



Single Antenna Bidirectional Radio Communications

Michael Knox
Industry Professor
Polytechnic Institute of NYU

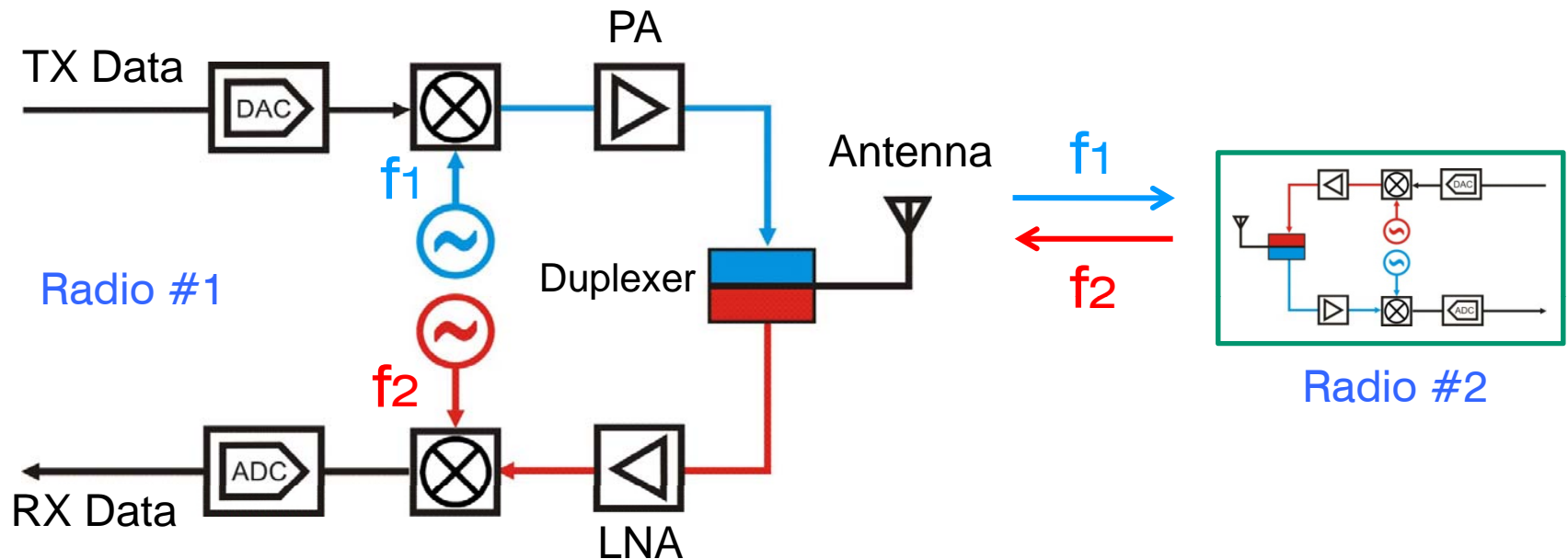
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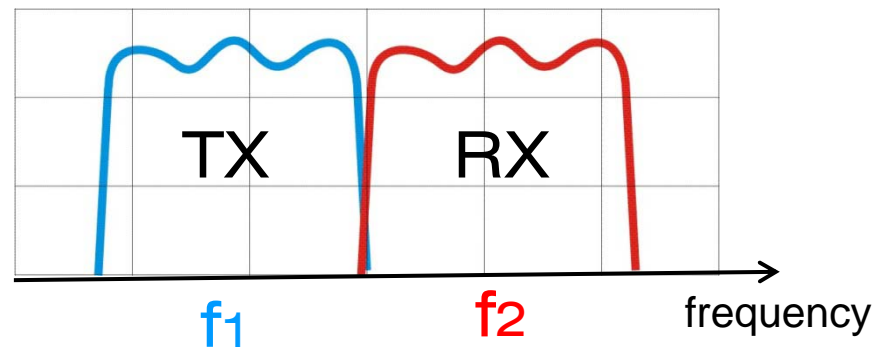
Outline

- Review Full Duplex Communications
- Limitations when using Common RF Carrier
- Tx-to-Rx Cancellation Techniques
- New Single Antenna Cancellation System

