A Real-time Algorithm Design and Prototyping Platform for MIMO Research

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Outline

- Introduction.
- Hardware architecture and system details.
- MIMO OFDM experiments on the proposed platform.
- Conclusions and future directions.
- References.

Introduction – What is it?

- PXIe series chassis from National Instruments (NI)
- PXIe series remote controllers
- PXIe peripheral modules: High performance FPGAs
- Versatile baseband and RF front-end
- User friendly development tool - LabVIEW

* PXIe (PCI express eXtensions for Instrumentation)

Introduction – Scope of Applications

- Multi-Input Multi-Output (MIMO) techniques for next generation communication.
- Research to address RF impairments
- Effectiveness and efficiency evaluation for novel algorithms running on real systems.
- Real cross layer design emulation.
- Other research areas on wireless communications

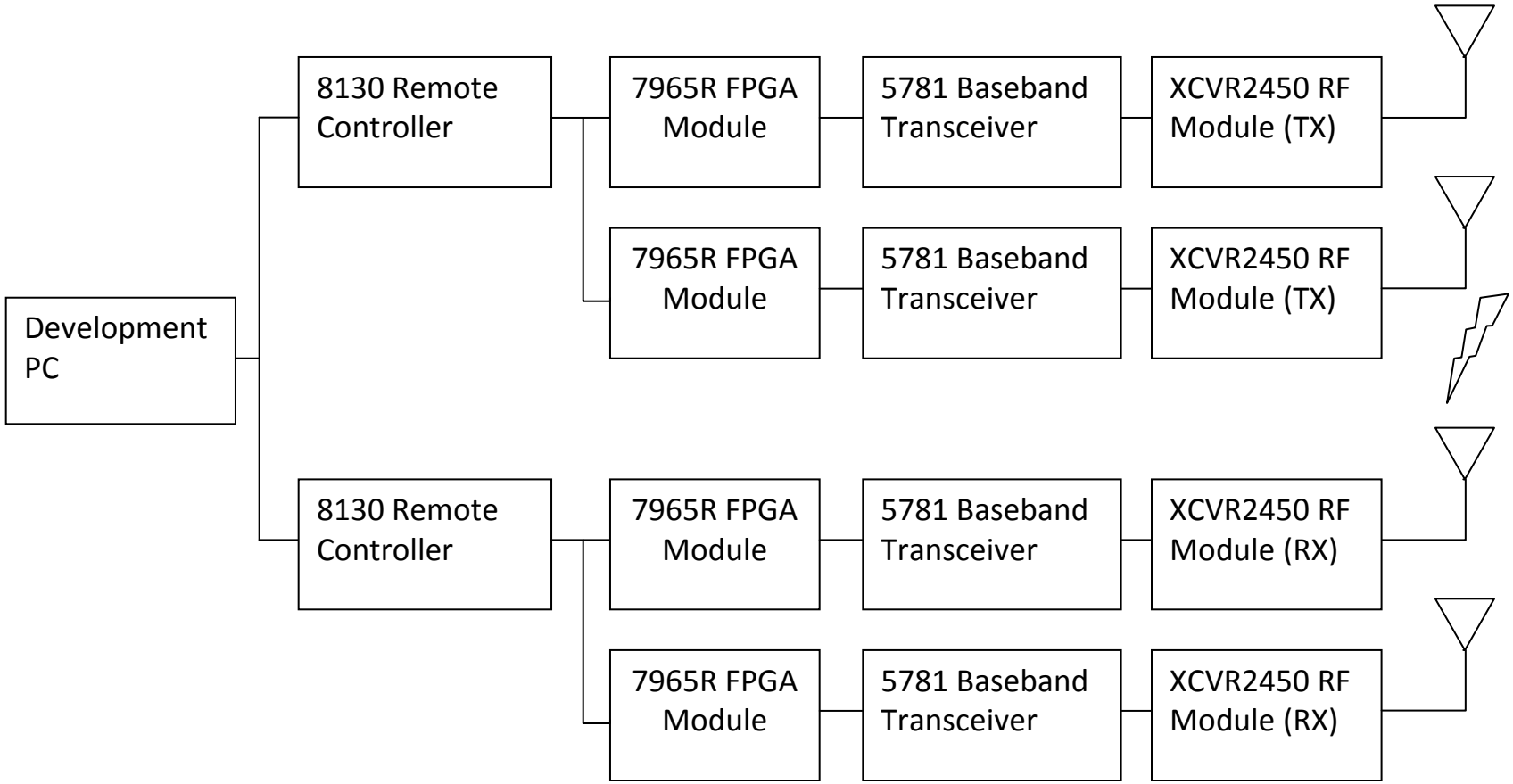
Introduction – Why do we use it?

