MAXEYE TECHNOLOGIES

MaxEye IEEE 802.15.4 UWB Measurement Suite

(Supports 249.6MHz to 10.6GHz BPM-BPSK Mode)

Data Sheet

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NATIONAL INSTRUMENTS™ Alliance Partner

Contents

1. Introduction

IEEE 802.15.4 UWB is a specification for a suite of high-level communication protocols used to create personal area networks built from small, low-power digital radios. HRP UWB PHY waveform is based upon an impulse radio signaling scheme using band limited pulses. It supports three independent bands of operation.

1) Sub-gigahertz band =>249.6 to 749.6MHZ
2) Low band =>3.1 GHz to 4.8GHz
3) High band=>6GHz to 10.6GHz

MaxEye Technologies provides generation and analysis functions in LabVIEW for generating and analyzing the IEEE 802.15.4 UWB standard complaint signals using National Instruments Vector Signal Generators (NI VSG) and Vector Signal Analyzers (NI VSA) or Vector Signal Transceivers (NI VST). The current version of the toolkit supports HRP UWB physical layer mode.

The standard defines BPM BPSK modulation scheme with different data rates based on the

Channel number.

Channel Number	Peak PRF MHz	Bandwidth MHz	Preamble Code Length	Modulation & Coding			Data Symbol Structure						Data		
				Viterbi Rate	RS Rate	Overall FEC Rate	#Burst Positions per Symbol N_{burst}	# Hop Bursts N_{hop}	# Chips Per Burst N_{cpb}	#Chips Per Symbol	Burst Duration T_{burst} (ns)	Symbol Duration T_{dsym} (ns)	Symbol Rate (MHz)	Bit Rate Mb/s	Mean PRF (MHz)
{0:3, 5:6, 8:10, 12:14}	499.2	499.2	31	0.5	0.87	0.44	32	8	128	4096	256.41	8205.13	0.12	0.11	15.60
	499.2	499.2	31	0.5	0.87	0.44	32	8	16	512	32.05	1025.64	0.98	0.85	15.60
	499.2	499.2	31	0.5	0.87	0.44	32	8	2	64	4.01	128.21	7.80	6.81	15.60
	499.2	499.2	31	1	0.87	0.87	32	8	1	32	2.00	64.10	15.60	27.24	15.60
{0:3, 5:6, 8:10, 12:14}	499.2	499.2	31	0.5	0.87	0.44	128	32	32	4096	64.10	8205.13	0.12	0.11	3.90
	499.2	499.2	31	0.5	0.87	0.44	128	32	4	512	8.01	1025.64	0.98	0.85	3.90
	499.2	499.2	31	0.5	0.87	0.44	128	32	2	256	4.01	512.82	1.95	1.70	3.90
	499.2	499.2	31	1	0.87	0.87	128	32	1	128	2.00	256.41	3.90	6.81	3.90
{0:3, 5:6, 8:10, 12:14}	499.2	499.2	127	0.5	0.87	0.44	8	2	512	4096	1025.64	8205.13	0.12	0.11	62.40
	499.2	499.2	127	0.5	0.87	0.44	8	2	64	512	128.21	1025.64	0.98	0.85	62.40
	499.2	499.2	127	0.5	0.87	0.44	8	2	8	64	16.03	128.21	7.80	6.81	62.40
	499.2	499.2	127	0.5	0.87	0.44	8	2	2	16	4.01	32.05	31.20	27.24	62.40

2. MaxEye IEEE 802.15.4 UWB Measurement Suite

2.1. Overview

Ultra Wide Band (UWB) is a well-known RF communication technique that relies on spreading RF energy over a wide bandwidth, typically larger than 500 MHz . Its larger bandwidth allows for large capacity channels. It can co-exist with narrowband communications. UWB can operate over unlicensed spectrum while traditional narrowband communications usually happen in the increasingly crowded ISM bands. Moreover UWB standard promise to give the market a cost-effective standard-based wireless network that supports high data rates, low power consumption, security, and reliability. The IEEE 802.15.4 standard, for wireless personal area networks (WPANs) specifies the Physical (PHY) and Medium Access Control (MAC) layers at the sub band(249.6 to 749.6MHZ),low band (3.1 GHz to 4.8GHz) and high band(6to 10.6 GHz).