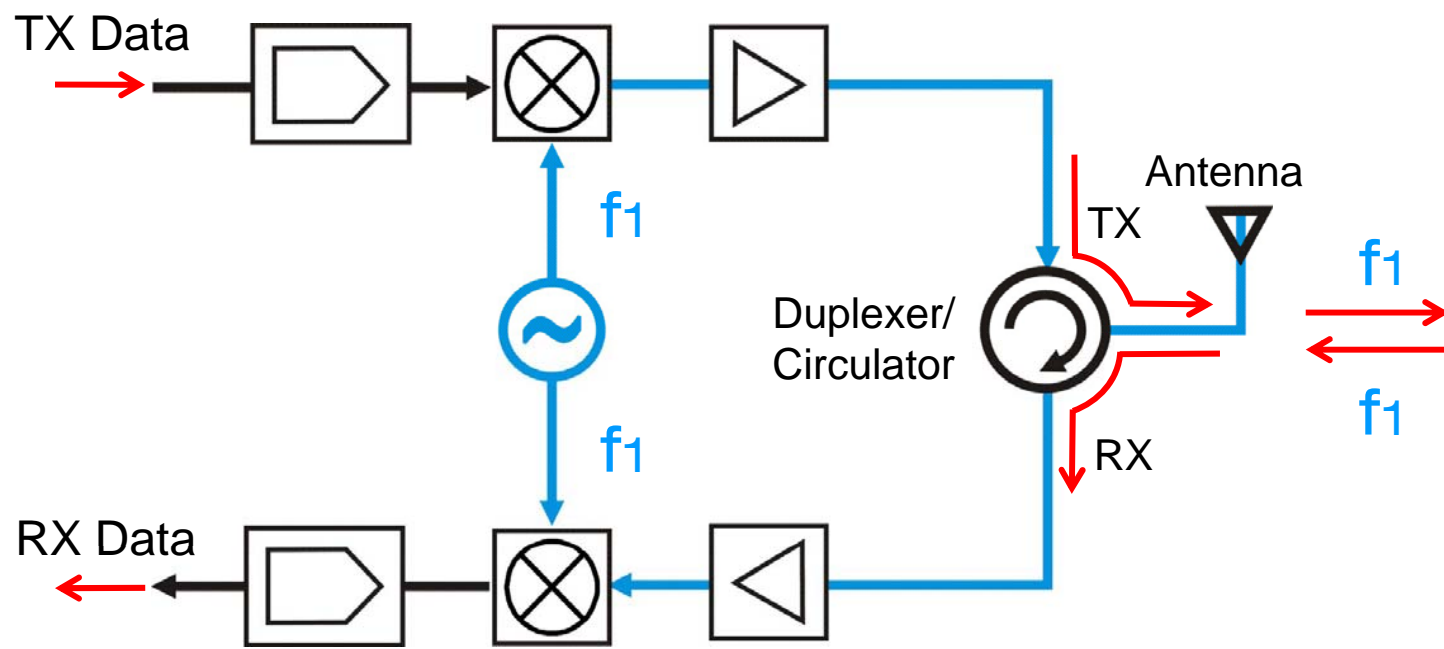
Traditional Full Duplex Communications



Duplexer provides frequency selective Tx-Rx isolation

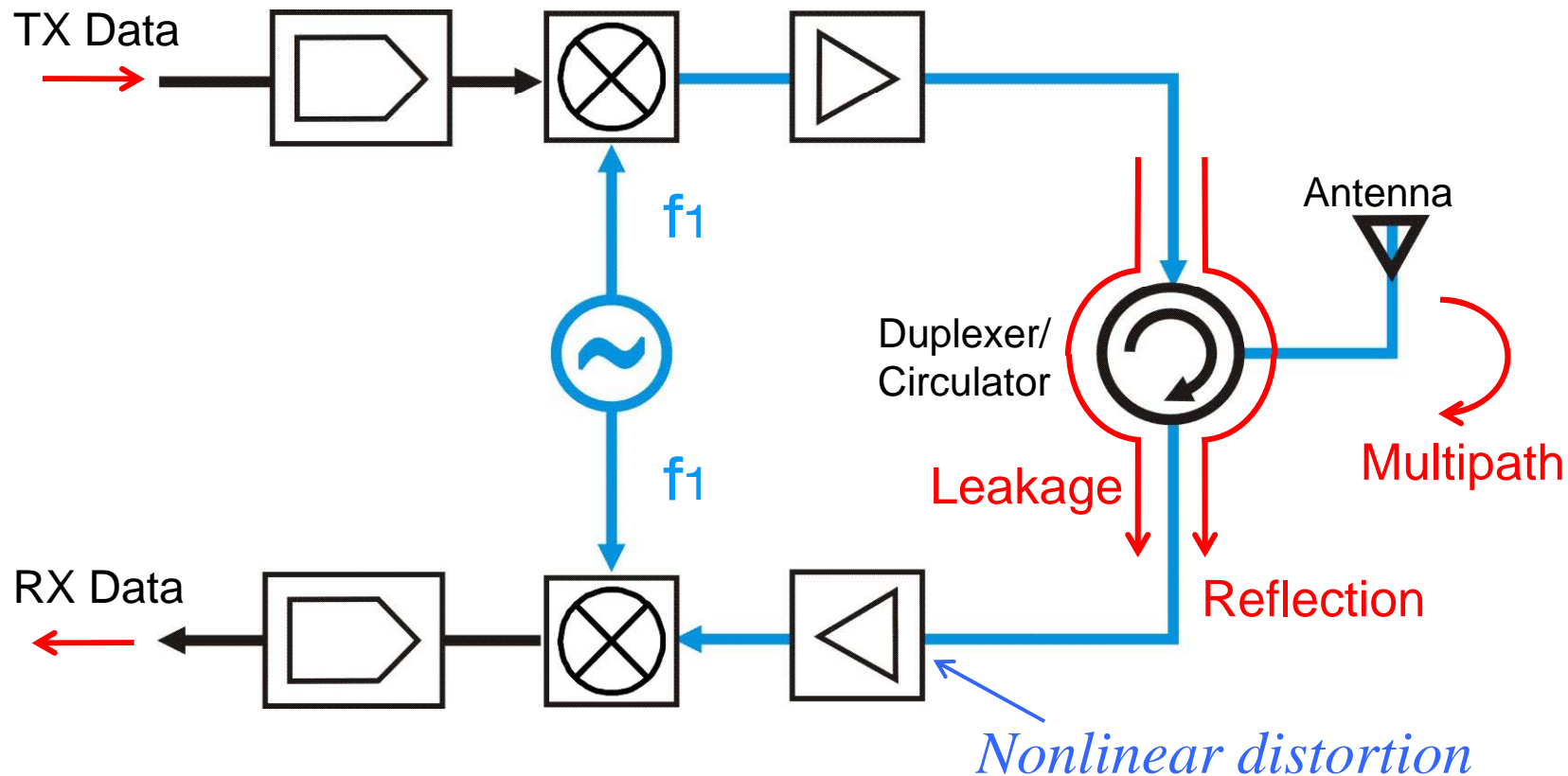


Full Duplex using Common Carrier



