TEST RESULTS OF THE DIRECT CONVERSION TRANSCEIVER DEMO BOARD

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ABSTRACT

Direct conversion of received signals into digital form immediately after an antenna allows practically complete elimination of analog elements in the channel. That technology is capable to bring into life a new generation of multi-mode radios that can handle multiple frequency bands, process multiple transmission protocols, be the bases for convergence of different services, able of being reconfigured on the fly, and be easily and cost-effectively upgraded by wirelessly downloading new software releases. Direct conversion technology may be viewed as the practical response to the call for action by many applications such as Dynamic Spectrum allocation, WiMax with its adjustable signal bandwidth as well as many applications based on using multiple systems operating in different frequency bands or even standards (i.e. disaster handling by different first response teams equipped with different radios). The list of applications benefiting from the direct RF signal conversion to its baseband equivalent is invariably growing over time. The paper considers test results of the Direct Conversion Transceiver Demo Board using Lycon™ family of transceiver chips and a programmable baseband processor in the WiMax operating environment. Shown results for the measured Error Vector Magnitude values for the 64 QAM signals are translated analytically into more familiar for systems engineers BER values. Operation at different carrier frequencies is reported. Full duplex multimedia communication between BTS-like node and its user counterpart was demonstrated and analyzed.

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1. INTRODUCTION

Terocelo (TechnoConcepts, Inc.) has previously reported on the test results of its "first silicon" Lycon™ transmitter and receiver chips implementing its True Software Radio® (TSR™) technology for frequency agile, programmable communications [1]. In a continuing commitment to serve the interested user community, Terocelo has developed evaluation boards for the transmitter and receiver (EVB101-TX and EVB101-RX, respectively). These boards have also been integrated with a baseband processor board from picoChip (the HDP102 based upon the picoChip PC102 integrated circuit) into a fully functional WiMAX (802.16(e)) evaluation platform (WMB101).

The purpose of this paper is to report on the results of those development and characterization efforts. The evaluation products have already been made available to certain select customers on a limited basis. *Terocelo expects to introduce next generation evaluation boards at the end of the first quarter of 2008 to a much wider user community*.

2. DETAILED DESCRIPTIONS OF THE EVALUATION BOARDS AND PLATFORM.

A photograph of the EVB101 evaluation board layout appears in Figure 1. The Lycon™ integrated circuit is located to the immediate right of the input transmission line (indicated by the red arrow in the figure).

Figure 1. Layout of the EVB101-RX and EVB101-TX. A red arrow indicates the location of the Lycon™ chips.

The layout of the EVB101 boards is such that multiple transmitters and receivers can be "daisy-chained" to create a transceiver, or to create systems with multiple transmitters and/or multiple receivers (such as MIMO).

A block diagram of the EVB101-RX appears in Figure 2. In addition to the on-chip filtering that is

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available on-board the Lycon™ chips, additional digital processing is provided for through the use of Xilinx FX-20 and SX-55 FPGAs. These FPGAs provide the ability to implement additional logic (such as for digital filtering) as well as provide for a PowerPC platform to implement simple baseband processing or data communications with baseband processing engines (for example using GigE or a proprietary interface).

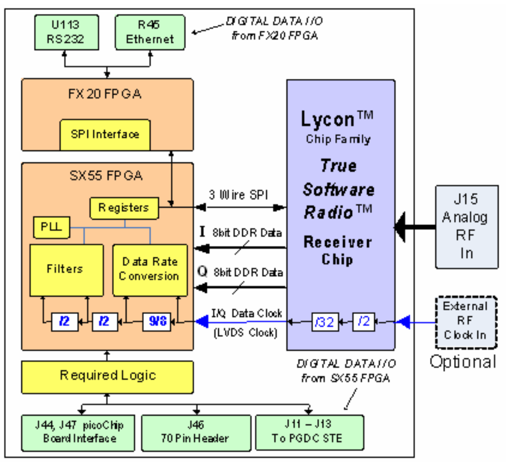

Figure 2. Block diagram of the EVB101-RX.

