



Accelerate your communications system deployment with the only commercial off-the-shelf software defined radio running an OFDM physical layer implementation of the Joint Tactical Radio System (JTRS) Wideband Networking Waveform (WNW).

### Benefits

- Reduce time to deployment by 12 to 18 months by providing developers with the WNW OFDM PHY fully integrated into a production-ready modem
- Concentrate on development of ad-hoc networking algorithms and protocols while utilizing a proven high throughput, network-ready OFDM PHY
- Reduce development costs using a high data rate, multipath resilient PHY developed for next generation ad-hoc networking waveform requirements
- Optimize link performance and Quality of Service (QoS) parameters in various operating environments through in-service reconfiguration
- Reduce costs through simple and economical license models that offer attractive development, demonstration, and production options

### Features

- Orthogonal Frequency Division Multiplexing (OFDM) physical layer (PHY) from the U.S. military's Wideband Networking Waveform (WNW)
- Achievable throughputs from low kbps to greater than 10 Mbps
- Packet-based system developed specifically for mobile ad-hoc networks (MANETs)
- Multiple operating modes with variable bandwidth, modulation order, FEC, spread factor, and diversity factor
- Supports data rate adaptation. Adaptable to maximize throughput in all channel conditions
- Source code for API examples provided as a tool to accelerate development efforts
- Optional Software Communications Architecture (SCA) Core Framework and optional support for JTRS Modem Hardware Abstraction Layer (MHAL)

### Applications

- Tactical Mobile Ad-Hoc Networking Communications
- Data Link Communications

### Description

The Wideband Networking Waveform<sup>1</sup> (WNW) is the next generation high throughput military waveform, developed under the Joint Tactical Radio System (JTRS) Ground Mobile Radio (GMR) program. Spectrum's PHY layer implementation of the WNW waveform was developed by L-3 Communications Nova Engineering and is currently used in several military applications such as the Wideband Networking Waveform (WNW) and the Operational Test - Test and Evaluation (OT-TES) Core Transceiver. The WNW OFDM PHY can achieve data throughputs of more than 10 Mbps with four bandwidths and 38 total modes of operation depending on the modulation order, FEC, spread factor and diversity factor.



Figure 1. The WNW OFDM PHY enables Concept of Operations (CONOPS) for which requirements are high throughput, large network size, vast area coverage, multipath robustness and mobile ad-hoc networking.

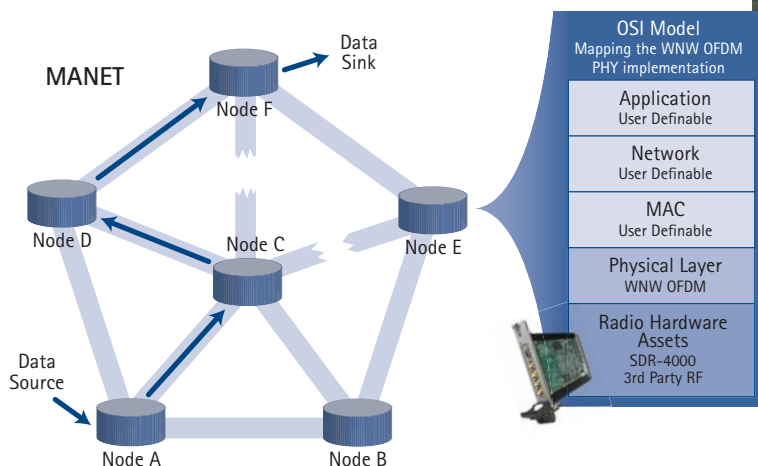


Figure 2. Implementation of a mesh network. Messages are delivered to the destination even though some connections cannot be made due to range or interference.



<sup>1</sup>Subject to U.S. export regulations

The WNW OFDM PHY was designed to allow the user to utilize the OFDM physical layer to develop optimized networking protocols for a wide range of requirements. The WNW OFDM PHY supports time division multiple access (TDMA) and carrier sense multiple access (CSMA), and will support other access schemes as well. Within each bandwidth, the WNW OFDM PHY supports link adaptation whereby the channel condition is sensed and data rate adjusted for optimal performance. Additionally, the data rate is automatically decoded upon packet reception allowing throughput to be adjusted based on an operational need whereby the data rate can be traded for link distance.

