MAXEYE TECHNOLOGIES

# Wi-SUN (IEEE 802.15.4g) Measurement Suite

**(Supports MR OFDM Mode)**

# Data Sheet

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**Version: 1.1.0**

NATIONAL INSTRUMENTS Alliance Partner

# Contents

# 1. Introduction

SUNs enable multiple applications to operate over shared network resources, providing monitoring and control of a utility system. SUN devices are designed to operate in very large-scale, low-power wireless applications and often require using the maximum power available under applicable regulations, in order to provide long-range, point-to-point connections. Frequently, SUNs are required to cover geographically widespread areas containing a large number of outdoor devices. In these cases, SUN devices may employ mesh or peer-to-peer multihop techniques to communicate with an access point.
MaxEye Technologies provides generation and analysis functions in LabVIEW for generating and analyzing the Wi-SUN 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 802.15.4g Standard supports multiple Physical Layer modes; the current version of the toolkits supports the following physical layer mode.

i. MR OFDM Physical Layer (2.4GHz)

The standard defines different modulation types, data rates based on the DFT Size.

| Parameter | OFDM Option 1 | OFDM Option 2 | OFDM Option 3 | OFDM Option 4 |
|---|---|---|---|---|
| Nominal bandwidth (kHz) | 1094 | 552 | 281 | 156 |
| Channel spacing (kHz) | 1200 | 800 | 400 | 200 |
| DFT size | 128 | 64 | 32 | 16 |
| Active tones | 104 | 52 | 26 | 14 |
| # Pilot tones | 8 | 4 | 2 | 2 |
| # Data tones | 96 | 48 | 24 | 12 |
| MCS0 (kb/s) (BPSK rate 1/2 with 4x frequency repetition) | 100 | 50 | — | — |
| MCS1 (kb/s) (BPSK rate 1/2 with 2x frequency repetition) | 200 | 100 | 50 | — |
| MCS2 (kb/s) (QPSK rate 1/2 and 2x frequency repetition) | 400 | 200 | 100 | 50 |
| MCS3 (kb/s) (QPSK rate 1/2) | 800 | 400 | 200 | 100 |
| MCS4 (kb/s) (QPSK rate 3/4) | — | 600 | 300 | 150 |
| MCS5 (kb/s) (16-QAM rate 1/2) | — | 800 | 400 | 200 |
| MCS6 (kb/s) (16-QAM rate 3/4) | — | — | 600 | 300 |

# 2. Wi-SUN Measurement Suite

## 2.1. Overview

The term Wi-Sun is the short form of Wireless Smart Utility Network. Wi-Sun is a secure optimized mesh network. Wi-Sun is promoted by Wi-Sun Alliance. Wi-Sun alliance promotes adoption of open industry standards used for wireless smart utility and smart city applications. Applications of Wi-Sun are advanced metering, distribution automation, municipal lighting, smart parking, environmental sensing etc. Wi-Sun network is developed as per IEEE 802.15.4g which defines PHY and MAC layer specifications.
The Physical Layer and RF front end of the Wi-SUN devices needs to be tested comprehensively to meet the requirements of the IEEE 802.15.4g standard. The familiarity of the standard is very important to start preparing to test the Physical layer of the Wi-SUN 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 Wi-SUN devices.

## 2.2. Wi-SUN Physical Layer

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

<table>
<tr><th>Octets: 2</th><th>1</th><th>0/2</th><th>0/2/8</th><th>0/2</th><th>0/2/8</th><th>0/5/6/10/14</th><th>variable</th><th>2</th></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)**

| | | Octets | | |
|---|---|---|---|---|
| | | 1 | | variable |
| Preamble | SFD | Frame length (7 bits) | Reserved (1 bit) | PSDU |
| SHR | | PHR | | PHY payload |