The Physical Layer and RF front end of the 802.15.4 UWB device needs to be tested comprehensively to meet the requirements of the IEEE 802.15.4 standard. The familiarity of the standard is very important to start preparing to test the Physical layer of the UWB device. MaxEye Technologies provides the signal generation and analysis tools using National Instruments Vector Signal Generators/Analyzers or Vector Signal Transceiver to test the physical layer and RF front end of the UWB device.

2.2. 802.15.4 UWB Physical Layer

The figure below shows the generic MAC and PHY Frame structure for the IEEE 802.15.4 standard. The MAC frame structure remains same for all the Physical Layer modes. The MaxEye IEEE 802.15.4 UWB measurement suite supports generating signal with the user specified MAC and PHY layer parameters.

<table>
<tr><td>Octets: 2</td><td>1</td><td>0/2</td><td>0/2/8</td><td>0/2</td><td>0/2/8</td><td>0/5/6/10/14</td><td>variable</td><td>2</td></tr>
<tr><td rowspan="2">Frame Control</td><td rowspan="2">Sequence Number</td><td>Destination PAN Identifier</td><td>Destination Address</td><td>Source PAN Identifier</td><td>Source Address</td><td rowspan="2">Auxiliary Security Header</td><td rowspan="2">Frame Payload</td><td rowspan="2">FCS</td></tr>
<tr><td colspan="5">Addressing fields</td></tr>
<tr><td colspan="7">MHR</td><td>MAC Payload</td><td>MFR</td></tr>
</table>

Figure 1 Generic MAC Frame Structure (MPDU)

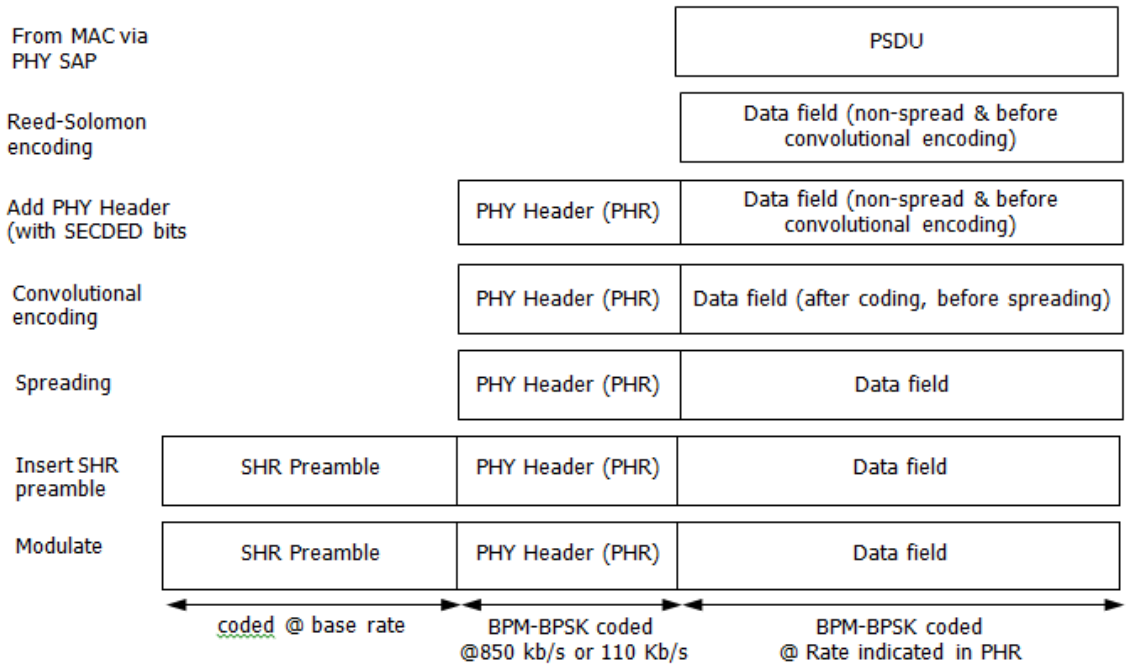


Figure 2 Generic PHY Frame Structure (PPDU)

