SeaMAX

An Approach to Fixed- and Mobile-WiMAX Test and Measurement

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The fast-growing WiMAX industry is all set to define a new era of fixed and mobile broadband services and network access. Fixed-station WiMAX is already enjoying widespread deployment in order to provide last-mile access for broadband, IP-based services globally. Its successor, mobile-WiMAX, is currently undergoing further amendments by the IEEE (as of February 2007) but is already in initial manufacturing and beta-testing phases around the world. The growth of this industry has spurred several players to enter WiMAX development and/or deployment, thus increasing the need for versatile testing tools and techniques during the design, production and deployment cycles.

In early December, 2006, SeaSolve Software Inc. announced the release of their Fixed- and Mobile-WiMAX RF Test and Measurement solutions suite for the very purpose of standard-based compliance testing of fixed- and mobile-WiMAX devices.

It is essential to choose the right signal generation and analysis tool for designing and developing various products based on wireless standards. SeaSolve's WiMAX suite of solutions, aptly named SeaMAX, enables standard-compliant test and measurement for both the fixed and mobile flavors of the WiMAX PHY as defined by the IEEE 802.16d-2004 and IEEE 802.16e-2005 standards, respectively. While most fixed-WiMAX devices use OFDM as a modulation envelope with fixed FFT sizes, mobile-WiMAX devices employ OFDMA with variable FFT sizes and support such features as subchannelization.

The SeaMAX suite is divided into a host of signal generation and analysis modules that enable the user (in most cases, a test engineer) to check the receiver and transmitter characteristics of WiMAX devices during the design and manufacturing stages, in the production line, and even in the field (post-production).

The SeaMAX Generator modules allow for the complete, custom configuration of a WiMAX PHY, including the definition of the data (MPDUs) carried by either downlink or uplink bursts. PHY parameters such as the DL- and UL-MAP, compression and ranging may also be user-defined, amongst others. The SeaMAX Generator suite also allows for the simulation of various RF impairments and channel models during signal generation to enable receiver performance testing.

Acting as 'virtual WiMAX receivers' are the SeaMAX Analyzer modules. These solutions are capable of demodulating the complete PHY of a received WiMAX signal and displaying its baseband characteristics (including decoded MPDU data) for the full WiMAX frame or for individual DL/UL bursts, depending on the module used. The demodulation is shown with a number of plots and measurements that enable the test engineer to verify a station's transmission as per the governing IEEE WiMAX standard.

All the SeaMAX modules are programmed using National Instruments' LabVIEW, thus making them flexible enough to be integrated with several test and measurement devices available in the market in order to facilitate real-time testing. The SeaMAX suite is provided in offline (without instruments) and online (real-time) modules. The real-time modules may be integrated with various vector signal generators and analyzers to test WiMAX devices in the lab or on the field, while the offline modules may be used to generate and/or analyze the IQ data of various WiMAX-specific signals.

Analysis – Transmitter Verification at the PHY and MAC Level

The SeaMAX-Analyzer suite may be used for design-time as well as post-production device verification in-house and, to a certain extent, on the field (using the right equipment*).

PHY parameters

SeaMAX provides analysis at the RF and baseband level through a number of plots and measurements that test engineers can use to verify the transmission characteristics of a WiMAX device-under-test (DUT). For the RF analysis of a received signal, the Analyzers provide power spectral density, spectral flatness, transmit power and channel response plots. These can be used to verify the signal's strength and frequency response across its occupied bandwidth. Additionally, the integrity of the DUT's transmission may be verified through the other parameters displayed by SeaMAX including Error Vector Magnitude (EVM) measurements, plots and constellation diagrams. This complete analysis, in real-time, may be used for a 'drive-test' scenario wherein it would be possible for engineers to carry portable test equipment (a vector signal analyzer) integrated with SeaMAX* to check various stations' signal strengths and transmissions. This would help towards planning a network layout, especially in the case of base station coverage as shown below: 'Location A' refers to a point close to a base station where strong signal strength characterizes a well-defined power spectrum and minimal EVM (seen through the constellation points). On the other hand, 'Location B' signifies a point-of-test at the edge of a base station's coverage area, where weak signals characterize a hazy power spectrum and constellation points with high, fluctuating EVM.