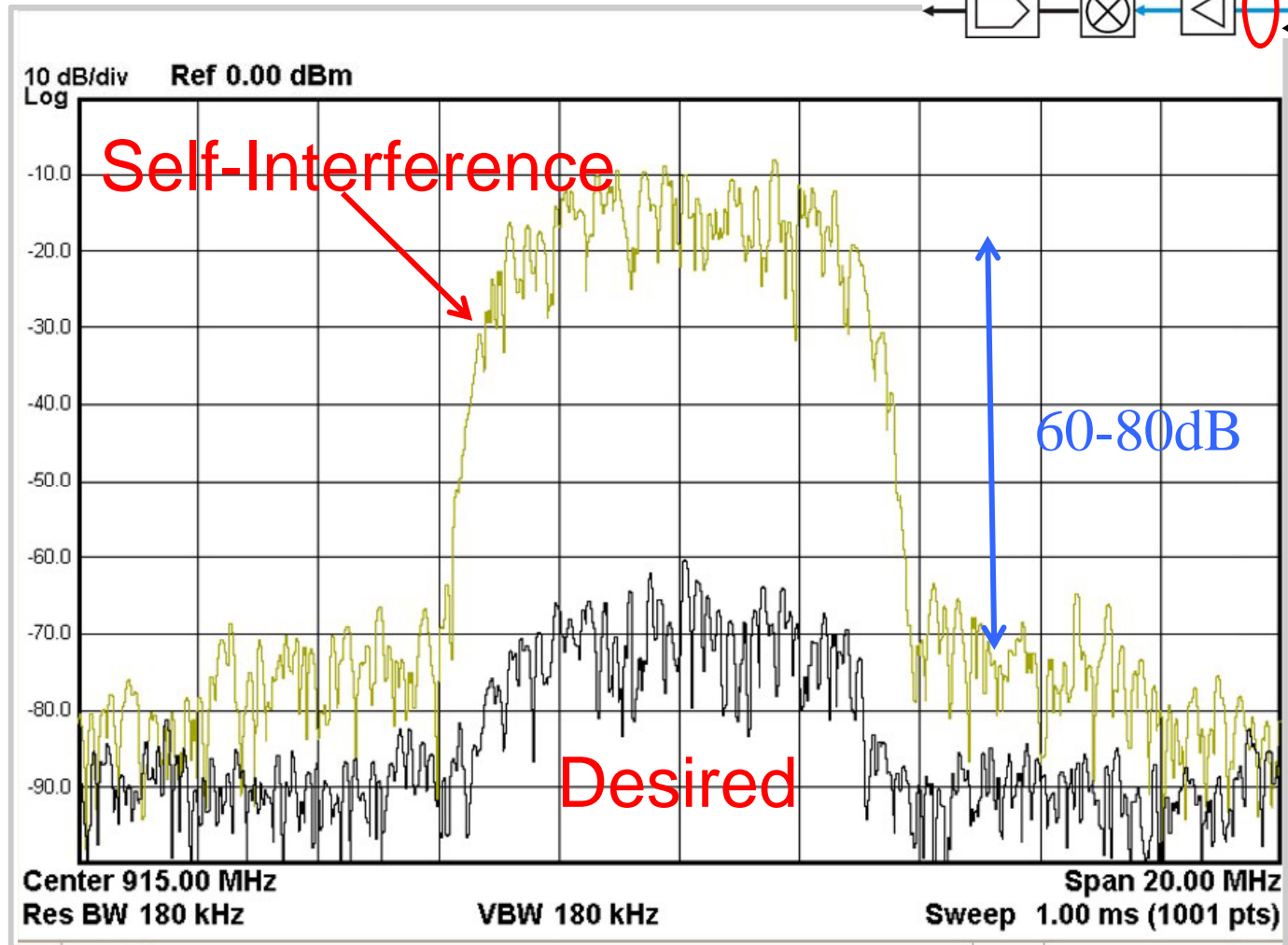
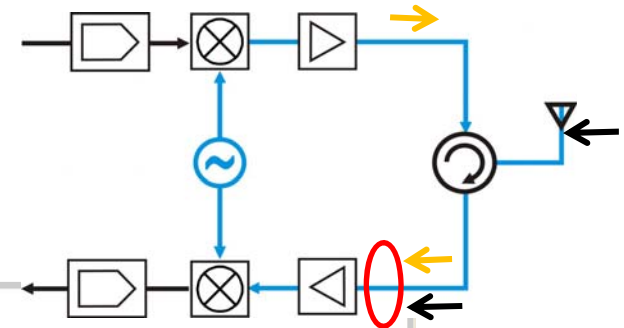
- *Theoretically achieve 2x system capacity*
- *Eliminate hidden terminal problem*
- *Low latency and fairness*
- *More efficient MAC designs*

