MAXEYE TECHNOLOGIES

ZigBee (IEEE 802.15.4) Measurement Suite

(Supports 2.4GHz OQPSK and 868/915MHz BPSK Mode)

Data Sheet

November 10, 2016

Version: 1.0.5

NATIONAL INSTRUMENTS Alliance Partner

Contents

1. Introduction

ZigBee is a specification for a suite of high-level communication protocols used to create personal area networks built from small, low-power digital radios. ZigBee is based on IEEE 802.15.4 standard. ZigBee operates in the industrial, scientific and medical (ISM) radio bands: 2.4 GHz in most jurisdictions worldwide; 784 MHz in China, 868 MHz in Europe and 915 MHz in the USA and Australia. Data rates vary from 20 kbit/s (868 MHz band) to 250 kbit/s (2.4 GHz band).

MaxEye Technologies provides generation and analysis functions in LabVIEW for generating and analyzing the ZigBee standard complaint signals using National Instruments Vector Signal Generators (NI VSG) and Vector Signal Analyzers (NI VSA) or Vector Signal Transceivers (NI VST). The IEEE 802.15.4 Standard supports multiple Physical Layer modes; the current version of the toolkits supports the following physical layer modes.

i. OQPSK Physical Layer (2.4GHz)

ii. BPSK Physical Layer (868/915 MHz)

The standard defines different modulation types, data rates based on the frequency band.

Band	**Frequency Range (MHz)**	**Modulation Type**	**Chip Rate (Kchips/sec)**	**Data Rate (Kbits/sec)**	**Pulse shaping Filter Type**
2.4 GHZ	2400 to 2483	OQPSK	2000	250	Half Sine Wave Filter
868 MHZ	868 to 868.6	BPSK	300	20	Raised Cosine
915 MHz	902 to 928	BPSK	600	40	Raised Cosine

2. ZigBee Measurement Suite

2.1. Overview

ZigBee and the underlying IEEE 802.15.4 standard promise to give the market a cost-effective standard-based wireless network that supports low 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 868 MHz, 915 MHz and 2.4 GHz ISM (Industrial scientific and Medical) band., while the ZigBee Alliance defines the network, security and application profile.

The Physical Layer and RF front end of the ZigBee devices 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 ZigBee devices. 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 ZigBee devices.

2.2. ZigBee Physical Layer

The figure below shows the generic MAC and PHY Frame structure for the IEEE 802.15.4 standard. The frame structure remains same for all the Physical Layer modes. The MaxEye ZigBee 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="4">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)

<table>
<tr><td colspan="2"></td><td colspan="2">Octets</td></tr>
<tr><td colspan="2"></td><td>1</td><td>variable</td></tr>
<tr><td>Preamble</td><td>SFD</td><td>Frame length (7 bits)</td><td>Reserved (1 bit)</td><td>PSDU</td></tr>
<tr><td colspan="2">SHR</td><td colspan="2">PHR</td><td>PHY payload</td></tr>
</table>

Figure 2 Generic PHY Frame Structure (PPDU)

The PPDU starts with the Synchronization Header (SHR). The SHR included 32 bits preamble and 8 its SFD. The SFD indicates the end of the synchronization header.

The 2.4GHz ZigBee uses offset quadrature phase shift keying (O-QPSK) modulation with direct sequence spread spectrum (DSSS). Each symbol is mapped to a 32 chip sequence. The length of the symbol is 4 bits and the symbol rate is 62.5Ksymbols/s. This results in chip rate of 2MChips/s (62.5Ks/s*32) and data rate of 250Kbits/s (62.5Ks/s*4bits/symbol). The chip sequences representing each data symbol are modulated onto the carrier using O-QPSK with half sine pulse shaping. A half sine wave filter is used to change the constellation from square to circle. This makes OQPSK signal into a constant envelope signal.

The 868/915MHz ZigBee uses binary phase shift keying (BPSK) modulation with direct sequence spread spectrum (DSSS). Each symbol is mapped to 15 chip sequence. The symbol rate of 868 MHz PHY is 20KSymbols/sec and 915MHz PHY is 40KSymbols/sec. This results in chip rate of 300 Kchips/sec and 600Kchips/sec respectively for the 868MHz and 915MHz mode. The raised cosine pulse shaping filter with roll-off factor = 1 is used for pulse shaping.

