

## 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>.

### Contents

1	wM-Bus S-Mode .....	2
2	wM-Bus S-Mode Patch.....	3
3	Building a Software Example.....	4
4	S2-Mode Measurement Summary.....	5
5	S1-Mode Measurement Summary.....	9
6	References .....	13

### List of Figures

1	32.768 kcps, ±50 kHz, 20-Byte Payload.....	6
2	32.113 kcps, ±40 kHz, 20-Byte Payload.....	7
3	33.423 kcps, ±80 kHz, 20-Byte Payload.....	8
4	32.768 kcps, ±50 kHz, 20-Byte Payload .....	10
5	32.113 kcps, ±40 kHz, 20-Byte Payload .....	11
6	33.423 kcps, ±80 kHz, 20-Byte Payload .....	12

### List of Tables

1	S-Mode Requirements .....	2
2	API Settings Required for the Patch .....	3
3	Additional Register Overrides Required for the Patch .....	4
4	Register Overrides to be Changed from 50 kbps, 2-GFSK Radio Register Settings .....	4
5	S2-Mode Typical 1% BER Sensitivity vs Frequency Deviation (80% PER, 20-Byte Payload) .....	5
6	S2-Mode Blocking .....	5
7	S1-Mode Typical 1% BER Sensitivity vs Frequency Deviation (80% PER, 20-Byte Payload) .....	9
8	S1-Mode Blocking .....	9

### Trademarks

SimpleLink, SmartRF are trademarks of Texas Instruments.  
All other trademarks are the property of their respective owners.

## 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 <sub>R</sub> receivers	≥ 35 dB – 10 log (BW <sub>kHz</sub> / 16 kHz) where BW is the RX filter bandwidth 196 kHz BW: ≥ 24.1 dB 311 kHz BW: ≥ 22.1 dB
Blocking @ 10 MHz offset for Class H <sub>R</sub> receivers	≥ 60 dB – 10 log (BW <sub>kHz</sub> / 16 kHz) where BW is the RX filter bandwidth 196 kHz BW: ≥ 49.1 dB 311 kHz BW: ≥ 47.1 dB
Adjacent band selectivity for Class H <sub>R</sub> 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
CMD_FS	loDivider	0x05
	Frequency	0x0364
CMD_PROP_TX	fractFreq	0x4CCC
	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  $\pm 25$  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.