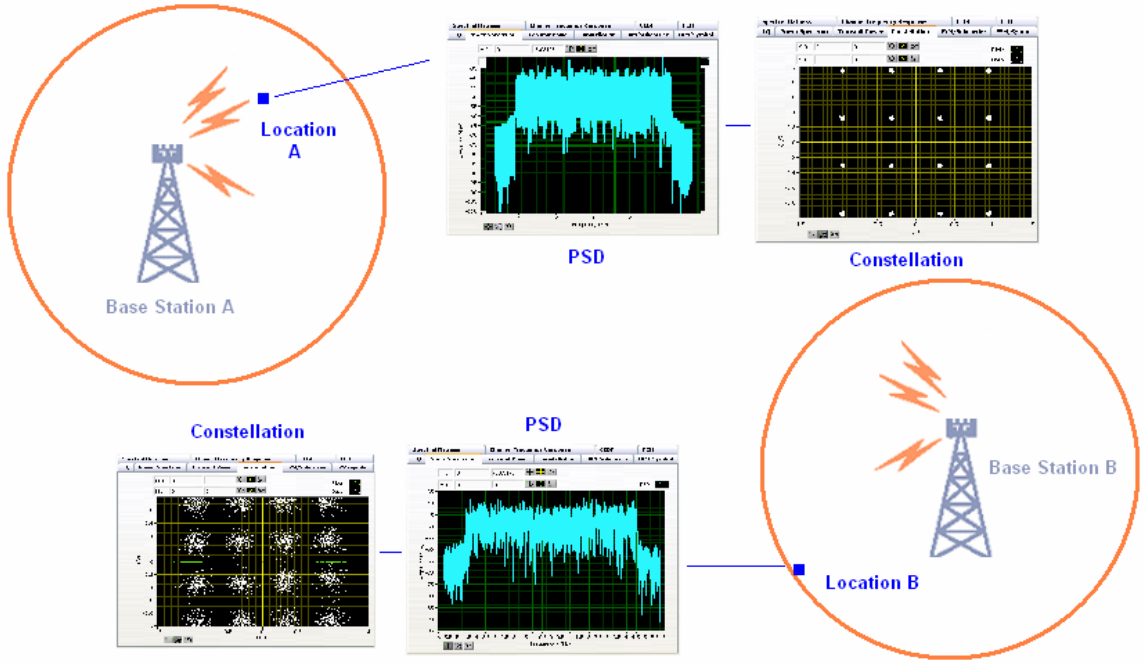

Figure 1: Use of SeaMAX-Analyzer Pro in a basic drive-test scenario, using portable test equipment

* As mentioned, the SeaMAX modules can be integrated into any RF vector signal test equipment capable of handling WiMAX frequencies. SeaSolve Software has integrated their modules into various RF instruments through the availability of LabVIEW APIs for that particular equipment.

Data demodulation

Given above is an example of how the SeaMAX-Analyzer modules are used for PHY layer analysis and reporting, as far as channel characteristics go. The modules are also capable, to a large extent, of decoding and displaying the MAC data that is received from the DUT, in addition to decoding critical PHY information included in the DL or UL subframe (depending on the DUT). For example, the SeaMAX Base Station Analyzers display fields decoded from the Frame Control Header (FCH) included in the downlink broadcast burst.

Furthermore, these decoded PHY parameters can give more information about a particular station. For example, a decoded DCD (downlink channel descriptor) can confer information about a base station such as its EIRP (useful for the drive-test) and its set values for the RTG and TTG (receive-to-transmit and transmit-to-receive transition gaps). Similarly, a decoded UCD can be checked against the defined values as prescribed by the WiMAX Forum Plugfest guidelines[2].

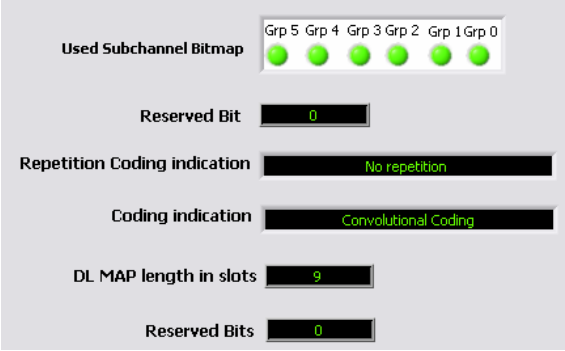

Figure 2: Decoded FCH fields in the SeaMAX Base Station Analyzer (Fixed- and Mobile-WiMAX)

Signal Generation – Receiver Verification

The SeaMAX-Generator suite allows users to define a fixed- or mobile-WiMAX signal at the baseband for transmission. Thus, the user has complete control over the signal's PHY characteristics (i.e. bandwidth, FFT-size if applicable, burst modulation) and has various options for defining the data payloads (MPDUs) carried by the DL or UL bursts in the respective modules.

The advantage of this approach is two-fold. First, and most important, the user is assured of a standard-compliant signal generation. Secondly, the user still has enough flexibility to test the receiver performance of a DUT under varying conditions and signal parameters.

Defining a Signal for Transmission

Primarily, the test engineer using the SeaMAX-Generator suite can define a WiMAX signal by its channel characteristics *and* encoded PHY parameters. These are seen below in the screenshot taken of the SeaMAX-Mobile Base Station Generator.

