Tu1C-3

A Software-Defined 1TX/2RX FDD Transceiver Employing Frequency-Selective Dual-Band Self-Interference Cancellation

Nimrod Ginzberg[1,2], Avi Lax[1,2], and Emanuel Cohen[1]

[1]Elbit Systems, Netanya, Israel

[2]Faculty of Electrical and Computer Engineering, Technion, Haifa, Israel

Agenda

- Introduction
- System Description
- Self Interference Cancellation (SIC) Stage
- Measurements
- Conclusion
- Q & A

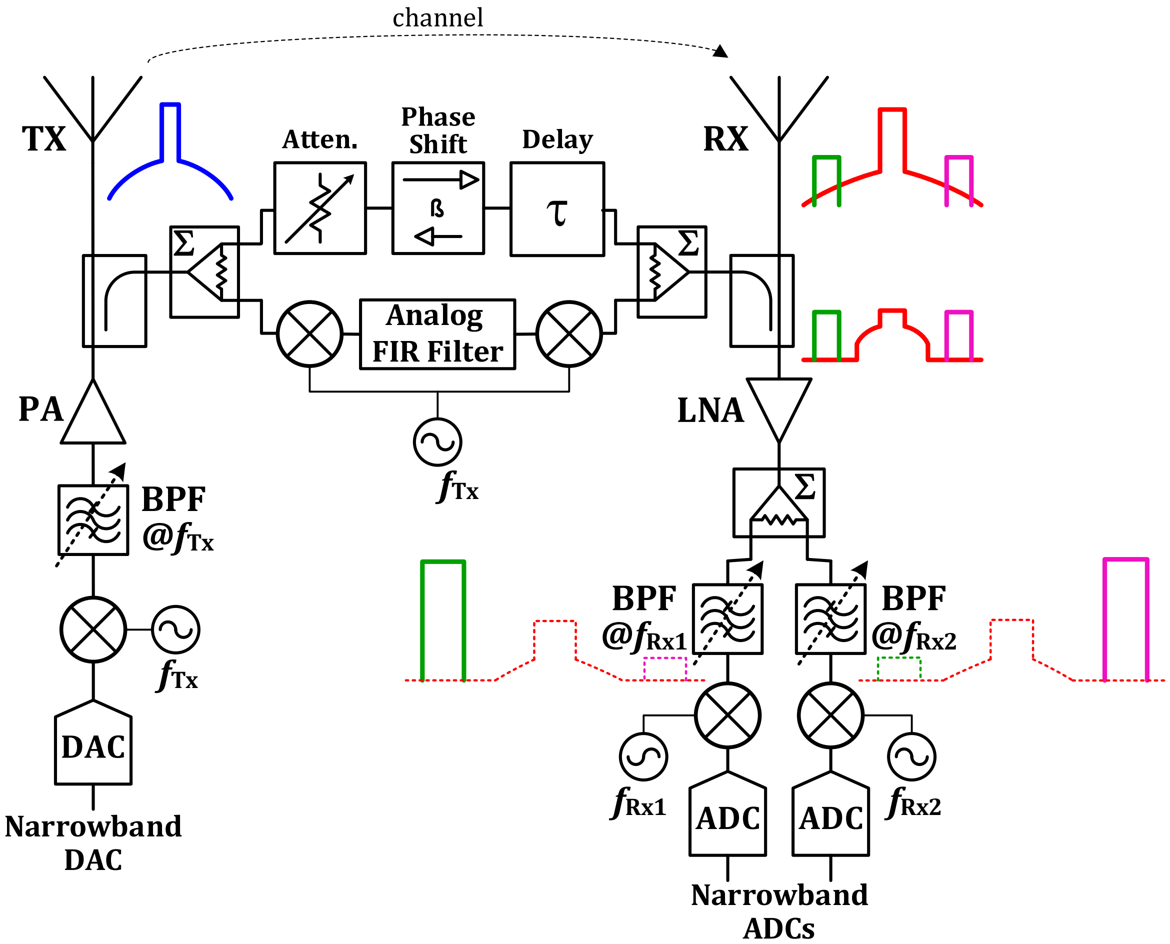
Introduction

- RF spectrum is extremely scarce resource
- FDD is a key to increase capacity
- Efficient utilization wide spectrum
- Multi Channel Operation
- SWaP – Size Weight and Power

System Description

- Transmitter lineup
- Receiver Lineup
- TX and RX separate and isolated Antennas
- SIC (Tunable RF Tap, Base-Band adaptive FIR filter)
- Analog and Digital mix signal (ADC, DAC, DSP)

System Description Block Diagram



SIC Stage

- RF Tap create complex coefficient of the form:

$$\alpha e^{j(\omega\tau+\phi)} \quad (1)$$

- BB analog FIR filter:
  - Utilizes multiple (M) complex weights
  - Generate adaptive frequency selective response of the form:

$$\boldsymbol{H}_{FIR}^{[N\times M]}\boldsymbol{W}^{[M\times 1]} = \boldsymbol{H}_{Leak}^{[N\times 1]} \quad (2)$$

- $\boldsymbol{H}_{FIR}^{[N\times M]}$; $\boldsymbol{H}_{Leak}^{[N\times 1]}$ Discrete frequency domain transfer function of the adaptive FIR filter and the TX-to-RX leakage respectively.