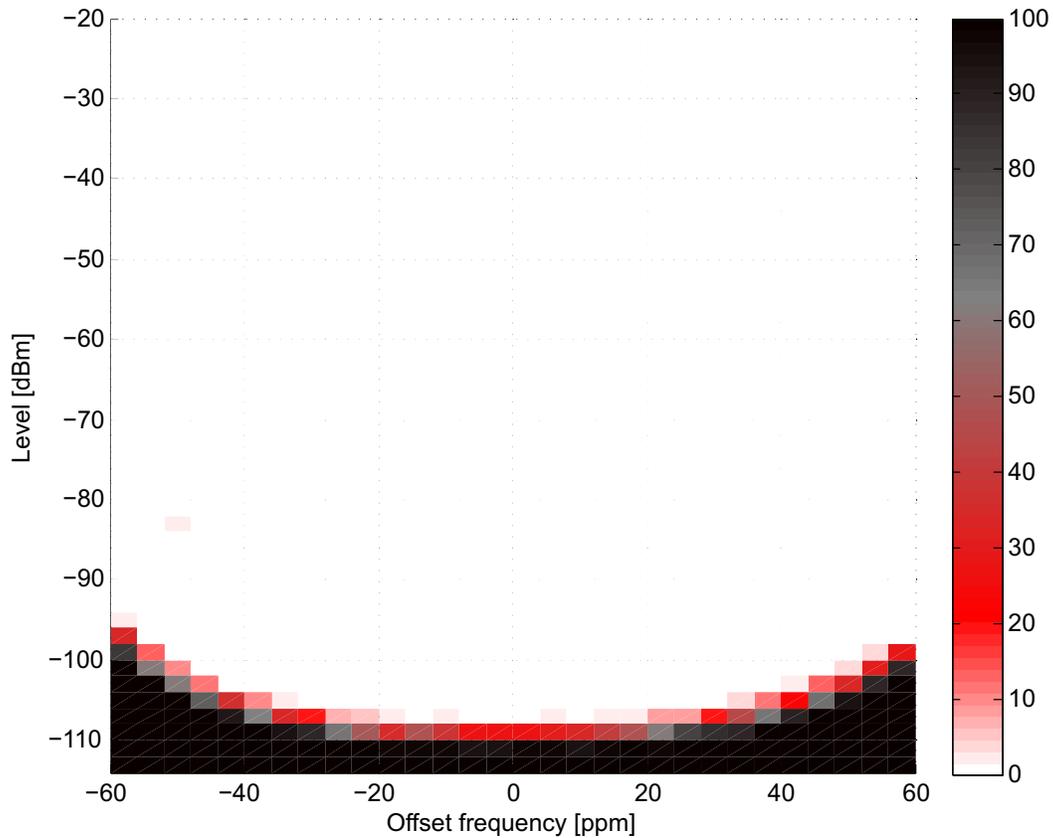


Figure 1. 32.768 kcps,  $\pm 50$  kHz, 20-Byte Payload

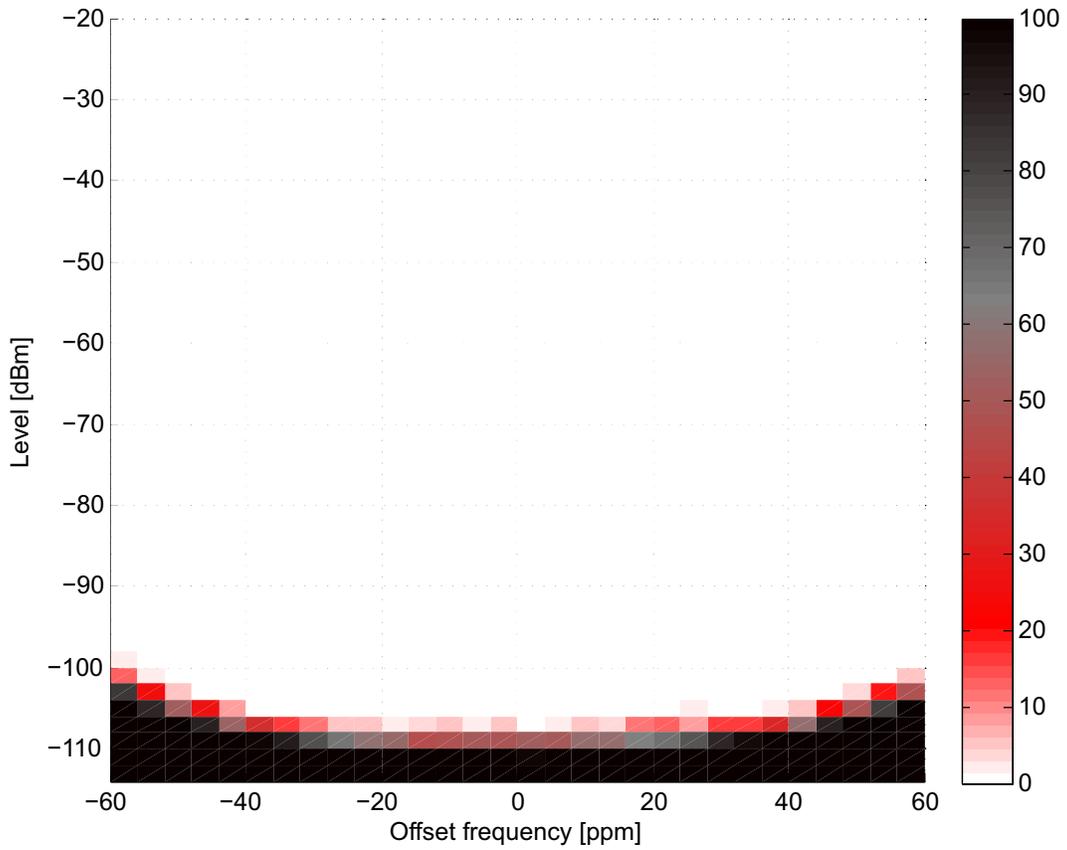


Figure 2. 32.113 kcps, ±40 kHz, 20-Byte Payload

