MAXEYE TECHNOLOGIES

Z-Wave (ITU-T G.9959) Measurement Suite

(Supports All Data Rates)

Data Sheet

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NATIONAL INSTRUMENTS Alliance Partner

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1. Introduction

Z-Wave is a low-power, low-cost wireless technology enabling consumer-grade products with networked features. Examples include remote controlled light dimmers, networked temperature sensors, electronic door locks and AV systems.. Z-Wave is based on ITU-T G.9959 standard. Z-Wave operates in the industrial, scientific and medical (ISM) radio bands: It uses 868.42 MHz in Europe and 908.42MHz in USA. Following Table-1 mentions basic features of Z-wave technology widely used in IoT(Internet of Things) due to low power and low data rate.

RF Profile	Region	Channel Configuration	RF Center Frequency	Data Rates
0	n/a			
1	European Union	1,2	868.40 MHz	100 kbps
2	European Union	1,2	869.85 MHz	40 kbps 9.6 kbps
3	European Union	1,2	869.85 MHz	40 kbps
4	United States	1,2	908.40 MHz	100 kbps
5	United States	1,2	916.00 MHz	40 kbps 9.6 kbps
6	United States	1,2	916.00 MHz	40 kbps
7	Hong Kong	1,2	919.80 MHz	100 kbps
8	Hong Kong	1,2	919.80 MHz	40 kbps 9.6 kbps
9	Hong Kong	1,2	919.80 MHz	40 kbps

10	**Australia and New Zealand**	**1,2**	**919.80 MHz**	**100 kbps**
11	**Australia and New Zealand**	**1,2**	**921.40 MHz**	**40 kbps** **9.6 kbps**
12	**Australia and New Zealand**	**1,2**	**921.40 MHz**	**40 kbps**
13	**Malaysia**	**1,2**	**919.80MHz**	**100 kbps**
14	**Malaysia**	**1,2**	**921.40MHz**	**40 kbps** **9.6 kbps**
15	**Malaysia**	**1,2**	**921.42 MHz**	**40 kbps**
16	**India**	**1,2**	**865.20 MHz**	**100 kbps**
17	**India**	**1,2**	**865.20 MHz**	**40 kbps** **9.6 kbps**
18	**India**	**1,2**	**865.20 MHz**	**40 kbps**
19	**Japan**	**3**	**922.50MHz**	**100 kbps**
20	**Japan**	**3**	**923.90MHz**	**100 kbps**
21	**Japan**	**3**	**926.30MHz**	**100 kbps**
22	**Israel**	**1,2**	**916 MHz**	**100 kbps**
23	**Israel**	**1,2**	**916 MHz**	**40 kbps** **9.6 kbps**
24	**Israel**	**1,2**	**916 MHz**	**40 kbps**
25	**Korea**	**3**	**920.90 MHz**	**100 kbps**
26	**Korea**	**3**	**921.70 MHz**	**100 kbps**

27	**Korea**	**3**	**923.10 MHz**	**100 kbps**
28	**Russia**	**1,2**	**869.00 MHz**	**100 kbps**
29	**Russia**	**1,2**	**869.00 MHz**	**40 kbps** **9.6 kbps**
30	**Russia**	**1,2**	**869.00 MHz**	**40 kbps**
31	**China**	**1,2**	**868.40 MHz**	**100 kbps**
32	**China**	**1,2**	**868.40 MHz**	**40 kbps** **9.6 kbps**
33	**China**	**1,2**	**868.40 MHz**	**40 kbps**

MaxEye Technologies provides generation and analysis functions in LabVIEW for generating and analyzing the ITU-T G.9959 standard complaint signals using National Instruments Vector Signal Generators (NI VSG) and Vector Signal Analyzers (NI VSA) or Vector Signal Transceivers (NI VST). The ITU-T G.9959 Standard supports three different data rates; the current version of the toolkits supports the following data rates.

i. R1 (9.6kbps)

ii. R2 (40 kbps)

iii. R3 (100 kbps)