## Architecture

### [ Modes and Variants ]

WNW OFDM PHY utilizes several different modes that vary several waveform characteristics in order to optimize throughput or link distance. The PHY supports bandwidth settings of 1.2 MHz, 3 MHz, 5 MHz and 10 MHz to allow flexibility in spectrum planning. The remaining waveform characteristics enable the user to trade throughput for link distance. There are two modulation orders (16-DPSK, QPSK), two forward error correction (FEC) schemes (Reed-Solomon, Turbo), four spreading factors (1, 4, 16, 64) and two diversity levels (1, 2). Spreading introduces redundancy within a packet. Diversity creates two identical packets but transmits each packet on a different frequency. The WNW OFDM PHY burst data rate ranges from 23 Mbps down to 100 kbps depending on the mode.

WNW OFDM Performance		
Bandwidth	Burst Data Rate	Signal-to-Noise Ratio
1.2	100 kbps - 2.4 Mbps	1.7 dB - 26.7 dB
3	100 kbps - 6.7 Mbps	0.5 dB - 26.7 dB
5	100 kbps - 11.5 Mbps	-0.5 dB - 26.7 dB
10	100 kbps - 23.0 Mbps	-1.5 dB - 26.7 dB

Table 1. The various modes offered by the WNW OFDM PHY enable the optimization of data rate and link distance.

## Software Composition

The WNW OFDM PHY is a packet-based physical layer that uses Orthogonal Frequency Division Multiplexing as the modulation technique. It contains a number of traditional OFDM signal processing blocks, but is particularly advanced in the high number of data rates and variable operating characteristics as well as its ability to perform automatic throughput recovery to support rate adaptation.

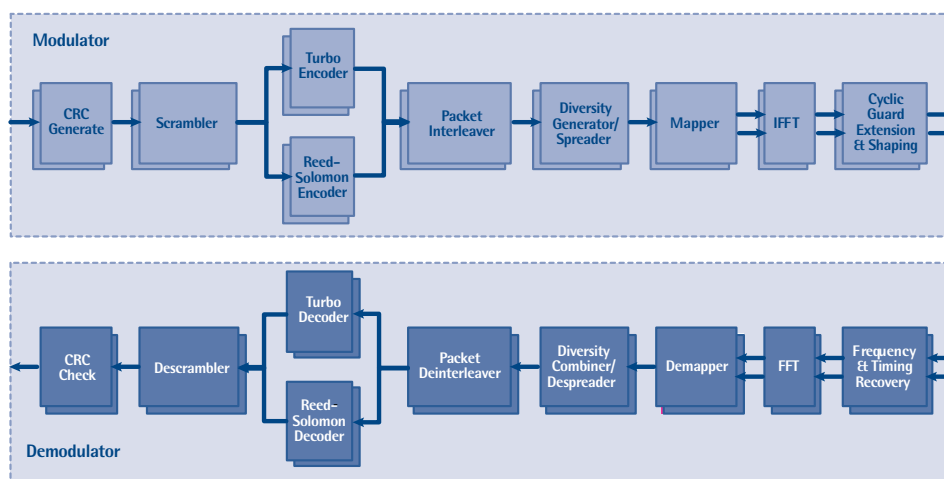


Figure 3. Software block diagram of the WNW OFDM PHY

The WNW OFDM PHY software architecture is shown in Figure 3. The modulation path includes CRC generation, data scrambling, forward error correction encoding, interleaving, diversity generation and data spreading, symbol mapping, time domain transformation and cyclic guard extension and shaping. The demodulation path includes CRC checking, data descrambling, FEC decoding, packet deinterleaving, diversity combining and data despreading, demapping, frequency domain transformation and frequency and timing recovery.

[ Channelization ]

Spectrum’s WNW PHY Layer implementation combines the WNW OFDM components with a user configurable multi-channel digital downconverter and upconverter FPGA core, allowing the user to quickly and easily create a true network-capable software defined radio.