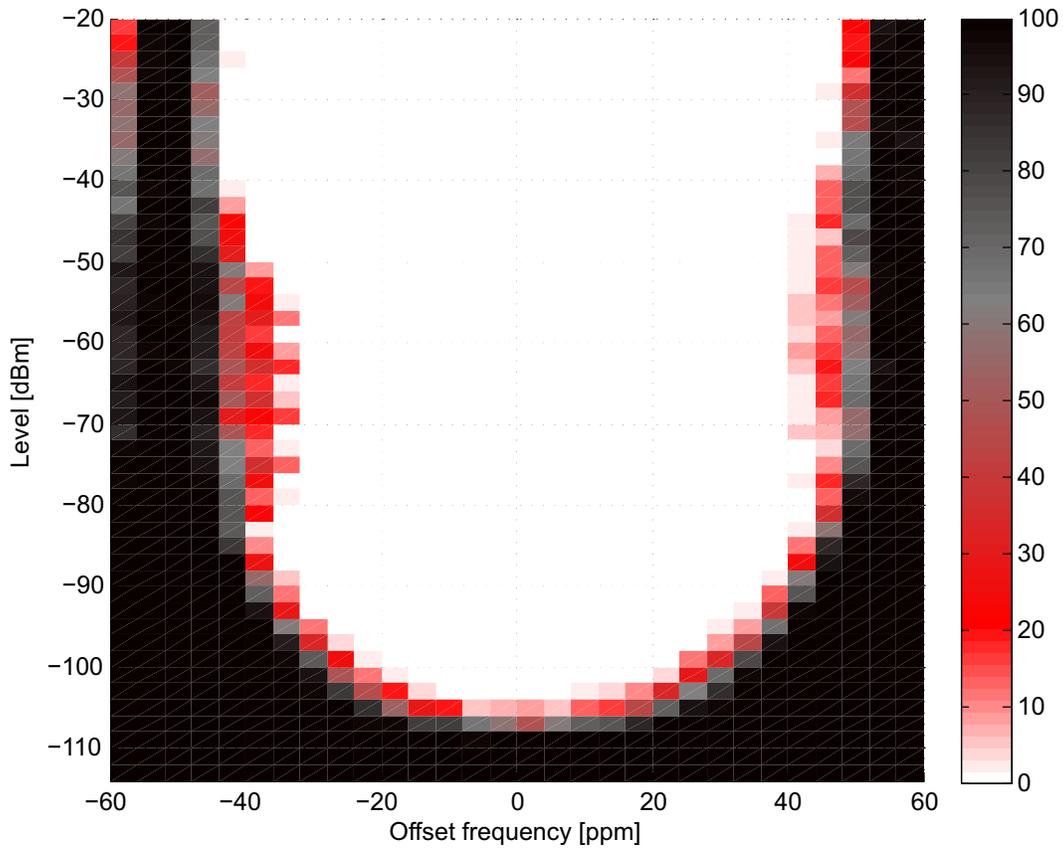


Figure 3. 33.423 kcps, ±80 kHz, 20-Byte Payload

## 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  $\pm 60$  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.