Self-Interference Limits Performance

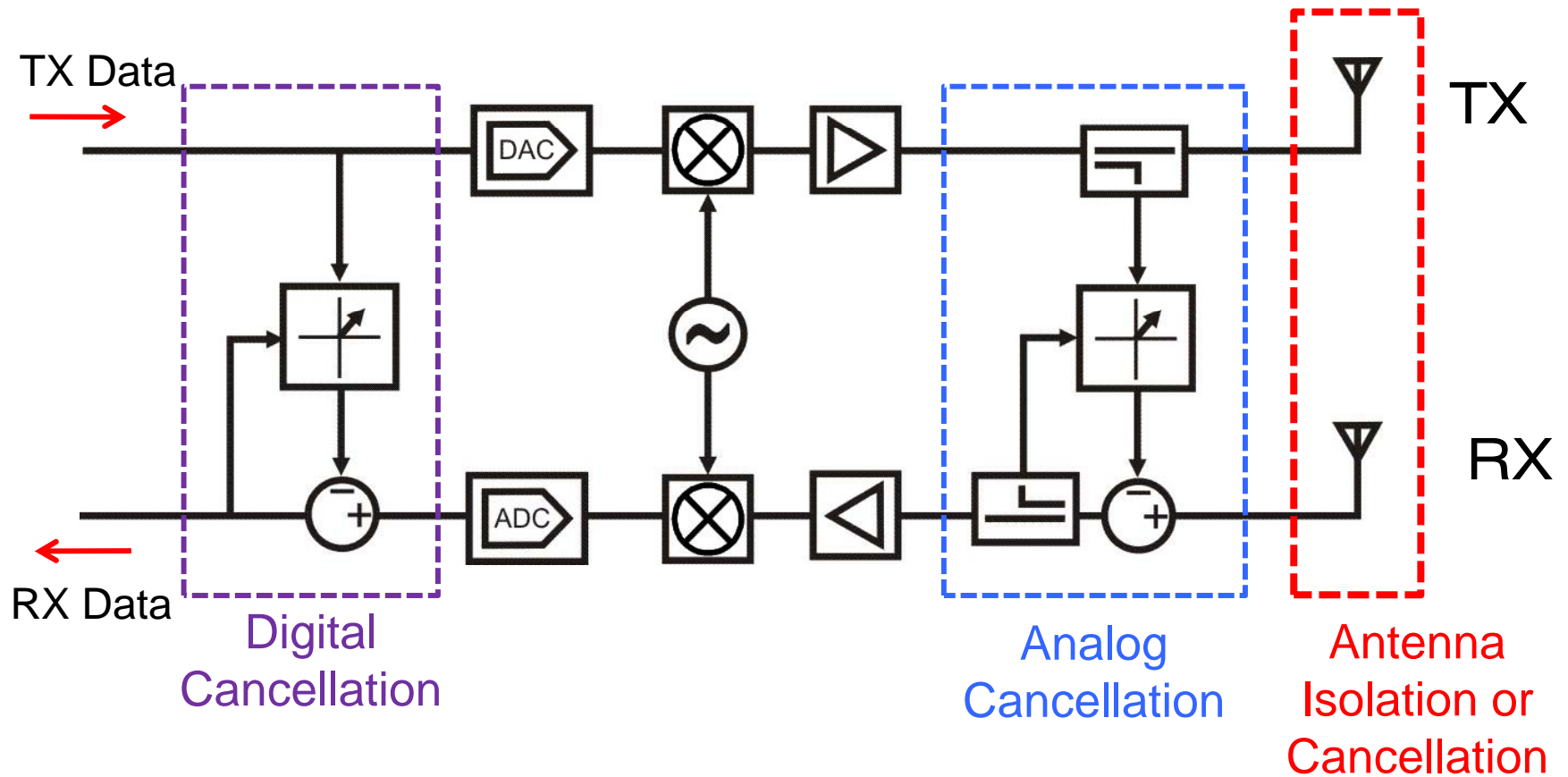


Duplexer Leakage, Antenna Reflection and Multipath Reflection severely reduces receiver dynamic range

Signals at LNA Receiver Input



TX-RX Cancellation Techniques



(10-20dB*)

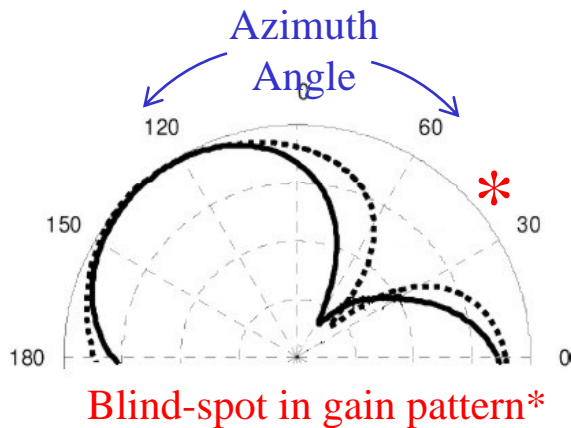
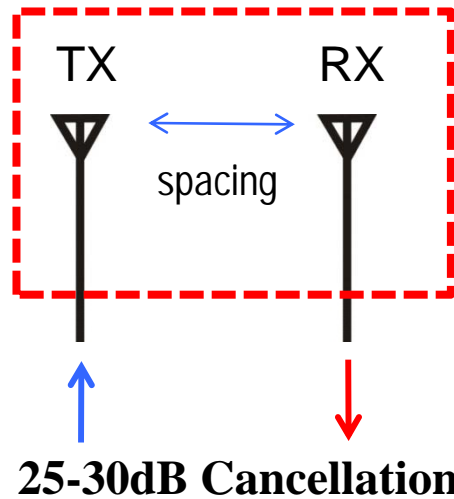
* Reported in the literature

(25-30dB*)

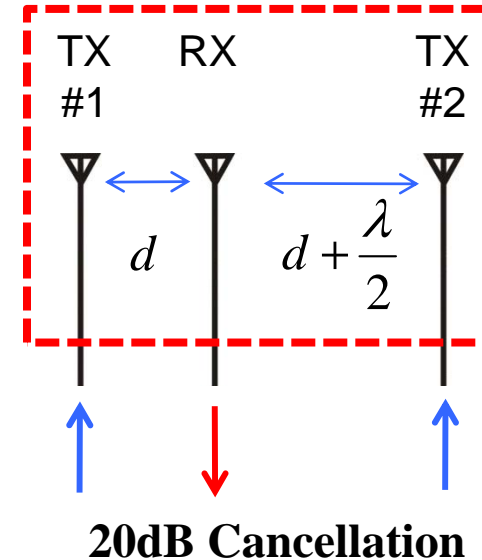
(25-40dB*)