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

Data Rate	**Bit Rate**	**Symbol Rate**	**Modulation Type**	**Coding**	**Frequency Offset**	**Seperation**
R1	9.6 kbps	19.2 kbaud	FSK	Manchester	20 kHz	40kHz±20%
R2	40 kbps	40 kbaud	FSK	NRZ	0 kHz	40kHz±20%

R3	100 kbps	100 kbaud	GFSK, BT=0.6	NRZ	0 kHz	58kHz±20%

2. Z-Wave Measurement Suite

2.1. Overview

Z-Wave and the underlying ITU-T G.9959 standard promise to give the market a cost-effective standard-based wireless network that supports low data rates, low power consumption, security, and reliability. Z-Wave is a low-power, low-cost wireless technology enabling consumer-grade products with networked features. Examples include remote controlled light dimmers, networked temperature sensors, electronic door locks and AV systems.

The Physical Layer and RF front end of the Z-Wave devices needs to be tested comprehensively to meet the requirements of the ITU-T G.9959 standard. The familiarity of the standard is very important to start preparing to test the Physical layer of the Z-Wave 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 Z-Wave devices.

2.2. Z-Wave Physical Layer

The figure below shows the generic MAC and PHY Frame structure for the ITU-T G.9959 standard. The frame structure remains same for all the Physical Layer modes. The MaxEye Z-Wave measurement suite supports generating signal with the user specified MAC and PHY layer parameters.

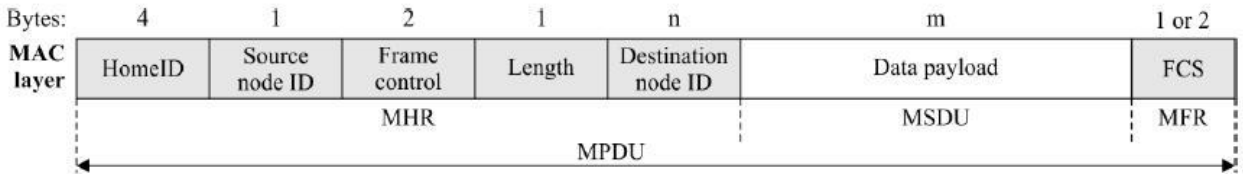


Figure 1 Generic MAC Frame Structure (MPDU)- Channel Configuration 1,2

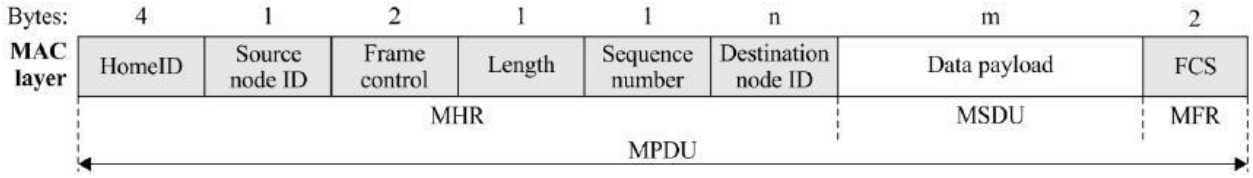


Figure 2 Generic MAC Frame Structure (MPDU)- Channel Configuration 3

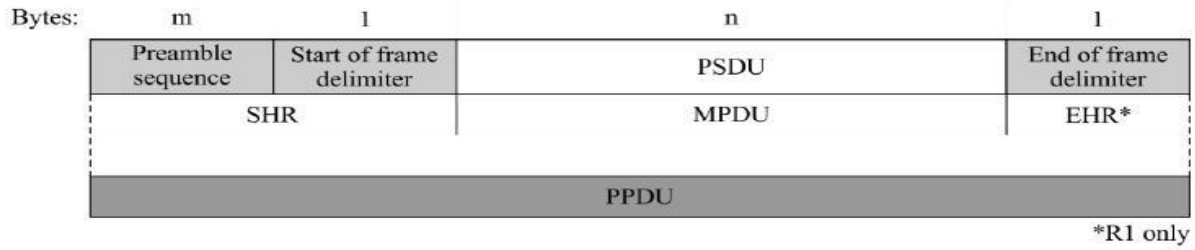


Figure 3 Generic PHY Frame Structure (PPDU)

The PPDU starts with the Synchronization Header (SHR). The preamble field allows a receiver to obtain symbol synchronization. The preamble field shall be composed of a sequence of bytes containing the binary pattern "01010101". The SOF is an 8-bit field terminating the preamble field and the start of the PSDU.

