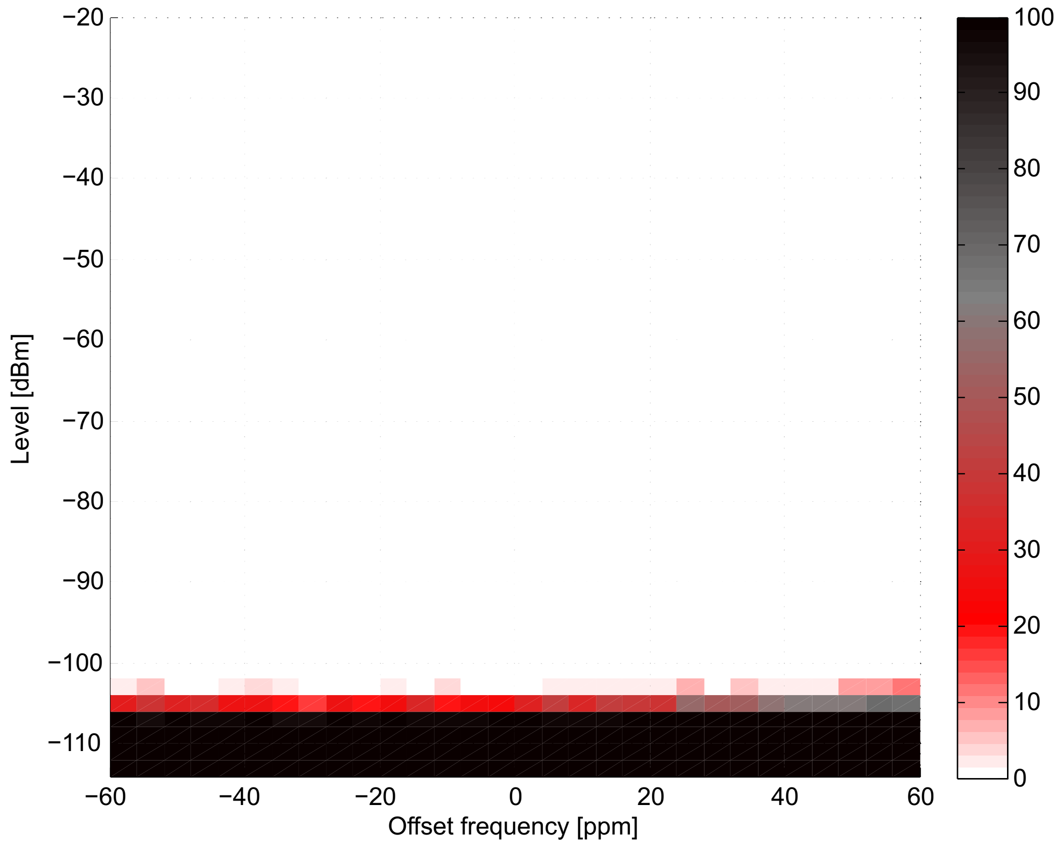


**Figure 5. 32.113 kcps, ±40 kHz, 20-Byte Payload**

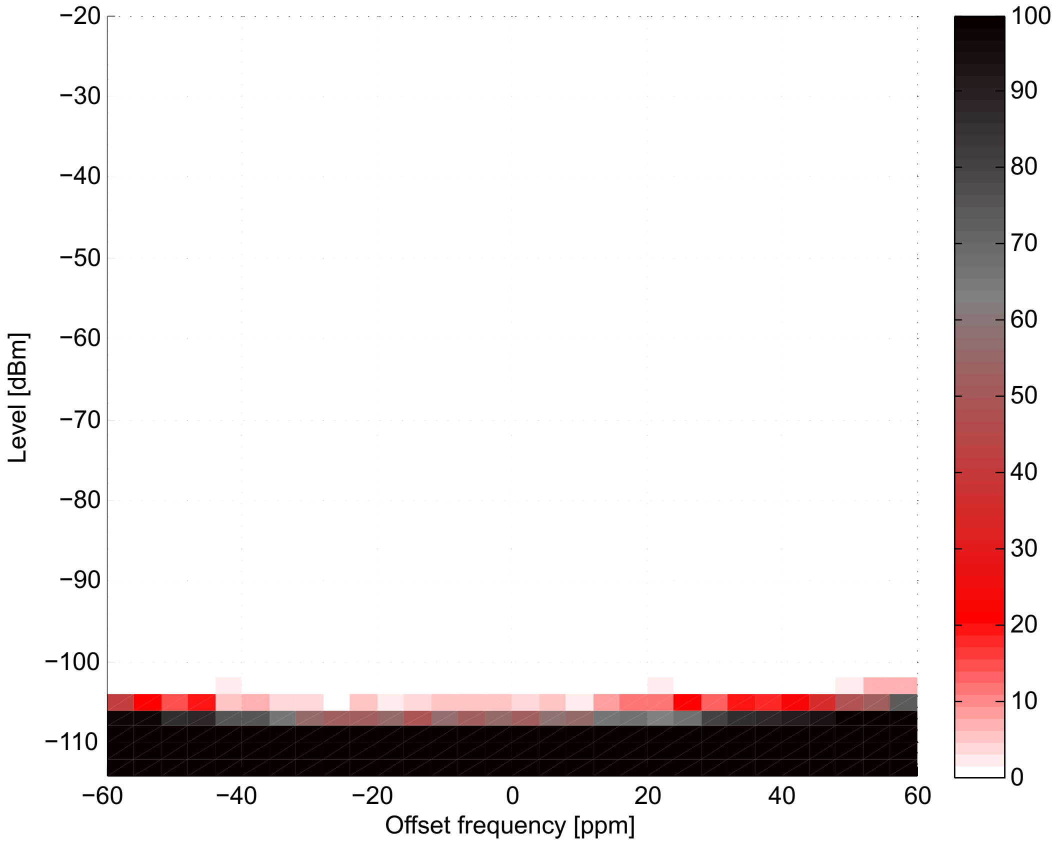


**Figure 6. 33.423 kcps, ±80 kHz, 20-Byte Payload**

## 6 References


1. Texas Instruments, CC13xxEM-7793_4L, Reference Design
2. European Standard, EN 13757-4:2012: Communication System for Meters and Remote Reading of Meters
3. Texas Instruments, SWRA512.zip (.zip file with recommended settings and overrides)
4. Texas Instruments, SmartRF Studio 7
5. Texas Instruments, SimpleLink CC13x0 Software Development Kit

## Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Original (March 2017) to A Revision | Page |
|---|---|
| • Updated the associated zip file for this document. | 1 |