WNW Deployment on the flexComm™ SDR-4000

Spectrum and L-3 Nova have partnered to offer WNW system integrators and radio providers a single, integrated solution that is available for commercialization and deployment. L-3 Nova’s field proven, robust WNW OFDM PHY operating at a sustained data rate of over 10 megabits per second is offered with Spectrum’s SDR-4000, a production-ready “IF-to-Ethernet” modem platform. SDR-4000 is a commercial-off-the-shelf (COTS) black-side wireless modem solution for Tactical Military Communications (MILCOM) and satellite communications (SATCOM) systems.

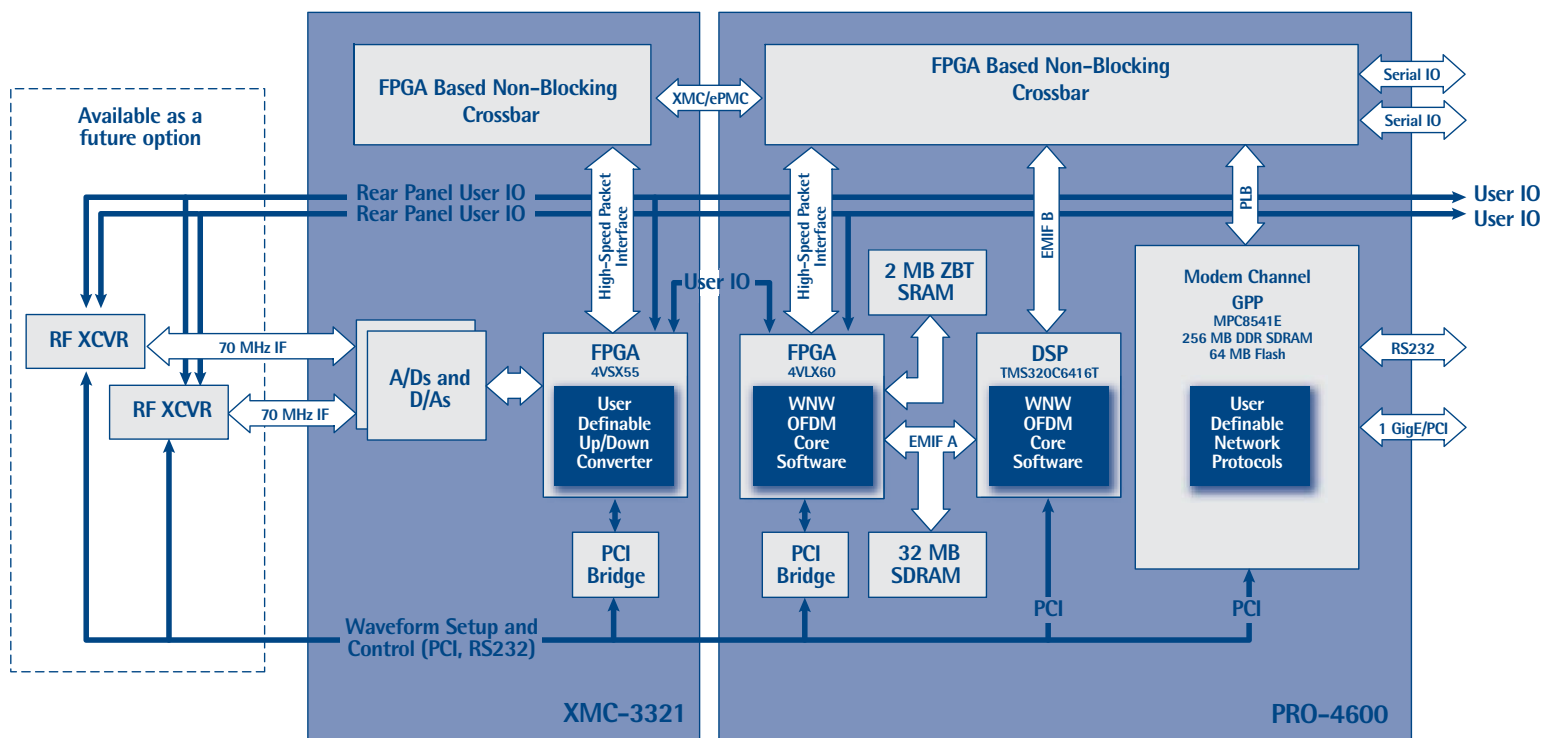


Figure 4. Deployment of the WNW OFDM on the SDR-4000 Wireless Modem (WM) Platform. Waveform component implementation indicated in dark blue boxes.