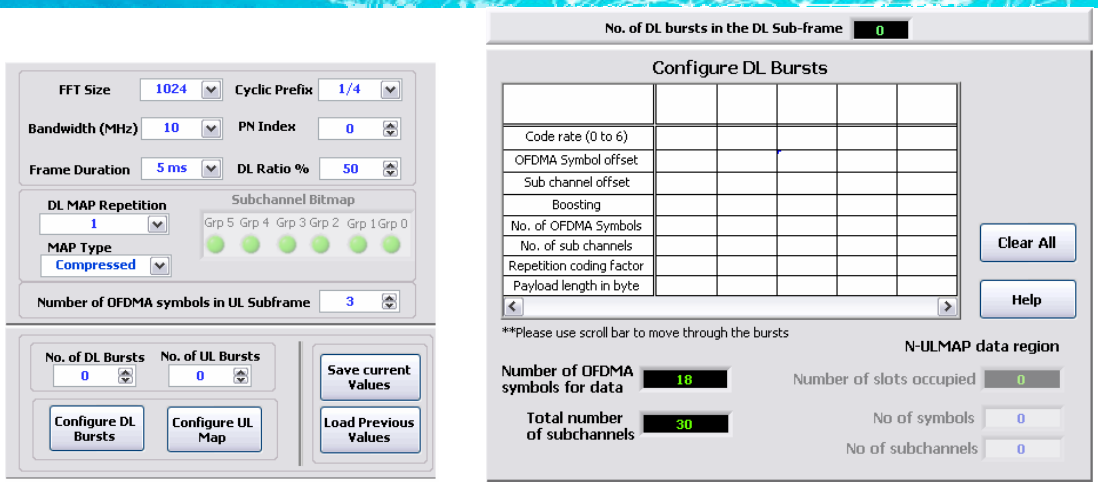

Figure 3: PHY parameters, DL-MAP and DL bursts configuration in SeaMAX-Mobile BS Generator

After defining the signal's physical characteristics, the user can now input the data payload of the various DL/UL bursts defined. SeaMAX provides various options for each MPDU including PN sequence and user-defined bit pattern, as seen in the configuration dialog below.

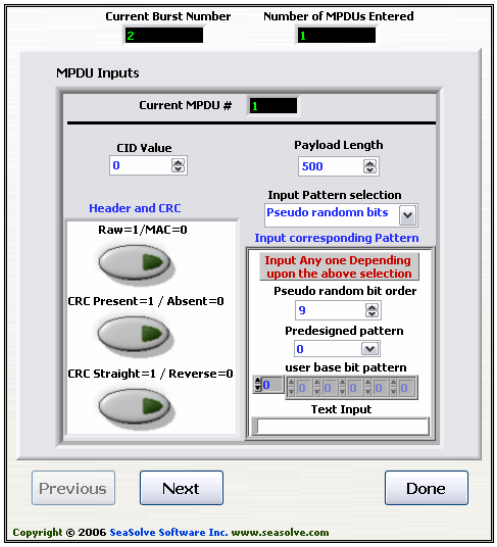

Figure 4: Defining the MPDU payloads for each burst in SeaMAX-Fixed Generator Pro

Further Flexibility – Subchannelization, CTC and Signal Impairments

Mobile-WiMAX uses subchannelization in order to optimize channel connection quality and to provide support for smart/adaptive antenna techniques that may possibly be implemented in the given mobile-WiMAX system[3].

The SeaMAX-Mobile modules support the generation and analysis of subchannelized carriers. In the SeaMAX-Mobile Base Station Generator, this feature is provided using a subchannel bitmap as defined by the IEEE 802.16e-2005 standard.

Table 268a—Subchannel index of the six subchannel groups

FFT size	Subchannel group	# Subchannel range	FFT size	Subchannel group	# Subchannel range
2048	0	0-11	512	0	0-4
	1	12-19		1	N/A
	2	20-31		2	5-9
	3	32-39		3	N/A
	4	40-51		4	10-14
	5	52-59		5	N/A
1024	0	0-5	128	0	0
	1	6-9		1	N/A
	2	10-15		2	1
	3	16-19		3	N/A
	4	20-25		4	2
	5	26-29		5	N/A

Table 1: Subchannel index reference from the IEEE 802.16e-2005 standard

In the SeaMAX-Mobile Subscriber Station Generator, the user has the option of transmitting data bursts in a selected sequence of subchannels comprising the present carrier. It is also possible to transmit the data bursts using *all* available subchannels; however, for a mobile station, this still qualifies as PUSC (partial usage of subchannels).

