AN-1285
APPLICATION NOTE

One Technology Way • P.O. Box 9106 • Norwood, MA 02062-9106, U.S.A. • Tel: 781.329.4700 • Fax: 781.461.3113 • www.analog.com

ADF7021-N Radio Performance for Wireless Meter-Bus (WM-Bus), Mode N

by Michael Dalton

INTRODUCTION

This application note describes the radio performance of the ADF7021-N transceiver when configured for operation according to the Wireless Meter-Bus (WM-Bus) standard document EN 13757-4, Mode N. This application note focuses on the key receiver parameters applicable to the 2.4 kbps and 4.8 kbps modes of operation. These parameters are packet error rate (PER) over power, sensitivity over carrier frequency error, blocking, and adjacent channel selectivity. All PER tests are carried out using the WM-Bus development kit available from Analog Devices, Inc. The development kit includes a full WM-Bus stack running on a Renesas RL78 microprocessor. Figure 1 shows a motherboard and daughter card, both of which are included with the development kit.

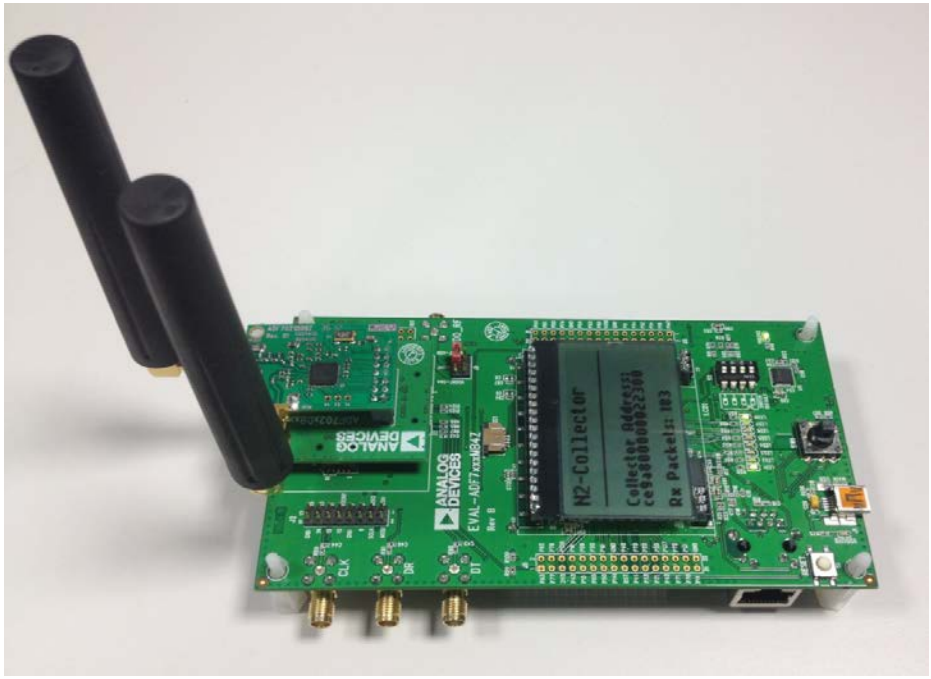

Figure 1. WM-Bus Development Kit (Includes Motherboard and Daughter Card)

TABLE OF CONTENTS

Introduction 1
Revision History 2
WM-Bus, Mode N 12.5 kHz Channel Plan 3
WM-Bus, Mode N Specification 4
Test Setup 5
2.4 kbps Mode Results 6
2.4 kbps Mode Sensitivity 6
2.4 kbps Mode Sensitivity vs. RF Frequency Error 6
2.4 kbps Mode Blocking 6
2.4 kbps Mode Adjacent Channel Selectivity 7
4.8 kbps Mode Results 8
4.8 kbps Mode Sensitivity 8
4.8 kbps Mode Sensitivity vs. RF Frequency Error 8
4.8 kbps Mode Blocking 8
4.8 kbps Mode Adjacent Channel Selectivity 9
Conclusion 10
References 11

REVISION HISTORY

2/14—Revision 0: Initial Version

WM-BUS, MODE N 12.5 kHz CHANNEL PLAN

Figure 2 gives an overview of the 12.5 kHz channel plan for the WM-Bus, Mode N. There are six 12.5 kHz channels available. Four of these channels are reserved for 4.8 kbps, and two of these channels are reserved for 2.4 kbps. Channel 1a and Channel 2a are used in this application note for evaluation.

