Flexible Testbed for Evaluation of Ultra-Wideband Radios

The proposed effort is to quantify and demonstrate the advantages of bandwidth, multiple pulse integration, and feedback loops through the use of a flexible narrowband (NB) and ultra-wideband (UWB) testbed.

Project Goals

This work is intended to assess and demonstrate the relative advantages of UWB compared to legacy NB links in terms of link robustness. Additionally, it will assess the impact of capacity (*e.g.*, bit rate) on vulnerability (*e.g.*, ease of detection) and the merits of different link configurations such as single-pulse modulation, feedback loops, and recursive demodulation.

Specific goals are to:

1. define techniques to improve the robustness of UWB communication;
2. provide a working flexible NB/UWB testbed;
3. establish validated and augmented analytic models characterizing benefits of spatial and temporal processing in UWB;
4. build preliminary models characterizing UWB propagation at longer non-line-of-sight ranges and demanding link situations; and
5. evaluate novel techniques such as single-pulse modulation and channel-matched signaling.

Relevance to LLNL Mission

The implementation of this software radio testbed will provide a better understanding of UWB and NB performance in realistic and stressed EM environments.

FY2005 Accomplishments and Results

For end-to-end testing and comparison of both UWB and NB, a software radio testbed was put together as shown in Figs. 1 through 3. This testbed system consists of two sections—the data generation/transmitter section and a data logging/receiver section—that are GPS synchronized. GPS synchronization permits time synchronization of the two for collection of high-speed RF data for analysis.

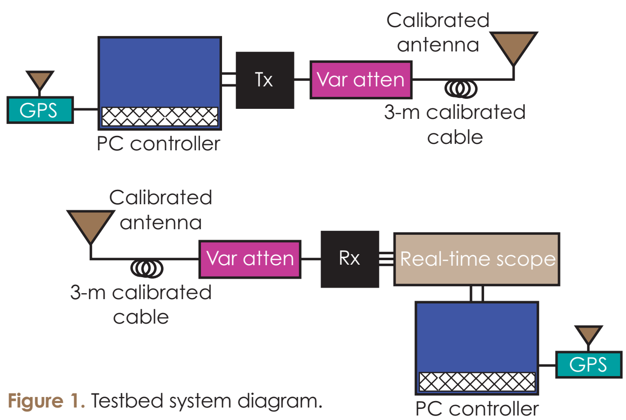


Figure 1. Testbed system diagram.

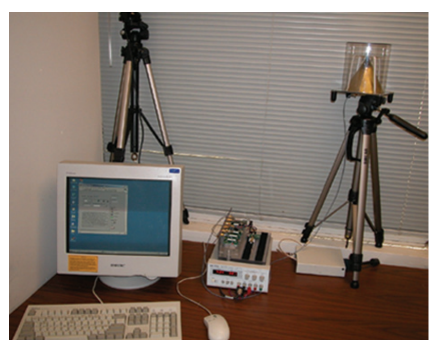
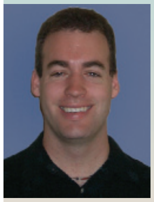


Figure 2. Testbed transmitter, antenna, and GPS.



For more information contact
Peter C. Haugen
(925) 422-0749
haugen2@llnl.gov

The merits of multiple-pulse integration and feedback loops were studied using the testbed system.

The multiple pulses/bit metric plots (Fig. 4) show the added benefit of sending multiple RF UWB bursts per each bit of data transmitted. The receiver accumulates the energy from all of these bursts to create one received data bit. In the plots, the blue lines represent the received SNR at various locations (path lengths) for a received "1" bit. The red lines provide a baseline for the noise at those locations or, the expected energy received for a "0" bit (no UWB transmission). As can be seen, by averaging a thousand RF pulses per data bit, the SNR can be greatly improved. Sending and averaging multiple RF pulses per data bit can reduce the ERP of the transmitter while still maintaining the same received SNR, which increases link covertness. However, the overall radiated power required to attain the same bit error rate (BER) can be shown to be greater than if a single, more powerful, burst had been sent.