Other Published Literature

1) Microsoft Research



2) Stanford



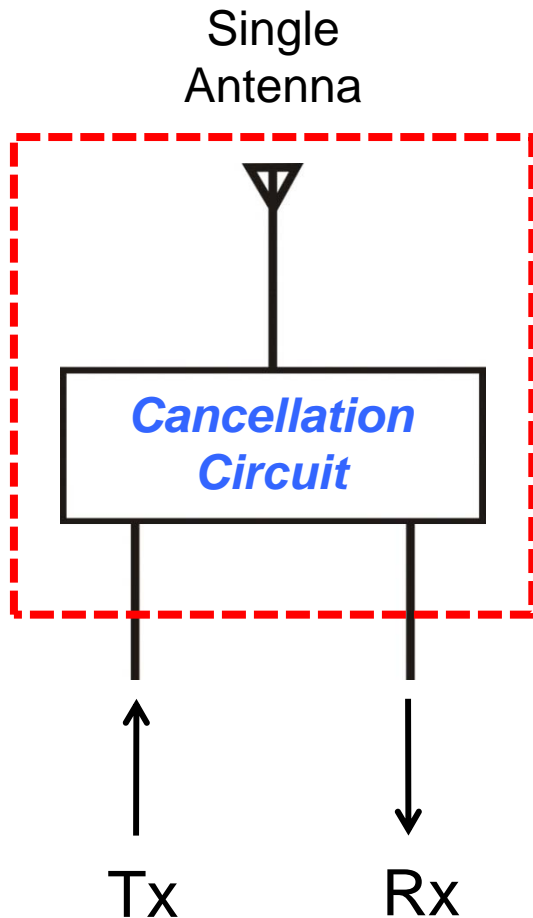
Require 2-3 "Half Duplex" antennas

- 1) Rethinking Indoor Wireless Mesh Design: Low Power, Low Frequency, Full-duplex, Bozidar Radunovic, et.al., Microsoft Research Cambridge
- 2) Achieving Single Channel, Full Duplex Wireless Communication Jung Il Cho, et.al., Stanford University

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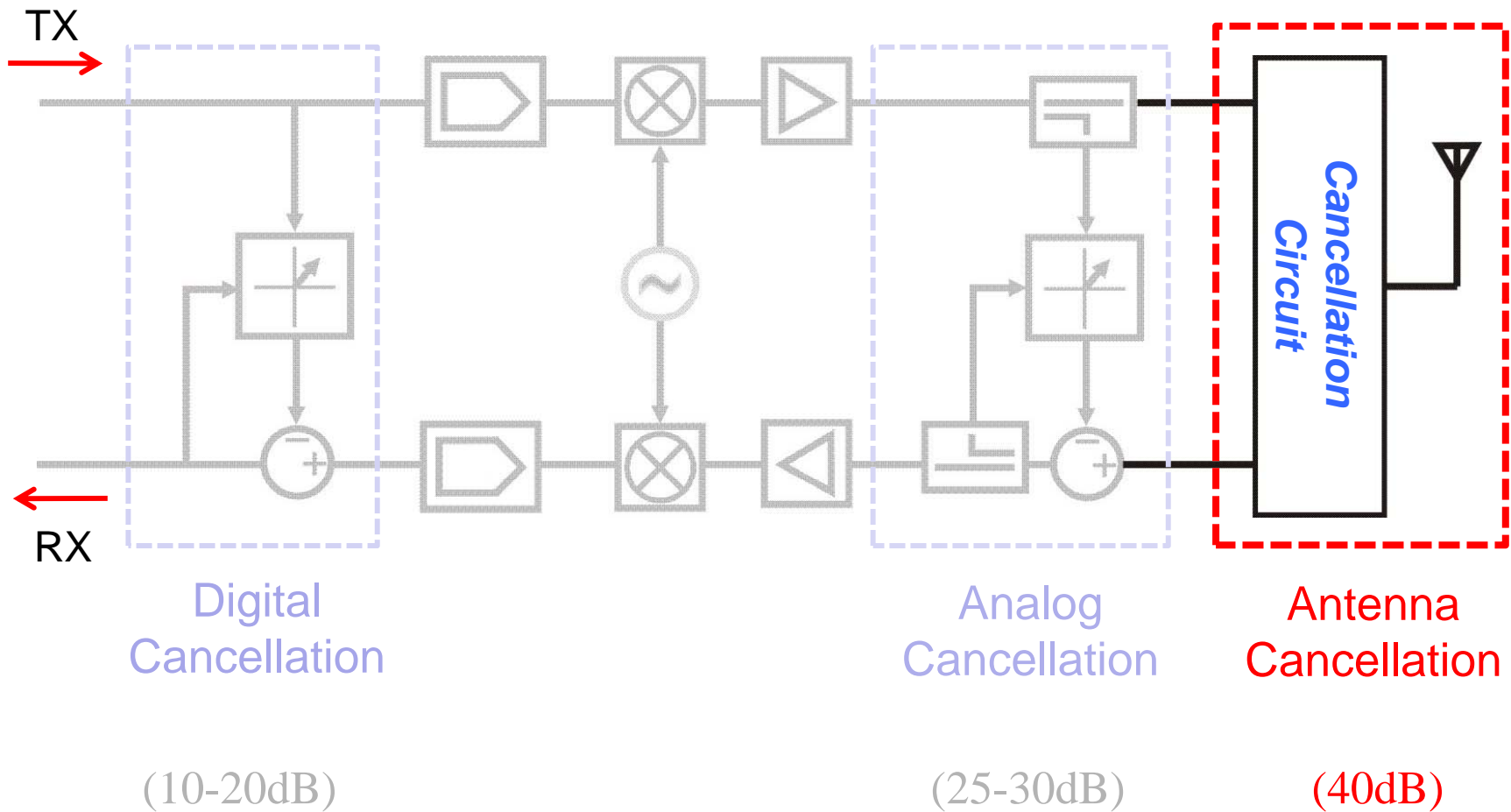
New “Single Antenna” Cancellation System



Performance Comparison

	Other	This Design
# of Antennas	2-3	1
Tx-Rx Isolation	20-30dB	40dB
Tx-Antenna Loss	3-6dB	<1dB
Antenna-Rx Loss	3-6dB	<1dB
Antenna Pattern	Nulls	Uniform
Tuning	Yes	No