- Hardware Architecture – easy to setup
- FPGAs – high performance for real-time
- Remote controller – suitable for high layer design
- Interface to RF - flexibility
- No need for hardware design and debug, especially the high rate inter-board communications – reduce development time and focus on algorithm task.

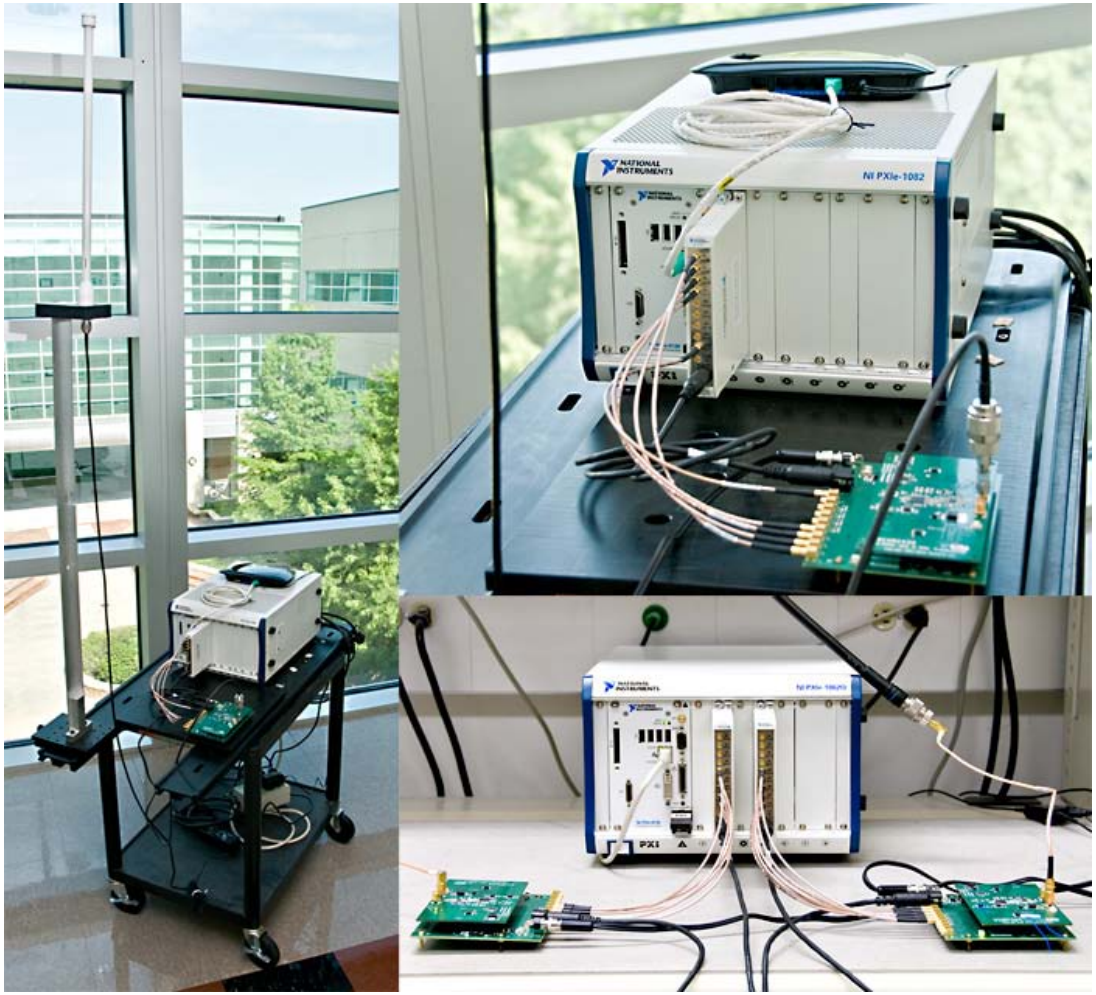
2x1 System – Architecture

1. NI PXIe-1082 chassis
2. NI PXIe-8130 remote controller
3. NI PXIe-7965R FPGA module
4. NI 5781R baseband transceiver
5. Ettus XCVR2450 RF transceiver

Real system – Block Diagram



Real System – Photos



Real System – FPGA comparison

FPGA device	Configurable Logic Blocks (Compared by distributed RAM (Kb))	DSP48E Slices	18*18 Multiplier Blocks	PowerPc Processor Core	Rocket IO	PCI Express Endpoint	Memory Block (RAM) (Kb)	CMTs	Maximum Clock Frequency (MHz)
Virtex II Pro 70	1,034	0	328	2	16 or 20	0	5,904	4	400
Virtex-5 SX95T	1,520	640	0	0	16	1	8,784	6	550