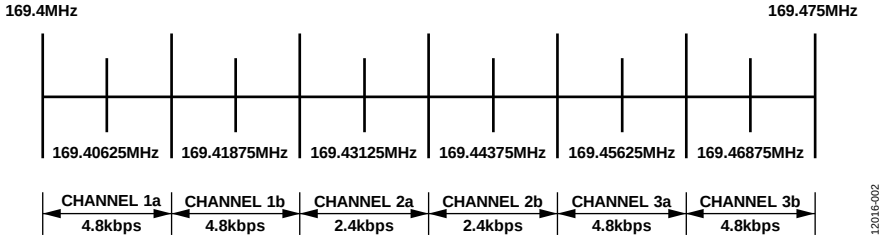

Figure 2. Overview of the 12.5 kHz Channel Plan for WM-Bus, Mode N

WM-BUS, MODE N SPECIFICATION

Table 1 shows the key specifications and performance requirements of EN 13757-4. WM-Bus compliant receivers are separated into three classes: H_R, M_R, and L_R, which are the highest, medium, and lowest performance, respectively. Minimum sensitivity is specified as PER <80%.

Table 1. WM-Bus EN 13757-4, Mode N Specification Summary

	Mode		
Parameter	**2.4 kbps**	**4.8 kbps**	**Notes**
Minimum Sensitivity	−115 dBm	−112 dBm	For a 20 byte frame at 80% PER
Frequency Error Tolerance	±2 kHz	±1.5 kHz	Receiver must be capable of correcting these carrier frequency errors
Frequency Deviation	2.4 kHz	2.4 kHz	Minimum ±1.68 kHz, maximum ±3.12 kHz
Modulation	Gaussian Frequency Shift Keying (GFSK)	GFSK	Gaussian BT = 0.5
Data Rate Tolerance	±100 ppm	±100 ppm	
Preamble Length	16 bits	16 bits	Data: 0x5555
Synchronization Length	16 bits	16 bits	Frame Format A Data: 0xF68D Frame Format B Data: 0xF672
Blocking, 2 MHz	37.5 dB	37.5 dB	Required for H_R class receiver; calculated according to EN 300 220-1, Section 8.4.3, where A = 9 kHz
Blocking, 10 MHz	62.5 dB	62.5 dB	
Adjacent Channel Rejection	40 dB	40 dB	Required for H_R class receiver

TEST SETUP

The test setup used to obtain the results in this Application Note are as follows:

- All PER tests were carried out using the WM-Bus development kit available from Analog Devices, Inc. The Renesas RL78 microprocessor included with this kit runs a full WM-Bus protocol stack.
- Test methods, where applicable, are consistent with EN 300 220-1.
- Figure 3 shows the packet used for all PER tests. This packet follows the formatting for a packet type of Format A. This packet is 24 bytes long, including the preamble and synchronization word (SWD). EN 13757-4 specifies a 20 byte frame for sensitivity measurements.
- The cyclic redundancy check (CRC) was not used to measure whether or not a packet was correct. A packet was only recorded when received if every bit in the SWD and 20 byte frame was correct. No forward error correction (FEC) was used.
- An automatic frequency control (AFC) algorithm was included on the Renesas RL78 to maximize sensitivity performance when a frequency error is present on the radio frequency (RF) carrier signal. This algorithm includes a preamble detect function that ensures a low false packet detect rate in the presence of noise. The RF frequency error cannot be corrected in the specified number of preamble bits without this algorithm.
- Note that the blocking and selectivity results were obtained using bit error rate (BER) tests. If the PER test method is used, the test results are degraded by 2 dB to 3 dB.
- The EVAL-ADF7021-NDB9Z board was used for the tests. Details of this board are available on the ADF7021-N product page.
- The results listed in this document are typical values measured at room temperature over five daughter cards.

PREAMBLE	SWD	LENGTH	CONTROL	MANUFACTURER ID	ADDRESS	BLOCK 1 CRC	BLOCK 2 CI	DATA	BLOCK 2 CRC
55 55	F6 8D	OF	44	9A CE	78 56 34 12 23 07	29 EF	A1	2F 2F 2F 2F 2F	75 79

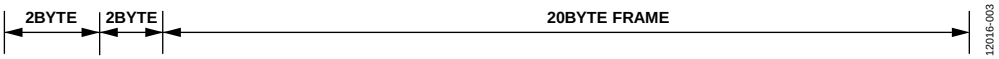

Figure 3. Packet Type Format A

2.4 kbps MODE RESULTS

The following results apply to Channel 2a and Channel 2b, which correspond to WM-Bus Submode N1c, Submode N2c, Submode N1d, and Submode N2d.