New "Single Antenna" System Integration



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Single Antenna Prototype

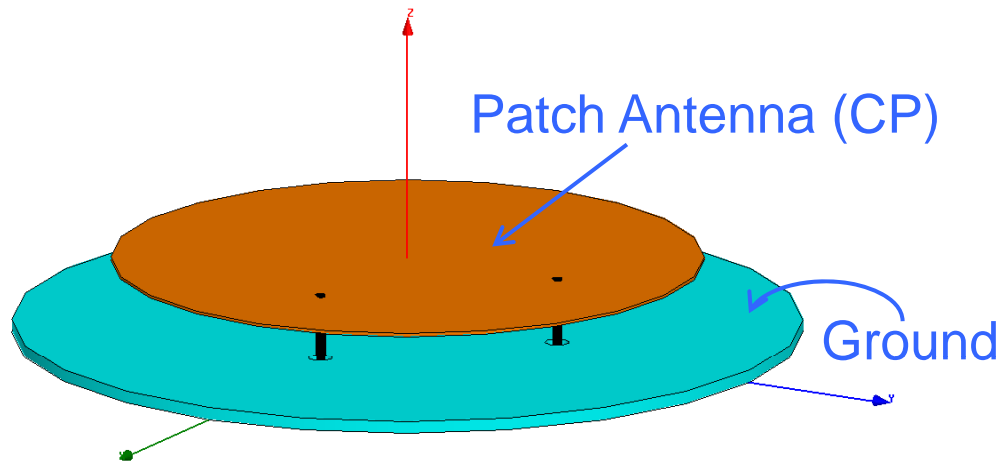


Photo of complete antenna



Assembly Diagram

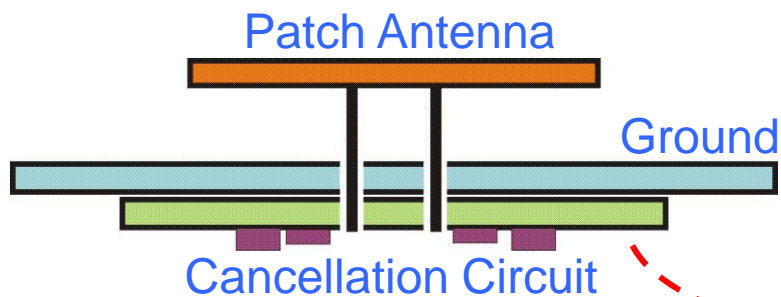
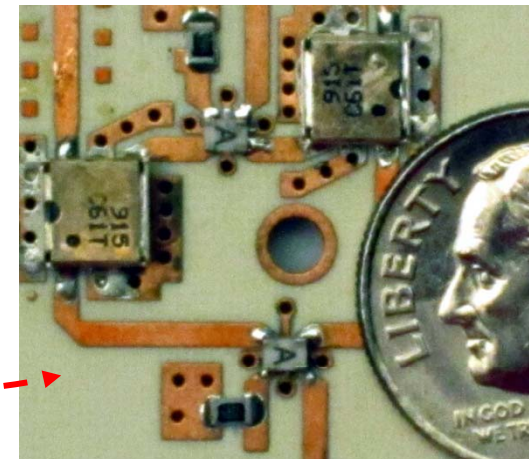
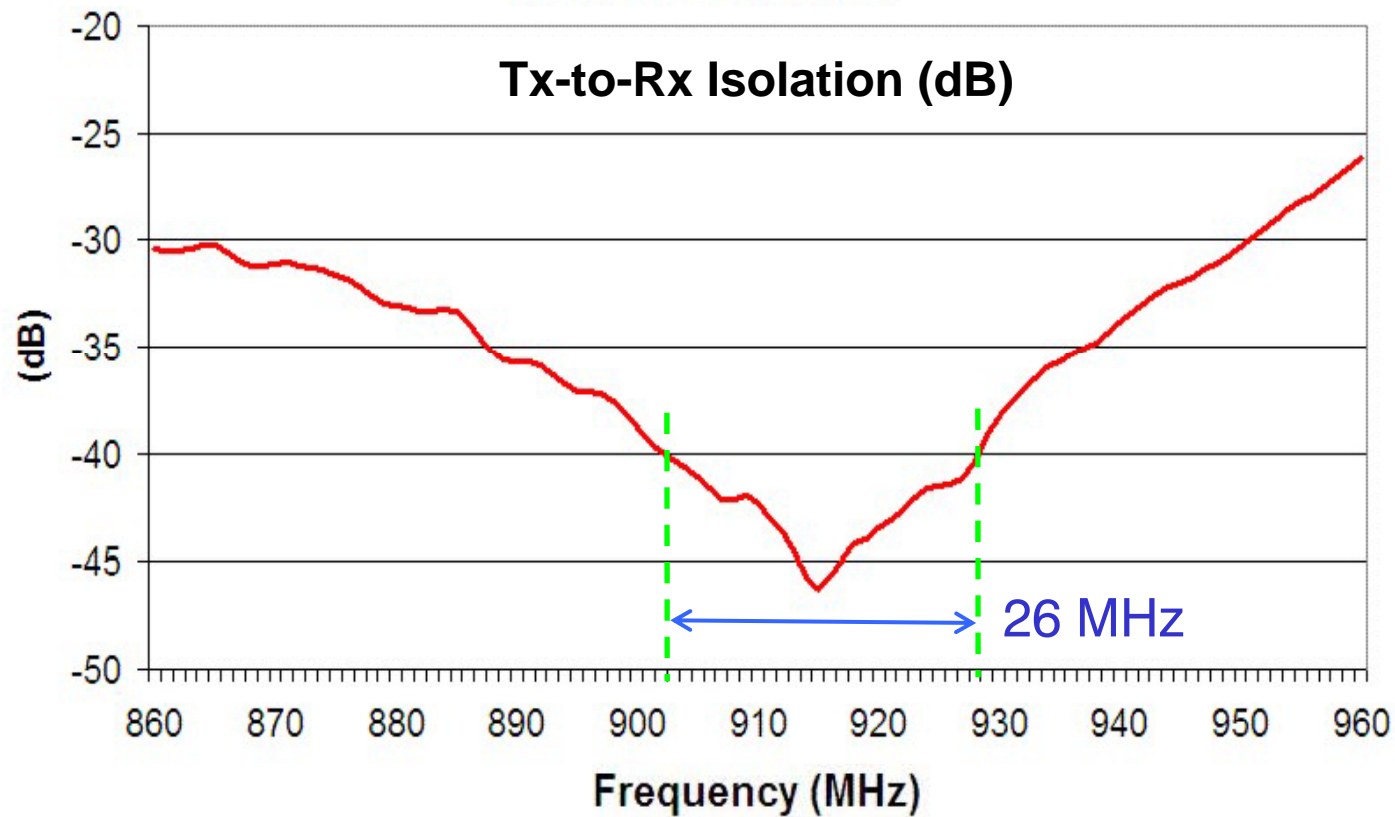
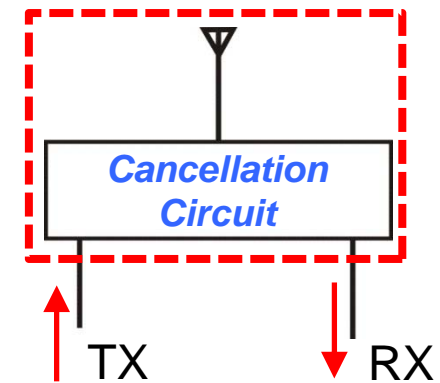