The PPDU starts with the Synchronization Header (SHR), for each frame consisting o the SHR, SFD, PHR, and a data field, there are four possible durations of the SHR. This is due to the four possible lengths of SYNC field in the SHR; The SYNC field consists of repetitions of the preamble symbol. The numbers of preamble symbol repetitions are 16, 64, 1024, and 4096 and SFD may be either 8 or 64 preamble symbols long.

Bit 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
R1	R0	L6	L5	L4	L3	L2	L1	L0	RNG	EXT	P1	P0	C5	C4	C3	C2	C1	C0
Data Rate		Frame Length							Ranging Packet	Header Extension	Preamble Duration		SECDED Check Bits					

Figure 3—PHR bit assignment

A PHR, as shown in Figure 3, shall be added after the SHR preamble. The PHR consists of 19 bits.

In the BPM-BPSK modulation scheme, a symbol is capable of carrying two bits of information: one bit is used to determine the position of a burst of pulses, while an additional bit is used to modulate the phase (polarity) of this same burst.

The structure and timing of a symbol is illustrated in figure 4. Each symbol shall consist of an integer number of possible chip positions, N_C, each with duration T_C. The overall symbol duration denoted by T_{dsym} is given by $T_{dsym} = N_C T_C$. Furthermore, each symbol is divided into two BPM intervals each with duration $T_{BPM} = T_{dsym}/2$, which enables binary position modulation.

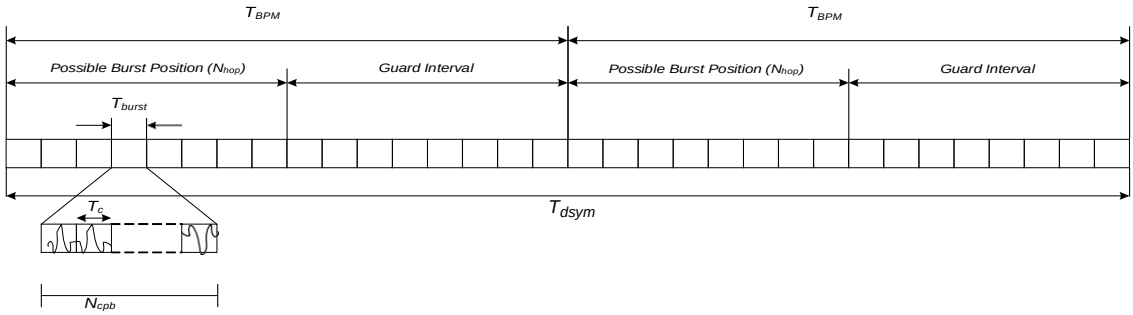


Figure 4—HRP UWB PHY symbol structure

A burst is formed by grouping N_{cpb} consecutive chips and has duration $T_{burst} = N_{cpb} T_C$. The location of the burst in either the first half or the second half of the symbol indicates one bit of information. Additionally, the phase of the burst (either –1 or +1) is used to indicate a second bit of information

2.3. 802.15.4 UWB Physical Layer Test

2.3.1 802.15.4 UWB Receiver Tests

The 802.15.4 UWB measurement suite supports generating signal as per the IEEE 802.15.4 standard MAC and PHY protocol. The MAC and PHY layer parameters can be configured using the LabVIEW API VIs.

Measurement Suite – Generation Key Features

- Supports both MAC and PHY Layer signal configuration
- Generation of various frame formats including Data Frame, Beacon Frame, Acknowledgement Frame.