SIC Algorithm

- The proposed dual-band SIC method:
  - Allow using narrowband ADC with low-speed and low power
  - Using selector matrix for the frequency band of interest

$$\boldsymbol{I}_{Sel}^{[(N_{RX1}+N_{RX2})\times N]} = \begin{pmatrix} [0] & \cdots & I_{N_{RX1}} & \cdots & [0] & \cdots & [0] \\ [0] & \cdots & [0] & \cdots & I_{N_{RX2}} & \cdots & [0] \end{pmatrix} \quad (3)$$

- N_{RX1}; N_{RX2} are the DFT sizes of the sub-bands RX1 and RX2 respectively.

SIC Algorithm Cont'

- Left multiplying both sides of (2) by I_{Sel} in (3)
- Reduce calculation complexity by decreasing the rank of the $\boldsymbol{H}_{FIR}^{[N\times M]}$ matrix to $\boldsymbol{H}_{FIR,final}^{[(N_{RX1}+N_{RX2})\times M]}$ where $(N_{RX1}+N_{RX2}) \ll N$

$$\boldsymbol{H}_{FIR,final}^{[(N_{RX1}+N_{RX2})\times M]} = \begin{pmatrix} \left[\boldsymbol{H}_{FIR,RX1}^{[(N_{RX1}\times M]}\right] \\ \left[\boldsymbol{H}_{FIR,RX2}^{[(N_{RX2}\times M]}\right] \end{pmatrix}; \boldsymbol{H}_{Leak,final}^{[(N_{RX1}+N_{RX2})\times M]} = \begin{pmatrix} \left[\boldsymbol{H}_{Leak,RX1}^{[(N_{RX1}\times M]}\right] \\ \left[\boldsymbol{H}_{Leak,RX2}^{[(N_{RX2}\times M]}\right] \end{pmatrix}$$

- $\boldsymbol{H}_{FIR}^{[N\times M]}$; $\boldsymbol{H}_{Leak}^{[N\times 1]}$ Discrete frequency domain transfer function of the adaptive FIR filter and the TX-to-RX leakage respectively.

SIC Algorithm Cont’

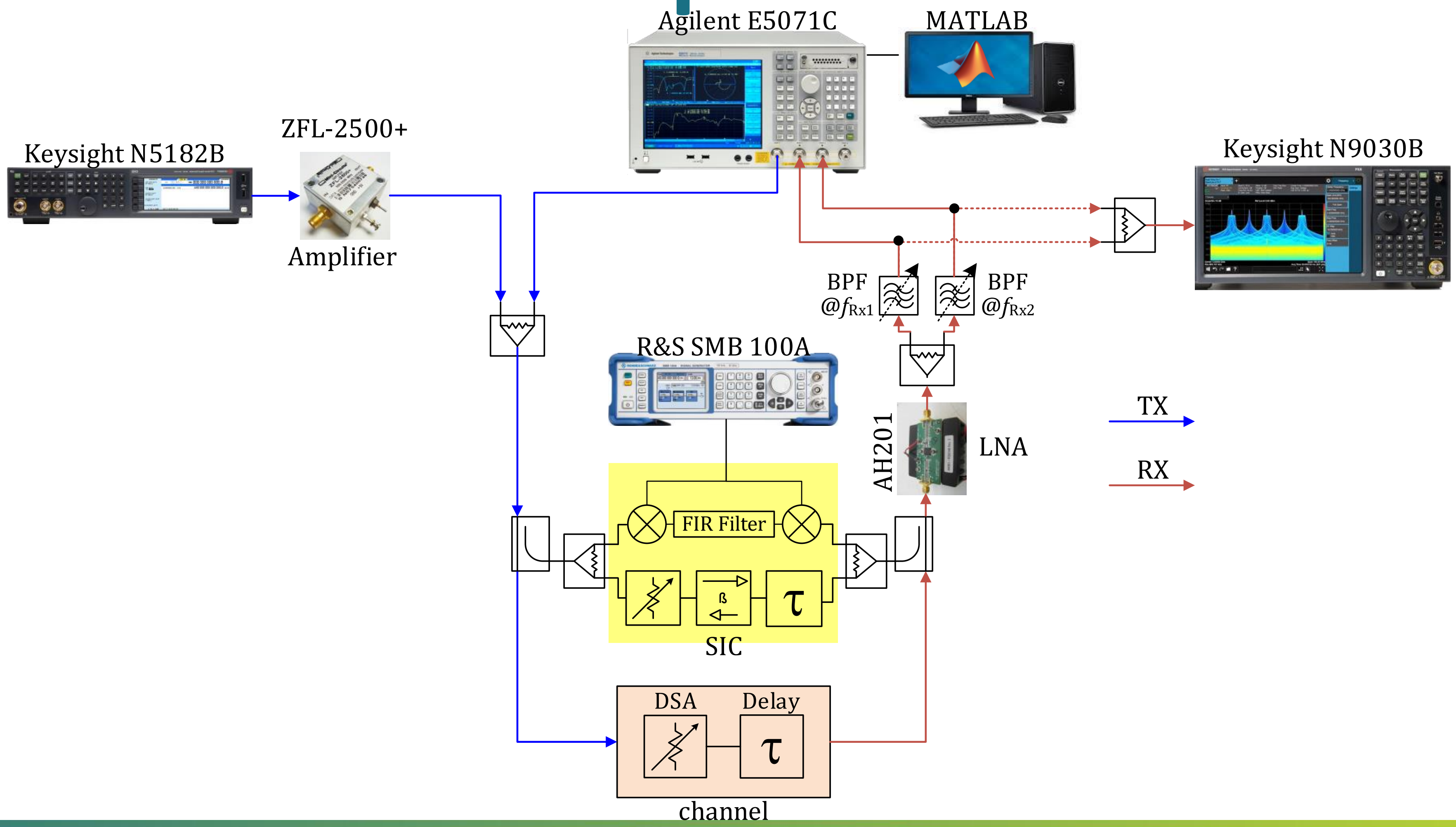
- Using Least Squares to find FIR filter’s weights $\boldsymbol{W}$ as follows:

$$\boldsymbol{W} = \left(\boldsymbol{H}_{FIR,final}^{\dagger} \cdot \boldsymbol{H}_{FIR,final}\right)^{-1} \cdot \boldsymbol{H}_{FIR,final}^{\dagger} \cdot \boldsymbol{H}_{Leak,final}$$

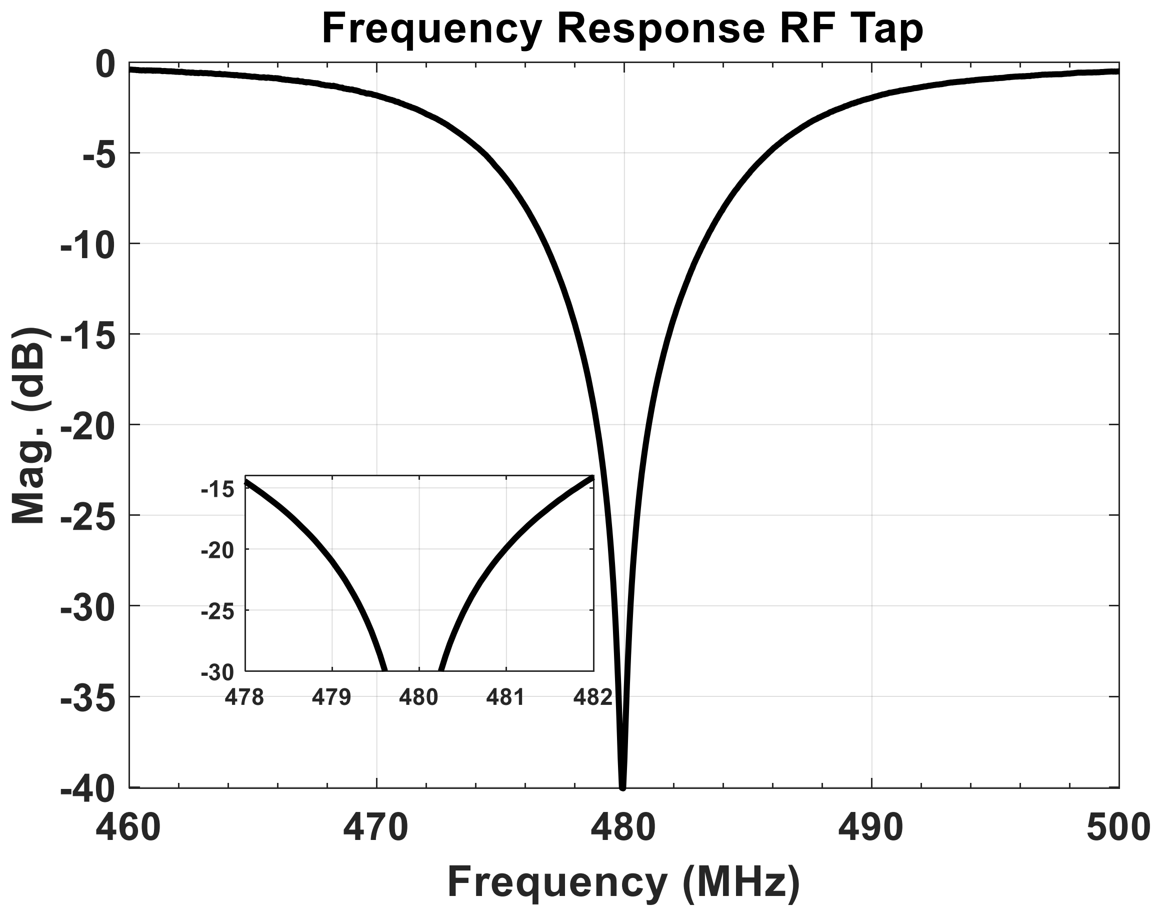
Where † is the conjugate transpose operator