A photograph of the WMB101 appears in Figure 3. The platform consists of a transmitter board, a receiver board, and an HDP102 evaluation board by picoChip.

Figure 3. Photograph of the WMB101 WiMax Evaluation Platform. The platform consists of three boards (from left to right): the EVB101-TX, the EVB101-RX and the HDP102 by picoChip.

A complete working link is created by using two platforms configured as a base station and a subscriber station. From a hardware standpoint, the two nodes are indistinguishable from one another – the only difference is in the WiMAX software variant that is running on the two different types of stations. A block diagram of the overall WiMAX demonstration system appears in Figure 4.

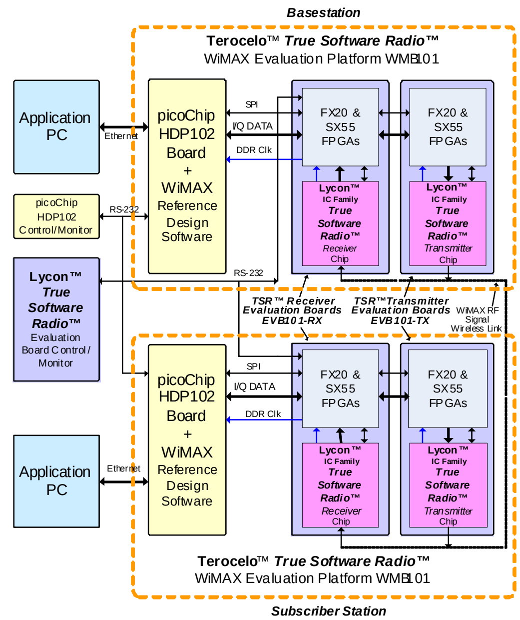

Figure 4. Block diagram of a complete WiMAX link constructed using two WMB101 WiMAX evaluation platforms.

3. TEST RESULTS.

The EVM101 evaluation boards and the WMB101 evaluation platform were tested using WiMAX signals generated by the baseband board (HDP102). The effective launched power from the transmitter board was -34 dBm with a 64 QAM constellation. The measurements were taken at a carrier frequency of 2.54862 GHz. A photograph of the test setup used for these measurements appears in Figure 5.

The test results were generated by using Vector Signal Analysis (VSA) software from Agilent, Inc. These results include the cumulative effects of the transmitter, receiver and wireless path loss. The results are summarized below.

Error Vector Magnitude (EVM):	-28.775 dB
I-Q Offset:	-42.071 dB
I-Q Time Skew:	-33.622 psec
Quadrature Error:	-406.5 mdeg
Gain Imbalance:	-0.019 dB

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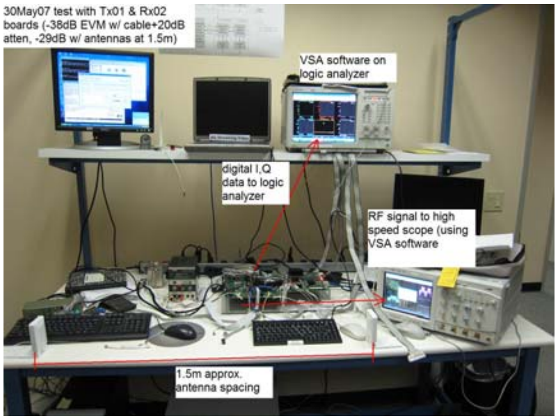

Figure 5. Photograph of the test setup used to measure performance of the EVB101-TX to EVB101-RX link implementing WiMAX protocol.

The VSA screen plot reflecting the above results is shown in Figure 6.

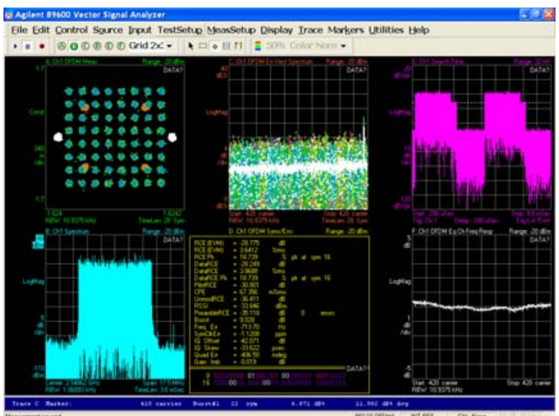

Figure 6. Plot from Agilent's Vector Signal Analysis (VSA) tool for the test measurements made using the setup of Figure 5.