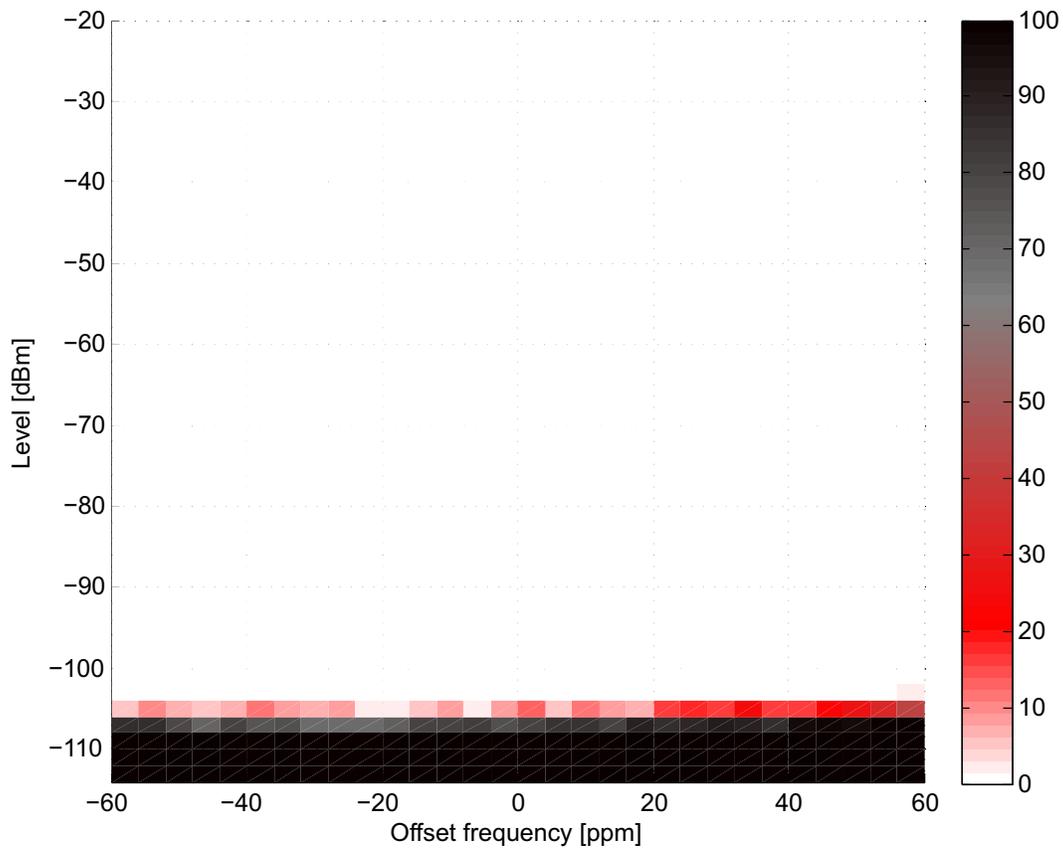


Figure 4. 32.768 kcps,  $\pm 50$  kHz, 20-Byte Payload

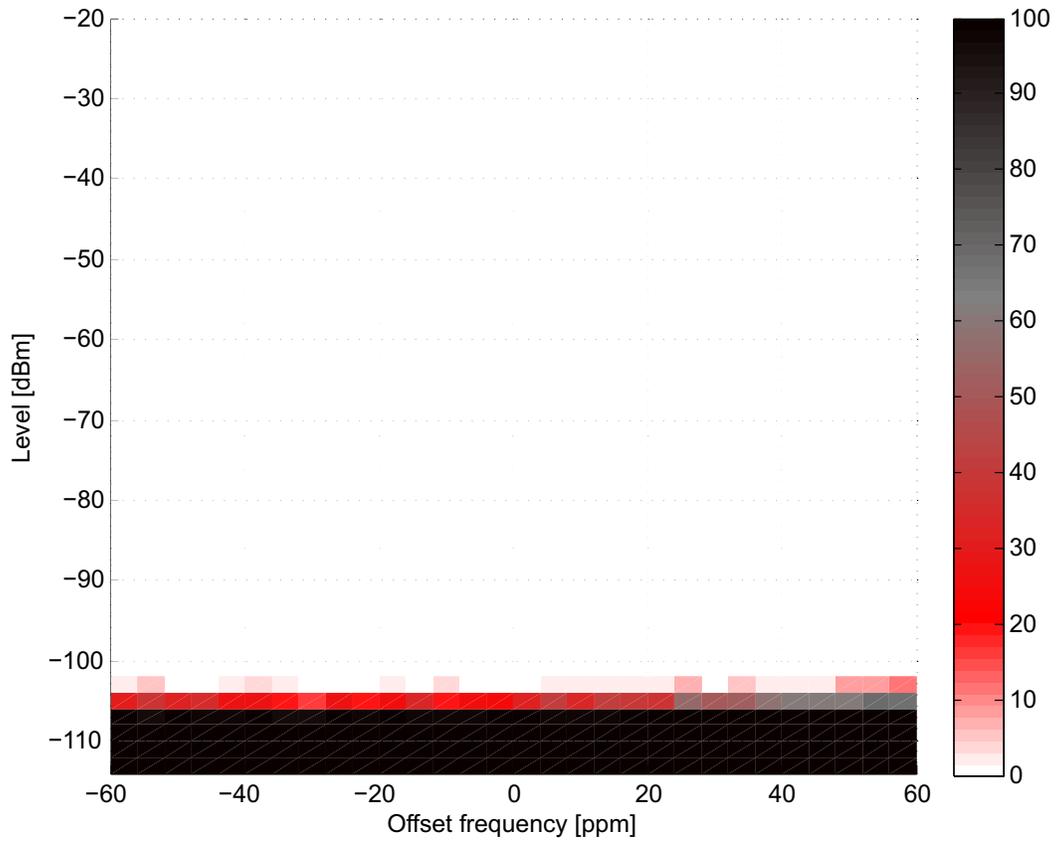


Figure 5. 32.113 kcps, ±40 kHz, 20-Byte Payload

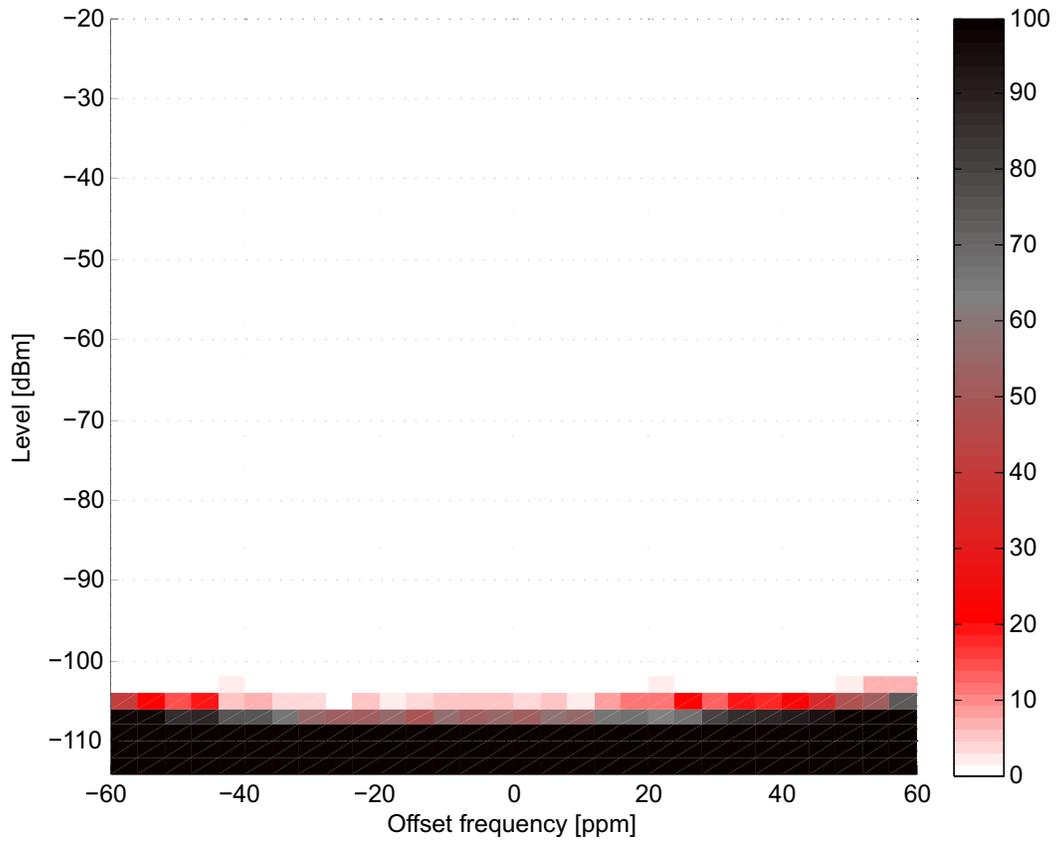


Figure 6. 33.423 kcps, ±80 kHz, 20-Byte Payload

## 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.

<b>Changes from Original (March 2017) to A Revision</b>	<b>Page</b>
• Updated the associated zip file for this document. ....	<b>1</b>

---

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](http://ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2022, Texas Instruments Incorporated