2.4 kbps MODE SENSITIVITY

Figure 4 shows the PER results obtained while sweeping the input power from −125 dBm to +10 dBm in 1 dB steps. The PER floor is not clear from the plot. This floor is measured as less than 0.2% for all powers above sensitivity. Table 2 lists spot measurements of the sensitivity level for various PER levels. The results satisfy the minimum sensitivity requirement.

Table 2. 2.4 kbps Mode Sensitivity Results

RF Channel (MHz)	Payload (Bytes)	PER (%)	Sensitivity (dBm)	WM-Bus Limit (dBm)
169.43125	20	80	−121.5	−115
		20	−120	N/A[1]
		1	−118	N/A[1]

[1] N/A means not applicable.

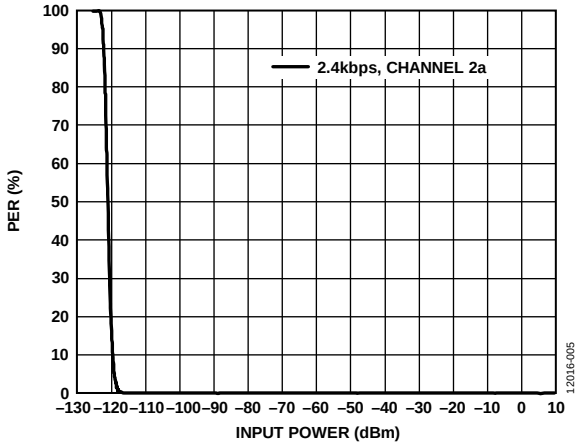

Figure 4. 2.4 kbps PER vs. Input Power

2.4 kbps MODE SENSITIVITY VS. RF FREQUENCY ERROR

Figure 5 shows the variation in sensitivity as the RF frequency error increases to the ±2 kHz limit levels specified in the EN 13757-4. The sensitivity level is 80% PER.

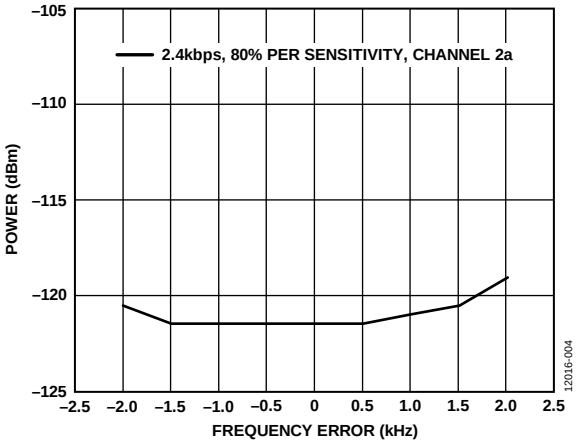

Figure 5. 2.4 kbps Sensitivity vs. RF Frequency Error

2.4 kbps MODE BLOCKING

Figure 6 shows the blocking performance of the receiver over ±30 MHz. The device was tested according to the method outlined in the EN 300 220-1, Section 8.4.2, using the BER conducted measurement method. Table 3 contains spot measurements at the offsets referred to in the EN 13757-4. The results satisfy the H_R class receiver requirements.

Table 3. 2.4 kbps Blocking Results

RF Channel (MHz)	Interferer Offset (MHz)	Blocking (dB)	H_R Class Receiver Limit (dB)
169.43125	+2	84	37.5
	−2	83.5	37.5
	+10	84	62.5
	−10	83	62.5

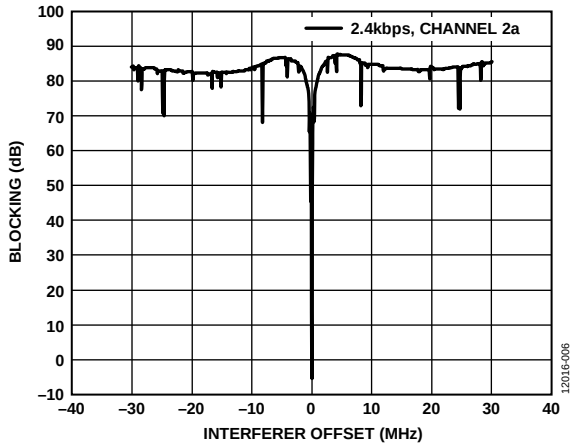

Figure 6. 2.4 kbps Mode, ±30 MHz Blocking

2.4 kbps MODE ADJACENT CHANNEL SELECTIVITY

Figure 7 shows the blocking performance of the receiver over ±100 kHz with fine interferer resolution steps. Other than the interferer step size, the test setup was identical to the 2.4 kbps Mode Blocking section. Table 4 lists spot measurements at the adjacent channels. The results satisfy the H_R class receiver requirements.