The WMB101 (WiMAX Evaluation Platform) was tested by implementing a complete two-way WiMAX link using two WMB101 platforms. A photo of the test setup used to test the complete bidirectional WiMax link appears in Figure 7.

To demonstrate the capabilities of the bidirectional WiMAX link, it was used to "watch" a real-time full motion video (a commercial movie stored on one laptop computer) on a second laptop computer. A plot of the network activity as the receiver station fills the buffer downloading the move is shown in Figure 8.

The results of this test clearly show the ability for transmitters and receivers to implement a real-time Ethernet link implemented using the WiMAX protocol.

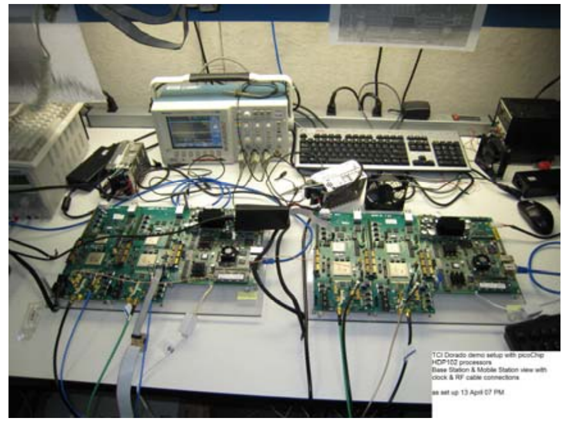

Figure 7. A complete bidirectional WiMAX link. This link was used to transport real-time video files between two computers.

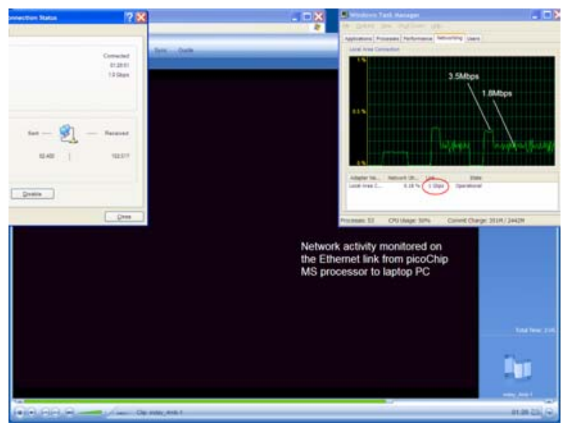

Figure 8. Plot from the PC operating system showing the network activity as the WiMAX link acquires the digital information associated with a movie.

4. CONCLUSIONS.

In this paper, Terocelo has reported on the results of its transmitter and receiver evaluation boards based upon the Lycon™ chip set. The test results have shown that Terocelo's True Software Radio® can indeed be used to implement state-of-the-art protocols with complex constellations and deliver performance comparable to or better than conventional single band analog systems.

This is a particularly significant result since WiMAX systems have multiple standards of operation and a

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truly "universal" WiMAX transceiver must conceivably be able to operate in many bands including those located at approximately 2.5 GHz and at roughly 3.4 GHz and several other frequencies between 2 and 66 GHz. The Lycon chipset offers the prospect of being able to cover many of these bands using a single transceiver instead of multiple banded transceivers.

References

1. Oleg Panfilov, et al., "Direct Conversion Transceivers as a Base for Designing Dynamic Spectrum Allocation Systems," *Dyspan 2007*, Dublin, Ireland.

2. Terocelo, *EVB101-TX and EVB101-RX Datasheet*, 2007.

3. Terocelo, *WMB101 Datasheet*, 2007.

4. Agilent, VSA Software.

5. picoChip, *HDP102 Datasheet*, 2007.

A larger view of Figure 3 appears below:

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