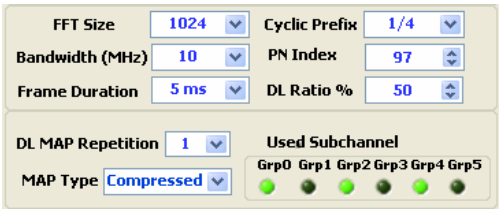

Figure 5: Subchannel bitmap selection from the SeaMAX-Mobile BS Generator

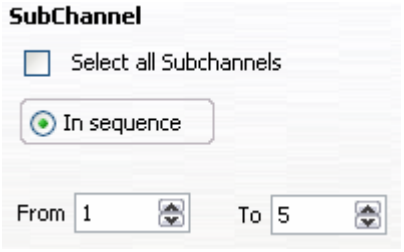

Figure 6: Subchannel selection for data bursts in SeaMAX-Mobile SS Generator

Convolutional Coding (CC) and Convolutional Turbo Coding (CTC) comprise the mandatory coding schemes implemented in mobile-WiMAX as one of the steps towards channel coding. While the FCH included the DL broadcast burst is coded using CC, it is recommended that CTC be used for all other PHY control parameters and the data bursts themselves[3].

The SeaMAX-Mobile suite allows user selection of channel coding for each burst excluding the FCH, which is mandatory CC.

In order to characterize receiver performance over a wide range of susceptible channel and signal quality, the SeaMAX-Generator suite allows for the simulation of RF impairments and channel models.

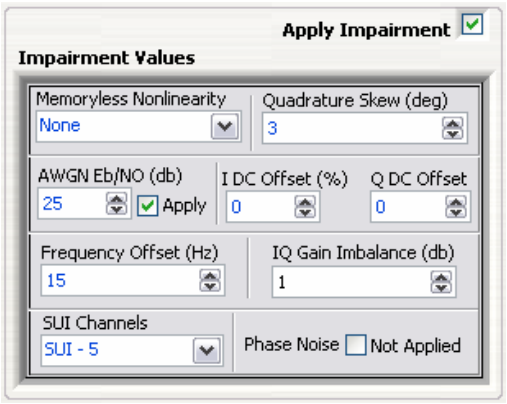

Figure 7: Impairments and SUI models in SeaMAX-Fixed

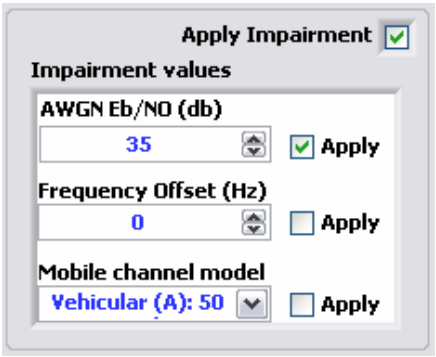

Figure 8: Impairments and mobility models in SeaMAX-Mobile

In SeaMAX-Fixed Generator Pro, SUI (Stanford University Interim) channel models are provided to emulate various terrain conditions that may cause multipath-loss in the given channel. In the SeaMAX-Mobile generators, on the other hand, pedestrian and vehicular channel models are provided in order to emulate mobility (at a certain speed) of the subscriber station.

The Future Roadmap – MIMO and Smart Antenna Techniques

At the time of this writing, SeaSolve Software is working on incorporating MIMO testing functionality into the SeaMAX suite, with a further roadmap of testing for smart antenna techniques mentioned in both the WiMAX standards and WiMAX Forum documents. The planned MIMO matrices that will be supported include 2 x 2 (MIMO) and 2 x 1 (MISO) systems. Subsequently, to enhance MIMO support, SeaMAX will initially support spatial multiplexing and beamforming.

Conclusion

The SeaMAX solutions as a whole are targeted towards the OEMs, device manufacturers and test-houses of the burgeoning WiMAX industry, with some applications geared towards WiMAX-service providers. With the SeaMAX Generator and Analyzer suites, it is then possible for them to verify their WiMAX devices prior to market release or, in the case of service providers, during deployment. The cost-effectiveness of the solutions stems from the fact that with their multi-featured interfaces (for example - RF, baseband and data analysis in one package), they are able to take the place of several 'one-box testers' that are available in the test and measurement market. Their implementation and focus on flexibility allows them to be integrated with any available RF vector signal generators and analyzers. SeaSolve Software, Inc. is also open to feedback and has adopted a customer-centric approach wherein solutions may be customized for individual clients depending on their requirements.

References

1. Institute of Electrical and Electronics Engineers, Inc., *IEEE Std. 802.16e-2005; IEEE Standard for Local and metropolitan area networks; Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems – Amendment 2, Corrigendum 1;* Section 8.4 Wireless MAN-OFDMA PHY. Feb. 28, 2006
2. Lorenz, et al., *WiMAX Forum Plugfest Guidelines – Malaga, Feb. 07*, Feb. 10, 2007
3. Gray, D., *Mobile-WiMAX : A Performance and Comparative Summary*, Sep. 2006

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