2.3. ZigBee Physical Layer Test

2.3.1 ZigBee Receiver Tests

The ZigBee 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

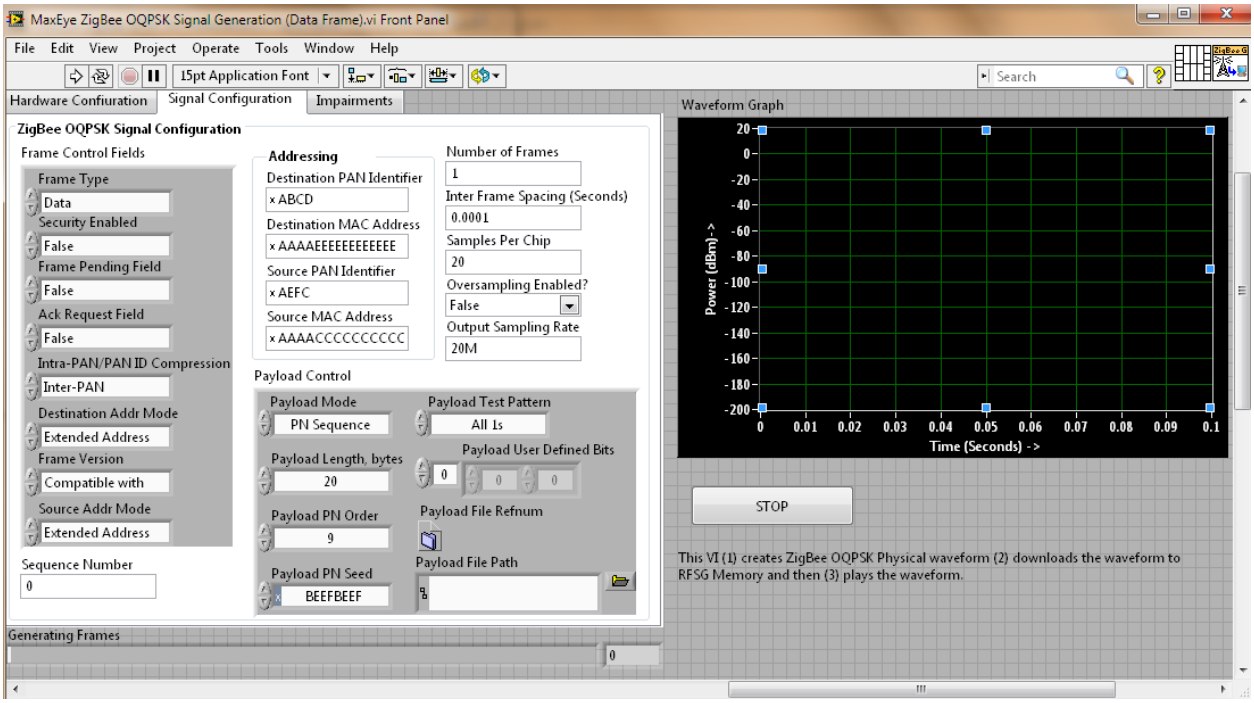


Figure 3 ZigBee Measurement Suite - Generation Example

The ZigBee 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 ZigBee Transmitter Tests