**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 multi-rate and multi-regional orthogonal frequency division multiplexing (MR-OFDM) PHY is RF band agnostic and supports data rates ranging from 50 kb/s to 800 kb/s. The subcarrier spacing is constant and is equal to 10416-2/3 Hz (or 31250/3 Hz). The symbol rate is 8-1/3 ksymbol/s, which corresponds or 120 μs per symbol. This symbol includes a quarter-duration cyclic prefix (CP; 24 μs) and a base symbol (96 μs).
This PHY includes four options, each one being characterized by the number of active tones during the PHR or PSDU. The total signal bandwidth for each option ranges from 1.2 MHz down to <200 kHz. While the standard does not specify the actual DFT size implemented in the system, the standard does support the following baseline DFT size: 128, 64, 32, and 16.

## 2.3. Wi-SUN Physical Layer Test

### 2.3.1 Wi-SUN Receiver Tests

The Wi-SUN measurement suite supports generating signal as per the IEEE 802.15.4g 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

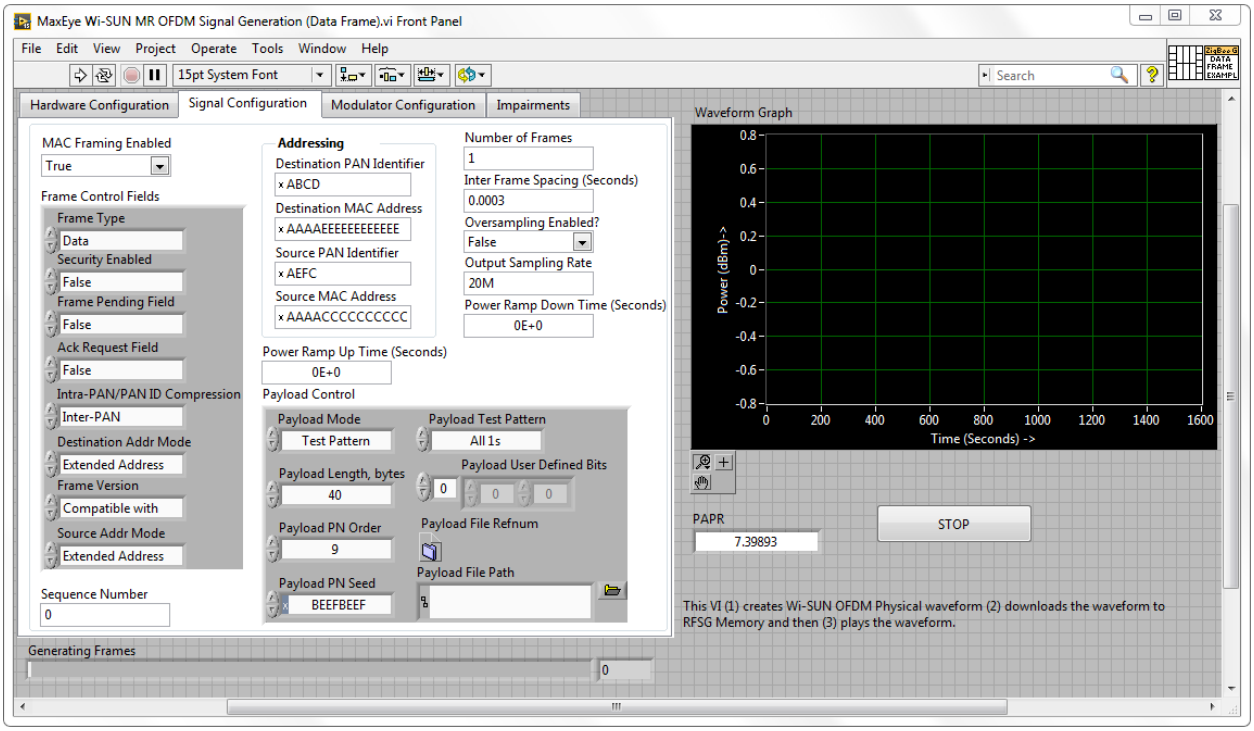



**Figure 3 Wi-SUN Measurement Suite - Generation Example**

The Wi-SUN measurement suite supports the following receiver tests specified by the IEEE 802.15.4g standard.