Photo of Cancellation Circuit

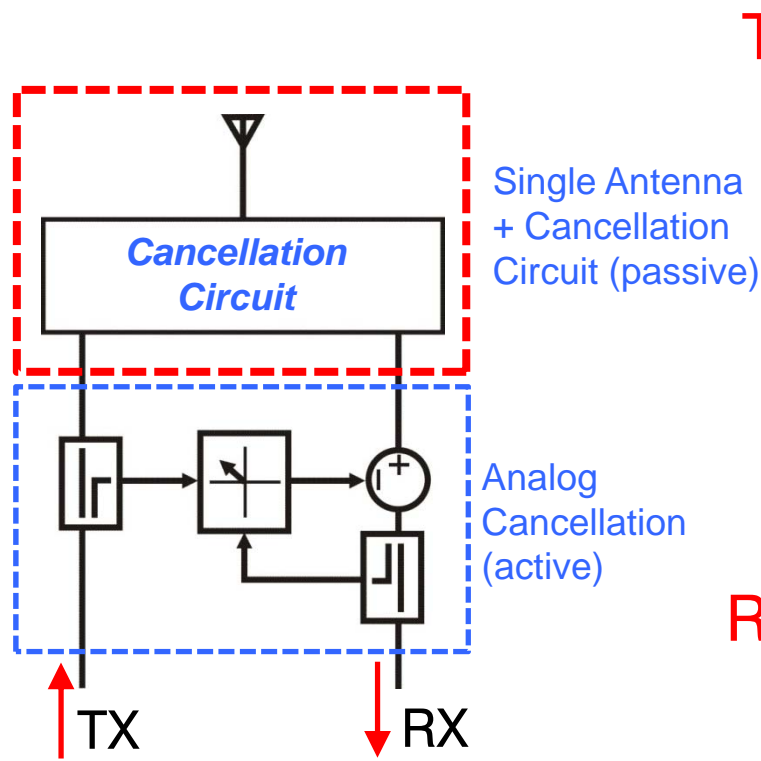


Patent pending

Prototype Measured Isolation

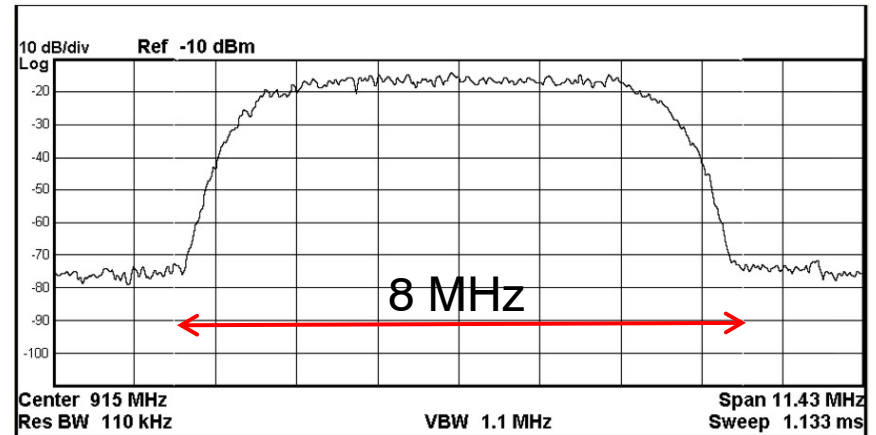


Single Antenna + Analog Cancellation



QPSK, 915MHz
Symbol Rate = 5 MHz

TX



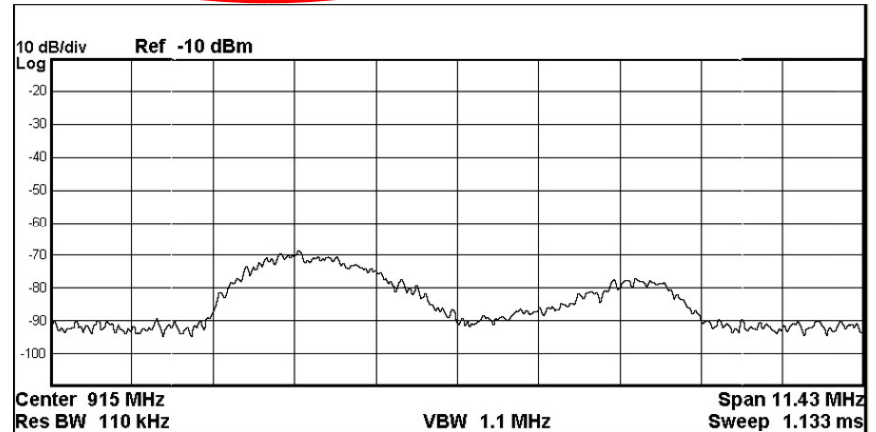
Channel Power

-0.21 dBm/ 8 MHz

Power Spectral Density

-69.24 dBm/Hz

RX



Channel Power

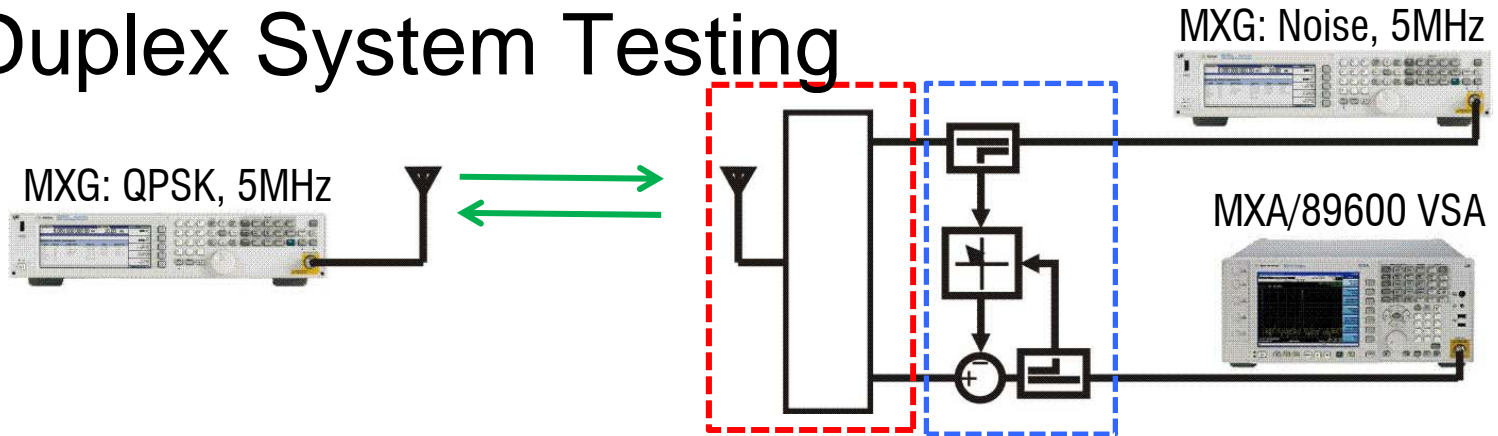
-58.74 dBm/ 8 MHz

Power Spectral Density

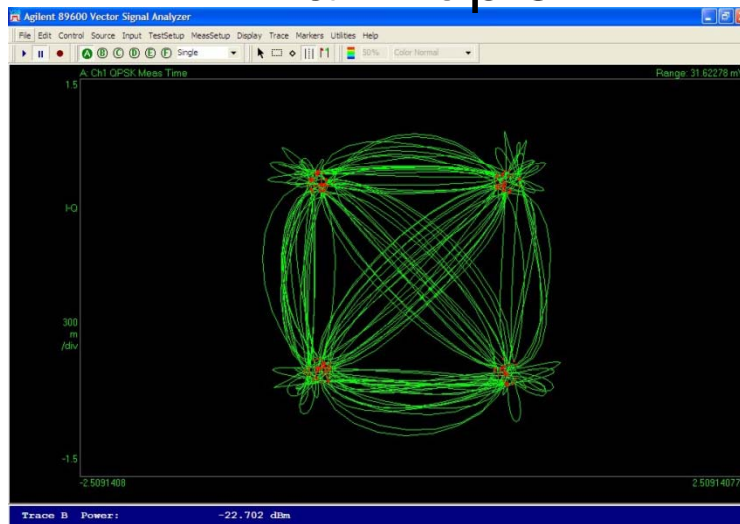