Similarly, the feedback loop plots (Fig. 5) use the same criteria to represent the added benefit from a UWB feedback loop implemented on the receiver. These two plots show how the addition of a feedback loop can further improve the SNR by adding the correlated UWB "1" bit RF bursts (blue), while removing some of the uncorrelated "0" bit RF noise (red).

Through the use of this software radio testbed and special algorithms, numerous RF subsystems have been tested, to the benefit of RF communications projects at LLNL.

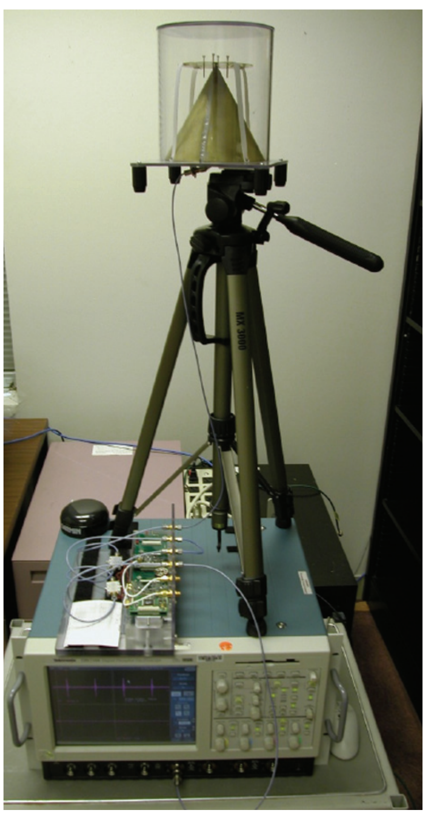


Figure 3. Testbed receiver system.

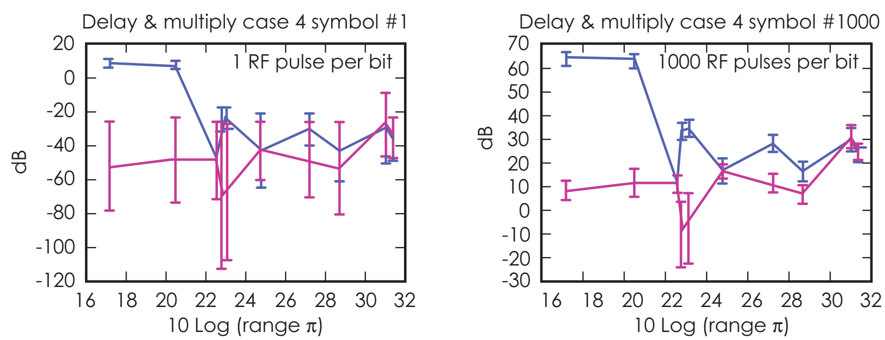


Figure 4. Merits of multiple RF pulses per data bit.

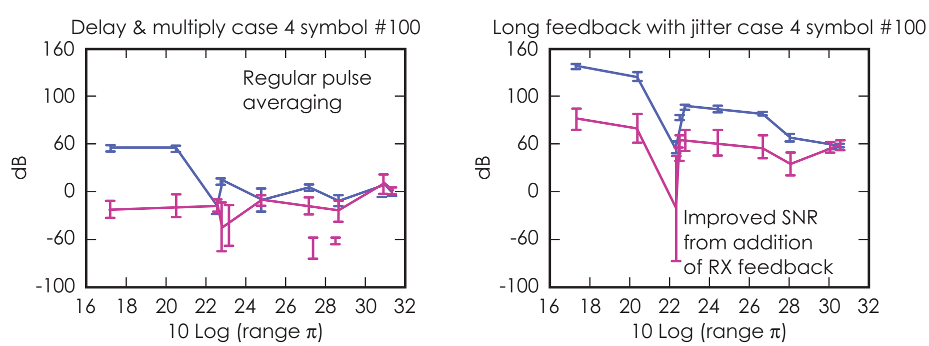


Figure 5. Merits of a receive feedback loop.