Table 4. 2.4 kbps Adjacent Channel Selectivity Results

RF Channel (MHz)	Interferer Offset (kHz)	Blocking (dB)	H_R Class Receiver Limit (dB)
169.43125	+12.5	42	40
	−12.5	42	N/A[1]

[1] N/A means not applicable.

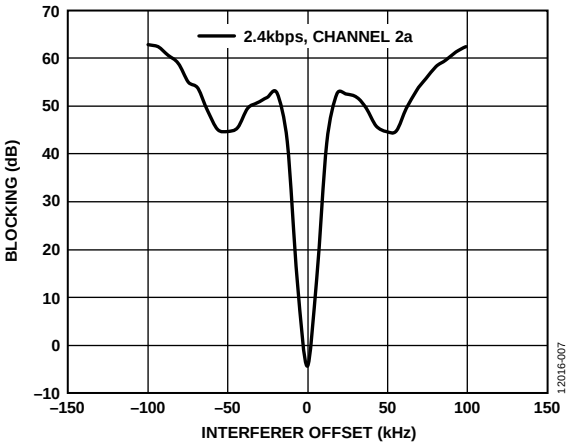

Figure 7. 2.4 kbps Mode, ±100 kHz Blocking

4.8 kbps MODE RESULTS

The following results apply to Channels 1a, Channel 1b, Channel 3a, and Channel 3b, which correspond to WM-Bus Submode N1a, Submode N2a, Submode N1b, Submode N2b, Submode N1e, Submode N2e, Submode N1f, Submode N2f.

4.8 kbps MODE SENSITIVITY

Figure 8 shows the PER results obtained while sweeping the input power from −125 dBm to +10 dBm in 1 dB steps. The PER floor is not clear from the plot. This floor was measured as less than 0.1% for all powers above sensitivity. Table 5 lists spot measurements of the sensitivity level for various PER levels. The results satisfy the minimum sensitivity requirement.

Table 5. 4.8 kbps Mode Sensitivity Results

RF Channel (MHz)	Payload (Bytes)	PER(%)	Sensitivity (dBm)	WM-Bus Limit (dBm)
169.40625	20	80	−121	−112
		20	−119	N/A[1]
		1	−117	N/A[1]

[1] N/A means not applicable.

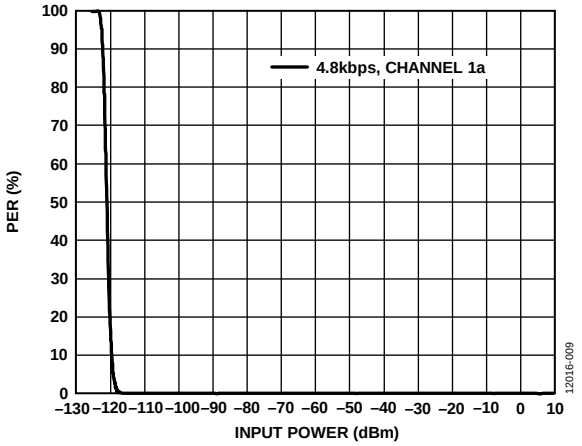

Figure 8. 4.8 kbps PER vs. Input Power

4.8 kbps MODE SENSITIVITY VS. RF FREQUENCY ERROR

Figure 9 shows the variation in sensitivity as the RF frequency error was increased to the ±1.5 kHz limit levels specified in the EN 13757-4. The sensitivity level is 80% PER.

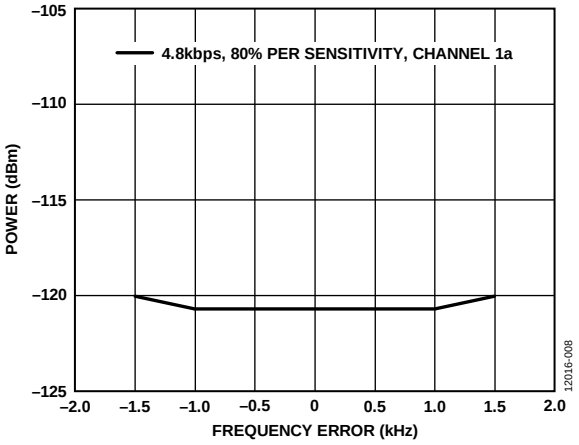

Figure 9. 4.8 kbps Sensitivity vs. RF Frequency Error

4.8 kbps MODE BLOCKING

Figure 10 shows the blocking performance of the receiver over ±30 MHz. The device is tested according to the method outlined in the EN 300 220-1, Section 8.4.2, using the BER conducted measurement method. Table 6 contains spot measurements at the offsets referred to in the EN 13757-4. The results satisfy the H_R class receiver requirements.