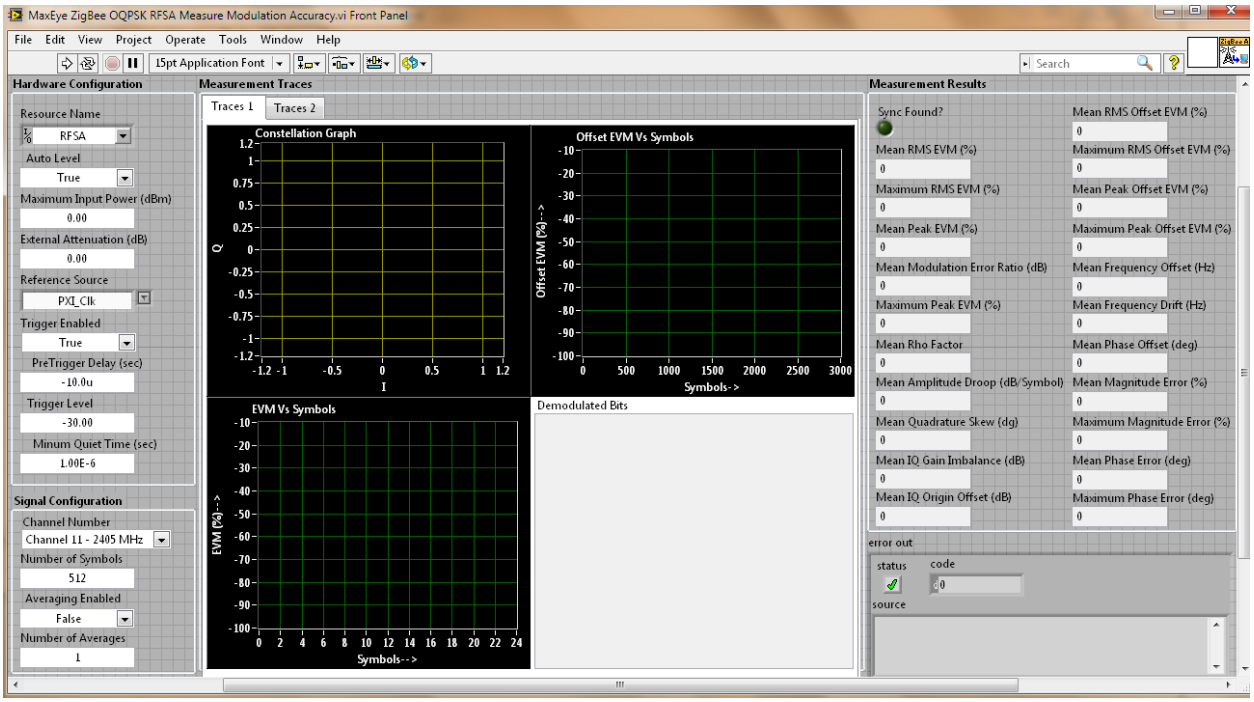
The ZigBee measurement suite supports analyzing signal as per the IEEE 802.15.4 standard 2.4GHz and 868/915MHz frequency band.

Measurement Suite – Analysis Key Features

The MaxEye ZigBee measurement suite supports the following measurements.

- Error Vector Magnitude (EVM) and Offset EVM measurements
- Frequency Offset
- Modulation Error Ration (MER)
- Magnitude and Phase Error
- IQ Gain Imbalance, Quadrature Skew
- IQ Offset (Carrier Leakage)
- Transmit Power
- Spectral Emission Mask and offset channel power measurements
- Demodulated Bits
- Physical Layer Payload bits (PPDU)
- MAC Payload Bits (MPDU)
- Packet Error Rate Measurement (PER)
- Supported Traces
    - Constellation Trace
    - EVM vs Symbols Trace
    - Offset EVM vs Symbols Trace
    - Magnitude Error vs Symbols
    - Phase Error vs Symbols

- Measured and Reference I vs Time and Q vs Time
- Power vs Time Trace
- Spectral Emission Mask Trace



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

- Transmit power spectral density test
- Error Vector Magnitude
- Transmit Center Frequency Tolerance
- Transmit Power
- LO Leakage Test

3. Supported Hardware

The ZigBee measurement suite supports National Instruments RF Vector Signal Generators, Vector Signal Analyzers and Vector Signal Transceivers. The toolkit supports the following hardware.

- NI PXI 5644R/5645R/5646R
- NI PXI 5673E/5663E
- NI PXI 5672

4. Supported Operating Systems

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

For more information about MaxEye Technologies products and services, please contact

info@maxeyetech.com

ramesh@maxeyetech.com

Phone Number: +91 80 2527 0024, +91 9448067717

www.maxeyetech.com