The WNW OFDM physical layer processing executes on the C6416T DSP and the XC4VLX60 FPGA on the PRO-4600 card as shown in Figure 4. The IF channelization (digital down/up conversion) and interface for external AGC control and frequency control is implemented on the XC4VSX55 FPGA XMC-3321 Dual Transceiver module.

The user develops networking algorithms and protocols on the general purpose processor (GPP). A simple set of interfaces and a test application is included and provides a means to interact and send test data to and from the physical layer.

## [ Application Programming Interfaces (APIs) ]

The WNW OFDM PHY is commanded through a set of pre-defined messages as shown in Figure 5. The GPP is either the source or destination of the messages. The specific message formats are defined in the WNW OFDM PHY Interface Control Document.

## [ Simulation ]

PHY layer test vectors are provided for a subset of the modes to aid in initial platform verification.

## [ Testing ]

A GPP test application is provided that commands the OFDM PHY using all of the supported API messages. In addition, a baseband-to-IF up/downconverter reference design is included with the purchase of the WNW OFDM PHY. The up/downconverter reference design provides a 30 MHz IF; source code is provided such that the IF can be user-defined.

Message Type	Message	Source	Target
GPP Commands	Initialize Modem	GPP	DSP
	Reset Modem	GPP	DSP
	Transmit Packet	GPP	DSP
	Receive Packet	GPP	DSP
	Status Request	GPP	DSP
	Timer Offset Adjust	GPP	DSP
Modem Notifications & Reports	Initialization Ack	DSP	GPP
	Epoch Event Report	FPGA	GPP
	Slot Start Report	DSP	GPP
	Receive Report	DSP	GPP
	Log Message	DSP/FPGA	GPP
	Status Report	DSP	GPP
	Reset Complete	DSP	GPP
	Reset Request	DSP	GPP

Figure 5. A list of supported WNW OFDM PHY source and destination messages by which the GPP interfaces to the physical layer.

## [ About the Platform SDR-4000 Rugged 3U CompactPCI ]

The SDR-4000 is a COTS black-side wireless modem solution for Tactical MILCOM and SATCOM systems. The standard SDR-4000 product line is 3U in size and follows the CompactPCI specification. In order to address tactical military needs for harsh environments, SDR-4000 cards are designed to support conduction-cooling, extended temperature range, and increased shock and vibration immunity.

The initial hardware offering within the SDR-4000 series of products is comprised of two major component level products: the PRO-4600 SDR modem processing engine and the XMC-3321 dual transceiver I/O mezzanine card. The PRO-4600 and XMC-3321 have been engineered to meet the requirements of a wide range of Tactical MILCOM applications and support Spectrum's *quicSpin* design methodology that enables rapid optimization of size, weight, power consumption, cost and ruggedization based on specific program requirements. For more information, please see the SDR-4000 family datasheet.

As a future option, Spectrum can integrate the SDR-4000 platform with an RF transceiver\*, providing an integrated "RF-to-Ethernet" solution covering the frequency band utilized by the Wideband Networking Waveform, as well as other frequency bands as appropriate. For more details, please contact Spectrum Sales.



## Licensing Terms and Ordering Information

Based on your program, you may choose one of the following license models for the OFDM WNW PHY IP packages: System Development and Demonstration (SDD) License or Production License. To order or for more information, please contact Spectrum Sales.

- 100-00564 Wideband Networking Waveform (WNW) OFDM PHY SDD License - US Version
- 100-00566 Wideband Networking Waveform (WNW) OFDM PHY Production License - US Version

The WNW OFDM implementation is subject to the export control laws of Canada. It is subject to the United States International Traffic in Arms Regulations (ITAR). For an internationally available wideband OFDM implementation, please contact Spectrum Signal Processing by Vecima.

- 650-00563 Commercial Air-Cooled SDR-4000 Board Bundle (PRO-4600 and XMC-3321) – INTEGRITY

See SDR-4000 datasheet for ordering information for other equipment that may be required. For optional SCA Core Framework and MHAL Support, please contact Spectrum Sales.



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