- Payload Types: PN Sequence, User Defined Bits, Test Pattern and From File
- Generation multiple frames with user configurable inter frame spacing. The payload is continuous across frames. This enables receiver sensitivity tests with longer payload sequence.
- Allows user to save the waveform in file. This waveform can be played back using NI RF Record and Playback application. This avoids generation of the waveform at the beginning of the tests.
- Supports adding the following impairments to the signal
    - AWGN
    - IQ Impairments (Gain Imbalance, Quadrature Skew and IQ offset)
    - Frequency Offset
    - Clock Offset

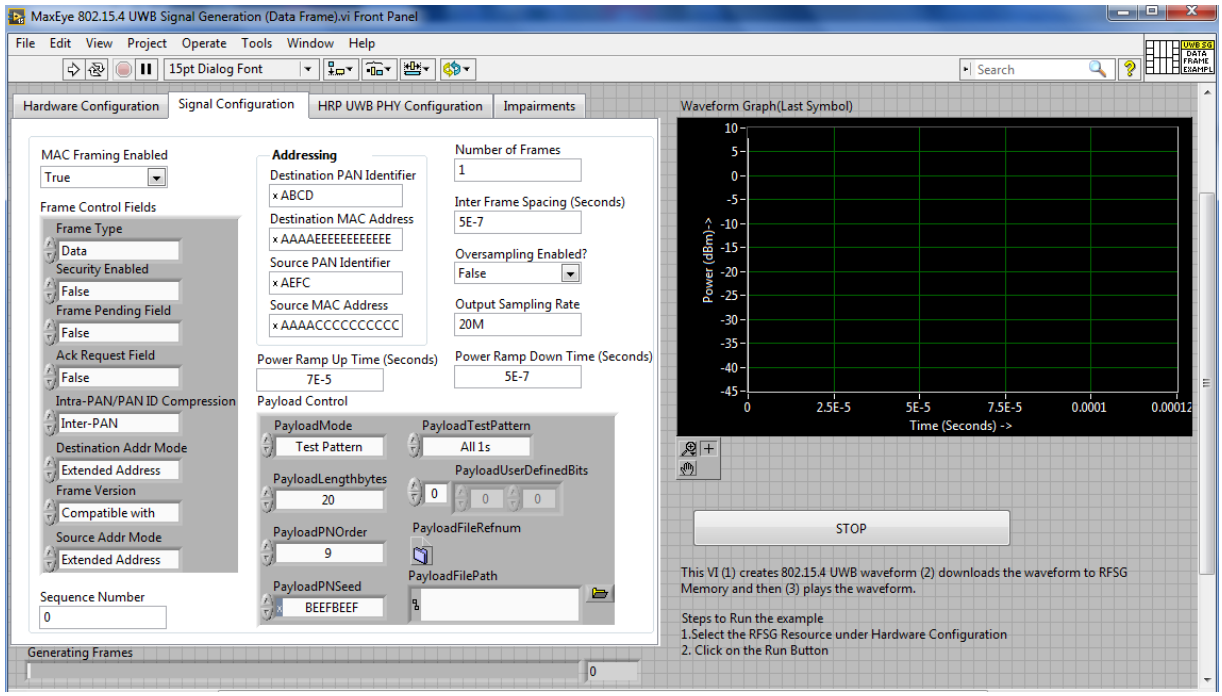


Figure 3 MaxEye IEEE 802.15.4 UWB Measurement Suite - Generation Example

The MaxEye IEEE 802.15.4 UWB measurement suite supports the following receiver tests specified by the IEEE 802.15.4 standard.

- Receiver Sensitivity Test
- Receiver Interference Test
- Receiver Adjacent Channel Rejection
- Receiver Maximum Input Power Level