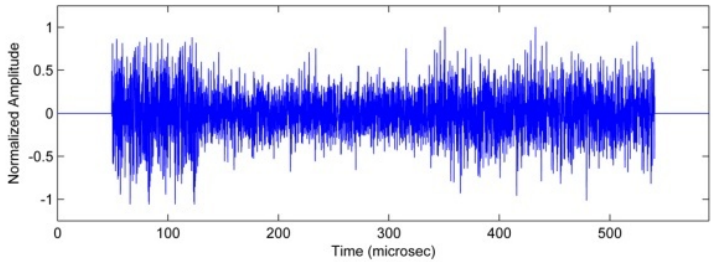
Wireless Experiment – System Description

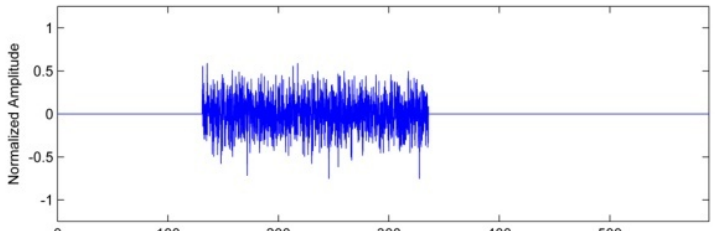
- 2x1 MISO with Alamouti scheme, 2x2 MIMO with Alamouti scheme and spatial multiplexing.
- Receiver algorithms
  - Time domain synchronization
  - Frequency offset estimation/correction
  - Channel estimation
  - Alamouti: space-time decoding
  - Spatial multiplexing: ML detection

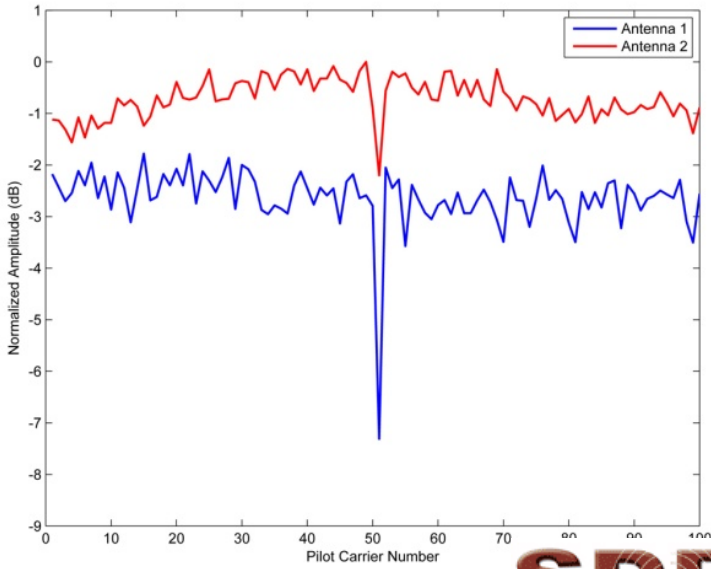
Wireless Experiment – System Parameters

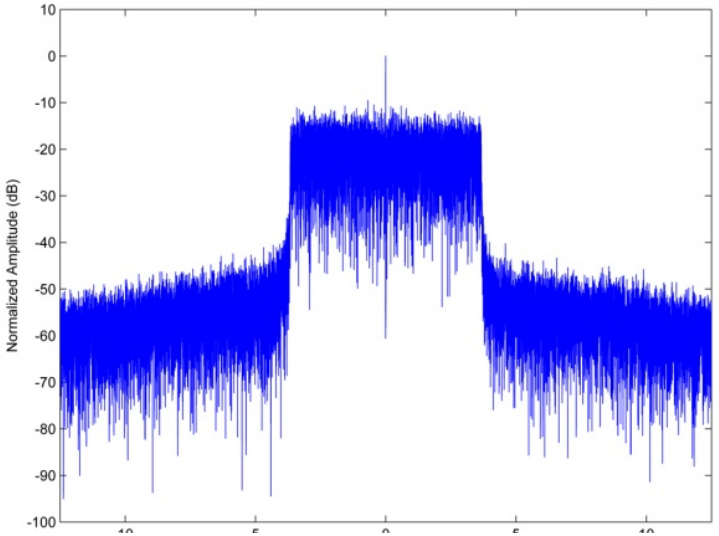
Parameter	Value
Total bandwidth	7.3242MHz
Sampling rate	25Msps
FFT size	2048
Bandwidth per subcarrier	12.207KHz
Number of subcarriers	600
Number of data subcarriers	392
Number of pilot subcarriers	196
Number of nulls near DC	12
Length of cyclic prefix	512 samples
Length of OFDM symbol	2048+512 samples
Modulation	QPSK