The Z-Wave uses binary frequency shift keying (BFSK) modulation with Manchester or NRZ Encoding. Each symbol is mapped to the number of samples per symbol (default is 16). Each data symbol are modulated onto the carrier using BFSK with no pulse shaping (data rates R1 & R2) and with Gaussian pulse shaping(data rate R3).

2.3. Z-Wave Physical Layer Test

2.3.1 Z-Wave Receiver Tests

The Z-Wave measurement suite supports generating signal as per the ITU-T G.9959 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 Singlecast, Multicast, Acknowledgement Frame, etc.

- 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

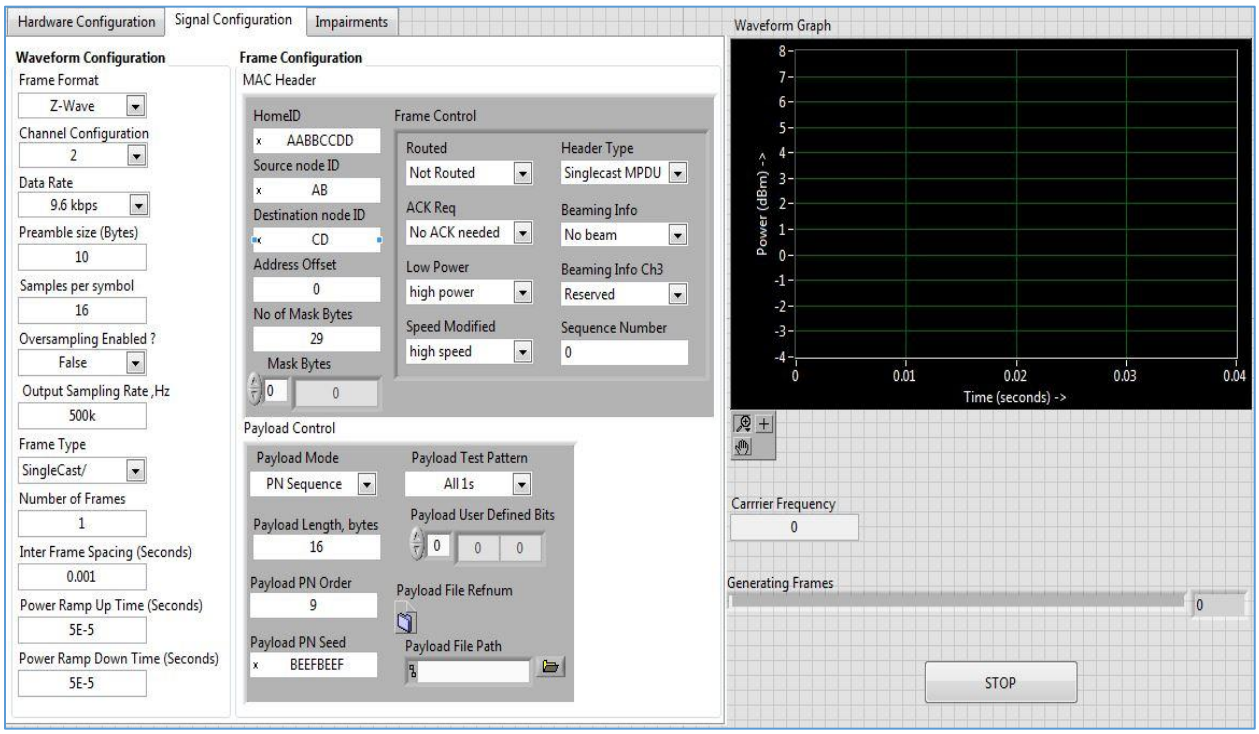


Figure 4 Z-Wave Measurement Suite - Generation Example

The Z-Wave measurement suite supports the following receiver tests specified by the ITU-T G.9959 standard.