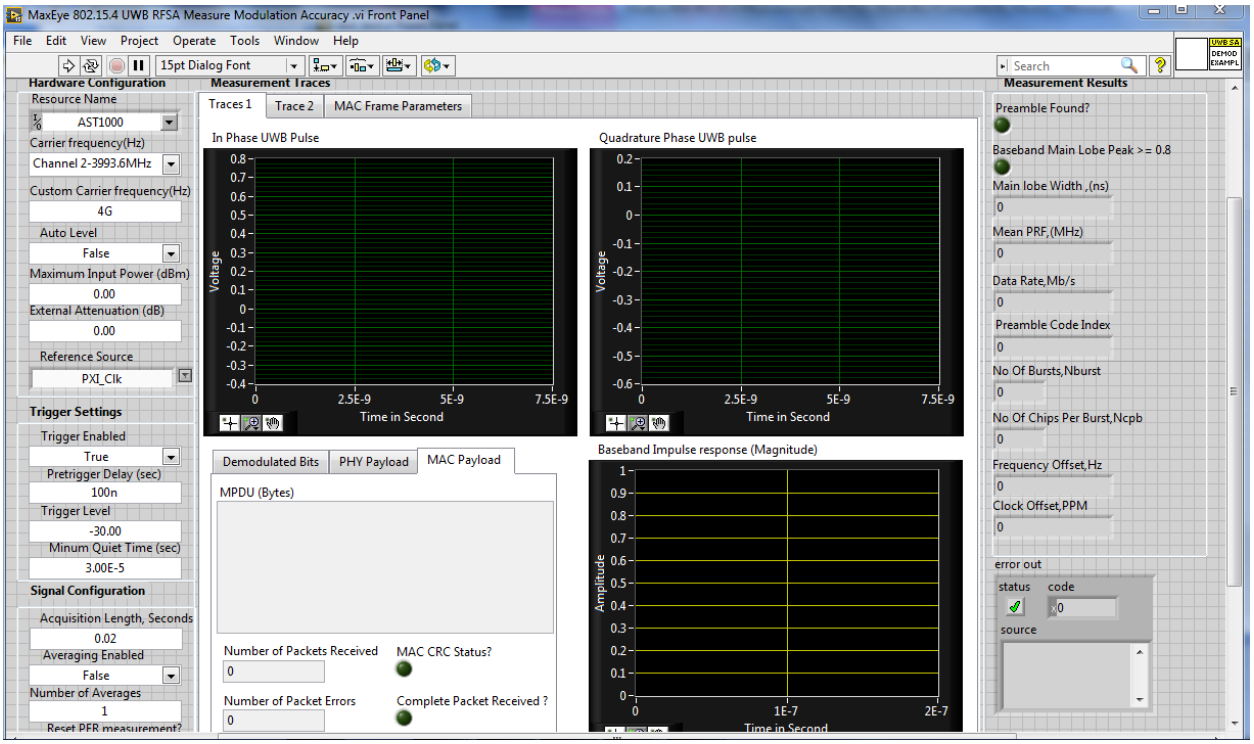
2.3.2 802.15.4 UWB Transmitter Tests

The MaxEye IEEE 802.15.4 UWB measurement suite supports analyzing signal as per the IEEE 802.15.4 standard within 249.6MHz to 10.6GHz band

Measurement Suite – Analysis Key Features

The MaxEye IEEE 802.15.4 UWB measurement suite supports the following measurements.

- Correlation Main lobe width Measurement
- Frequency Offset
- Clock offset
- Mean PRF Measurement
- Bit rate measurement
- Demodulated Bits
- Physical Layer Payload bits (PPDU)
- MAC Payload Bits (MPDU)
- Packet Error Rate Measurement (PER)
- Supported Traces
    - Baseband Impulse Response Trace
    - Measured I vs Time and Q vs Time



The MaxEye IEEE 802.15.4 UWB measurement suite supports the following transmitter tests specified by the IEEE 802.15.4 standard.

- Transmit power spectral density test
- Baseband Impulse Response
- Transmit Center Frequency Tolerance
- Transmit Power
- LO Leakage Test

3. Supported Hardware

The MaxEye IEEE 802.15.4 UWB measurement suite supports National Instruments RF Vector Signal Generators, Vector Signal Analyzers and Vector Signal Transceivers. The toolkit supports the following hardware.

- NI PXIE-5840

4. Supported Operating Systems

- Windows 8/Windows 7 /Windows Vista/Windows XP with all available critical updates and service packs.

MAXEYE TECHNOLOGIES

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