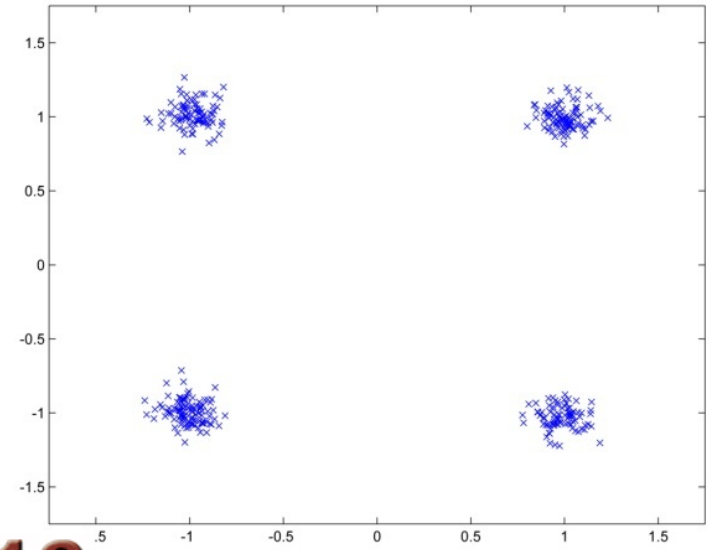
Wireless Experiment – Figures











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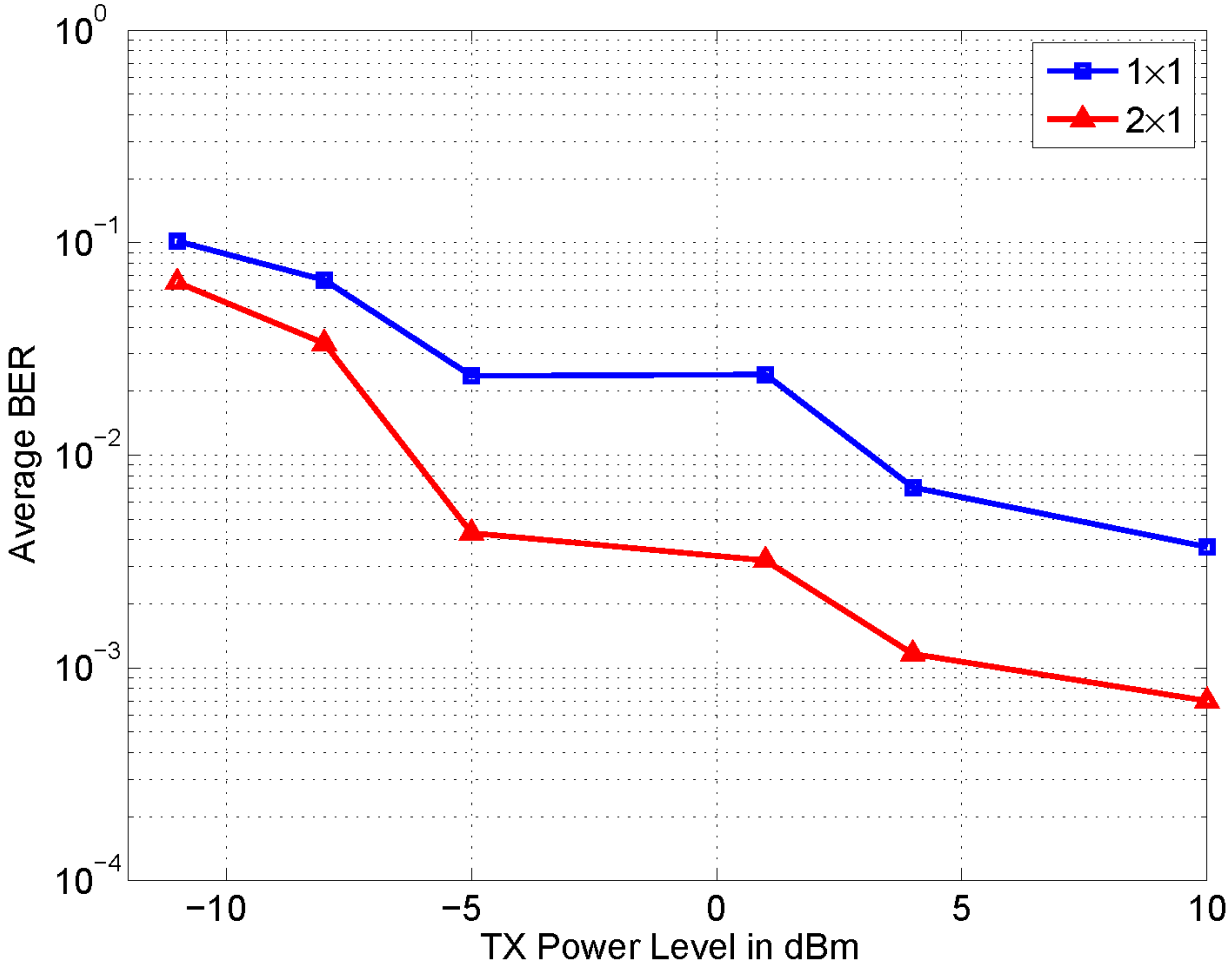
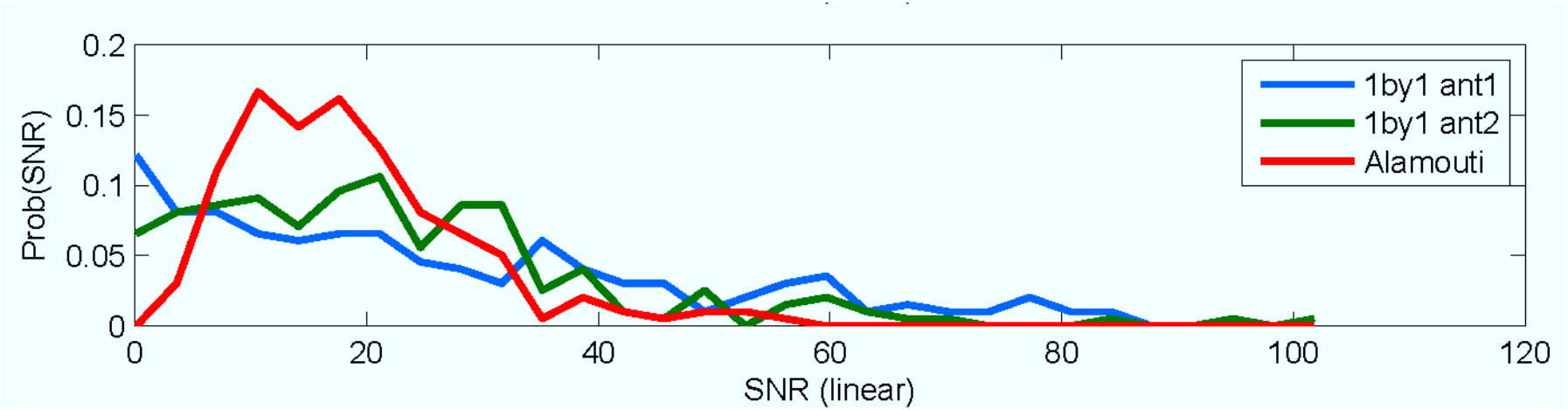
Experiment Results – BER



Experiment Results – Statistics



This figure shows the different distribution of signal to noise ratio for 2x1 and 1x1 system. Even they has the same average SNR, the SNR is more concentrated to its mean value after alamouti combination, which makes the bit error rate much lower.

Conclusions and Future Directions

- Presented the design of MIMO testbed with real-time capabilities
- Demonstrated the RT capabilities of our testbed with building basic blocks of a MIMO OFDM system
- Plan to move DSP functions presently running on the RT embedded processor onto the 7965R's FPGA for true real-time operation

References

[1] “Data Sheet of PXIe-1082, PXIe-8130, PXI-7965R and NI 5781R.” [Online]. Available: http://www.ni.com

[2] “Data Sheet of XCVR2450.” [Online]. Available: http://www.ettus.com

[3] “Data Sheet of Virtex5 Series FPGA and Virtex II Pro Series FPGA.” [Online]. Available: http://www.xilinx.com

[4] M. S.-W. C. D. Cbric, I. D. O’Donnell and R. W. Broadersen, “Spectrum sharing radios,” IEEE Circuits and System Magazine, vol. 6, no. 2, pp. 30–45, June 2006.

[5] D. Kim and M. Torlak, “Rapid prototyping of a cost effective and flexible 4 4 MIMO testbed,” in Proc. of IEEE International Workshop on Sensor Array and Multichannel Signal Processing, Darmstadt, Jul. 2008, pp. 5–8.

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Any questions?

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