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

2.3.2 Z-Wave Transmitter Tests

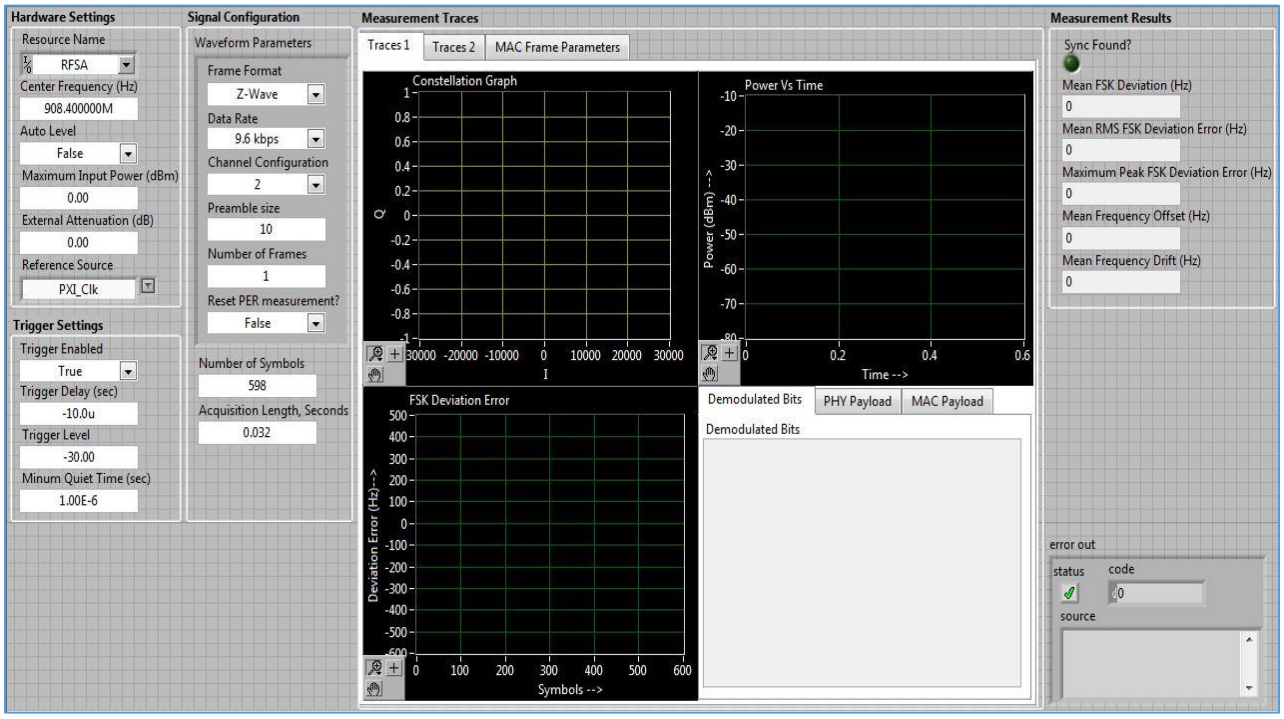
The Z-Wave measurement suite supports analyzing signal as per the ITU-T G.9959 standard frequency band.

Measurement Suite – Analysis Key Features

The MaxEye Z-Wave measurement suite supports the following measurements.

- Frequency Deviation measurements
- Frequency Offset
- 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
    - Measured and Reference I vs Time and Q vs Time
    - Power vs Time Trace

- Spectral Emission Mask Trace



The Z-Wave measurement suite supports the following transmitter tests specified by the ITU-T G.9959 standard.

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

3. Supported Hardware

The Z-Wave 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.

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