- Receiver Sensitivity Test
- Receiver Interference Test
- Receiver Adjacent Channel Rejection

- Receiver Maximum Input Power Level

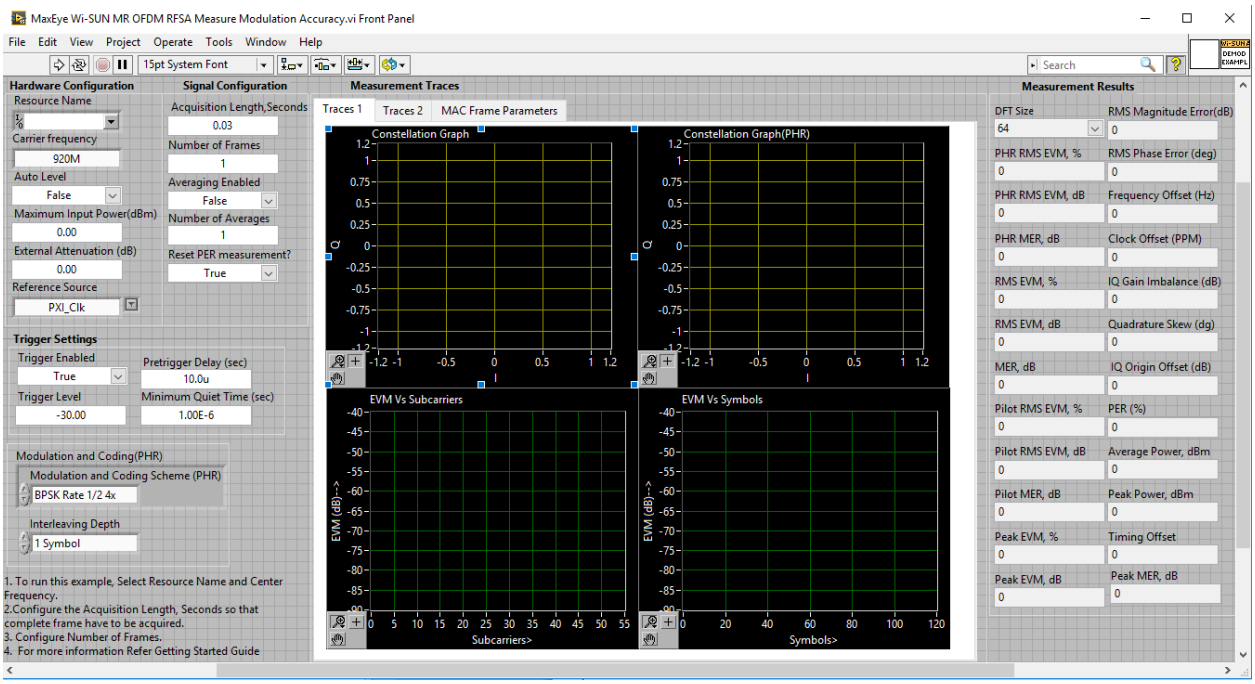
### 2.3.2 Wi-SUN Transmitter Tests

The Wi-SUN measurement suite supports analyzing signal as per the IEEE 802.15.4 standard .

**Measurement Suite – Analysis Key Features**

The MaxEye Wi-SUN 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 Subcarriers
    - Power vs Time Trace
    - Spectral Emission Mask Trace




The Wi-SUN measurement suite supports the following transmitter tests specified by the IEEE 802.15.4g standard.

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

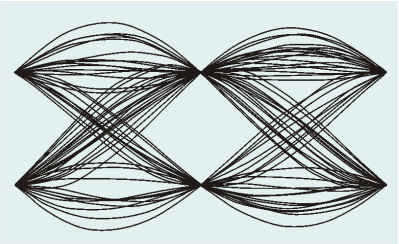
## 3. Supported Hardware

The Wi-SUN 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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