Table 6. 4.8 kbps Blocking Results

RF Channel (MHz)	Interferer Offset (MHz)	Blocking (dB)	H_R Class Receiver Limit (dB)
169.40625	+2	83	37.5
	−2	82	37.5
	+10	84	62.5
	−10	83	62.5

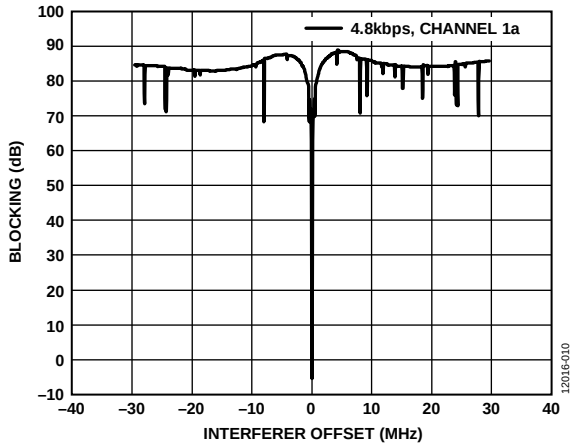

Figure 10. 4.8 kbps Mode, ±30 kHz Blocking

4.8 kbps MODE ADJACENT CHANNEL SELECTIVITY

Figure 11 shows the blocking performance of the receiver over ±100 kHz with fine interferer resolution steps. Other than the interferer step size, the test setup was identical to the 4.8 kbps Mode Blocking section. Table 7 lists spot measurements at the adjacent channels. The results satisfy the H_R class receiver requirements.

Table 7. 4.8 kbps Adjacent Channel Selectivity Results

RF Channel (MHz)	Interferer Offset (kHz)	Blocking (dB)	H_R Class Receiver Limit (dB)
169.40625	+12.5	42	40
	−12.5	41	N/A[1]

[1] N/A means not applicable.

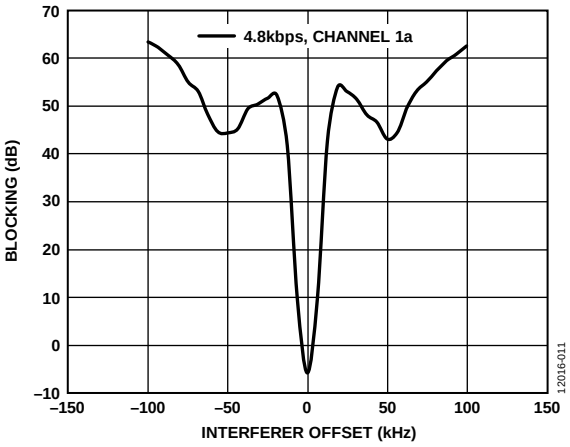

Figure 11. 4.8 kbps Mode, ±100 kHz Blocking

CONCLUSION

The ADF7021-N has excellent sensitivity when configured for WM-Bus, Mode N, providing a significant margin to the required minimum sensitivity specification.

The AFC algorithm running on the Renesas RL78 ensures that excellent sensitivity is maintained when a frequency error is present on the RF carrier. The algorithm includes a preamble detect function, which provides a low false packet detect rate in the presence of noise.

Blocking performance provides significant margin for the H_R class receiver requirements.

Adjacent channel selectivity satisfies the H_R class receiver requirements with a small margin.

The WM-Bus development kit provides a fully operational stack, reference code, and a graphic user interface (GUI) for evaluation. For additional information about purchasing a WM-Bus development kit, contact your local Analog Devices sales representative.

REFERENCES

[1] *EN 13757-4:2013*. "Communication systems for meters and remote reading of meters — Part 4: Wireless meter readout (Radio meter reading for operation in SRD bands)" (European Normal standard, 2013).

[2] *ETSI EN 300 220-1,V2.4.1 (2012-1)*, "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW" (European Telecommunications Standards Institute (ETSI) standard, 2012).

NOTES

AN12016-0-2/14(0)