-127.77 dBm/Hz

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Full Duplex System Testing

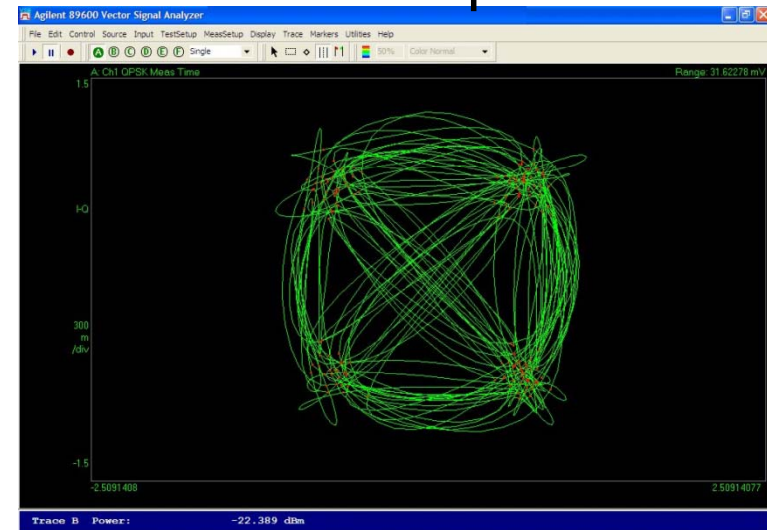


Half Duplex



EVM = 6.9%
SNR = 23.2dB

Full Duplex



EVM = 14.6%
SNR = 16.7dB

Conclusion

- Achieved full duplex “single” antenna operation
- Self-interference cancellation of 40dB at antenna
- Low loss (<1dB) between Tx-antenna & antenna-Rx

Next Steps

- Implement SDR system with digital cancellation
- Examine MAC architectures that exploit full duplex
- Full duplex MIMO