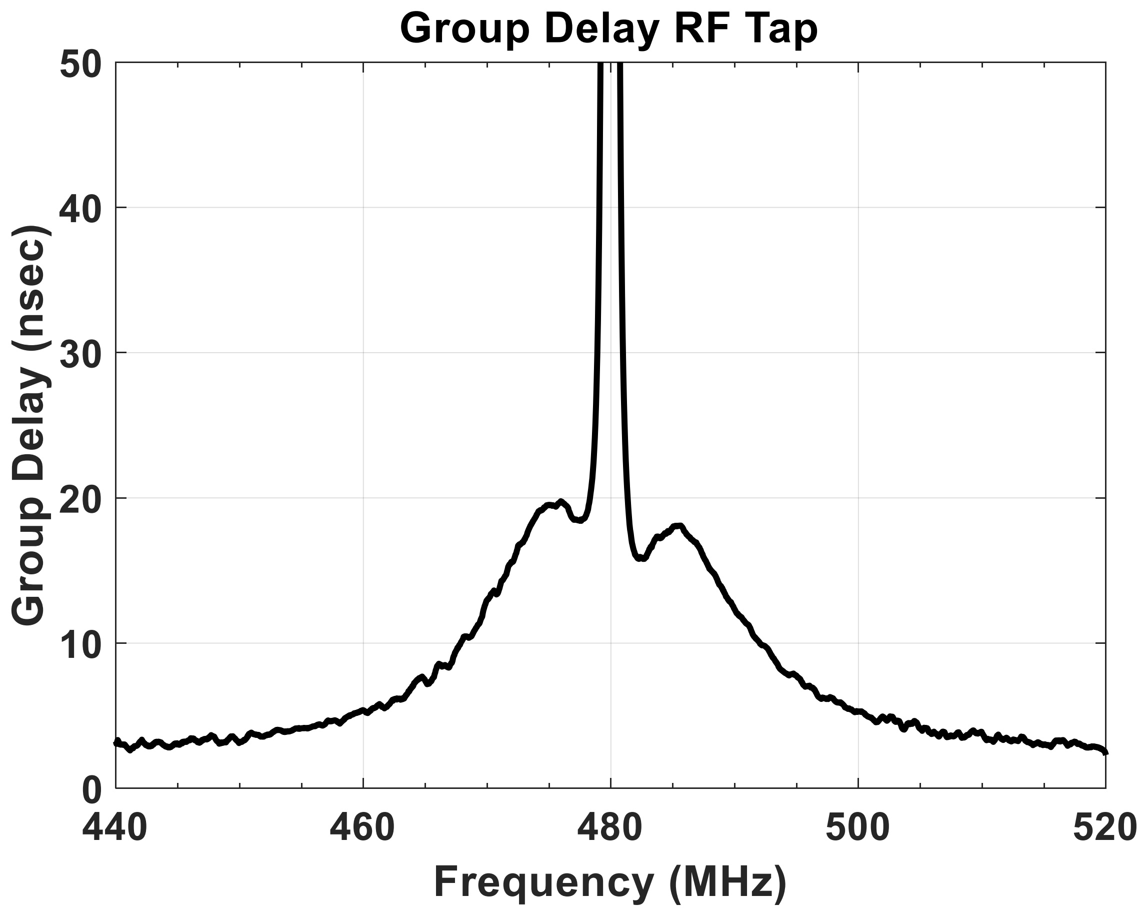
- $\boldsymbol{H}_{FIR}^{[N\times M]}$; $\boldsymbol{H}_{Leak}^{[N\times 1]}$ Discrete frequency domain transfer function of the adaptive FIR filter and the TX-to-RX leakage respectively.

Measurement Setup

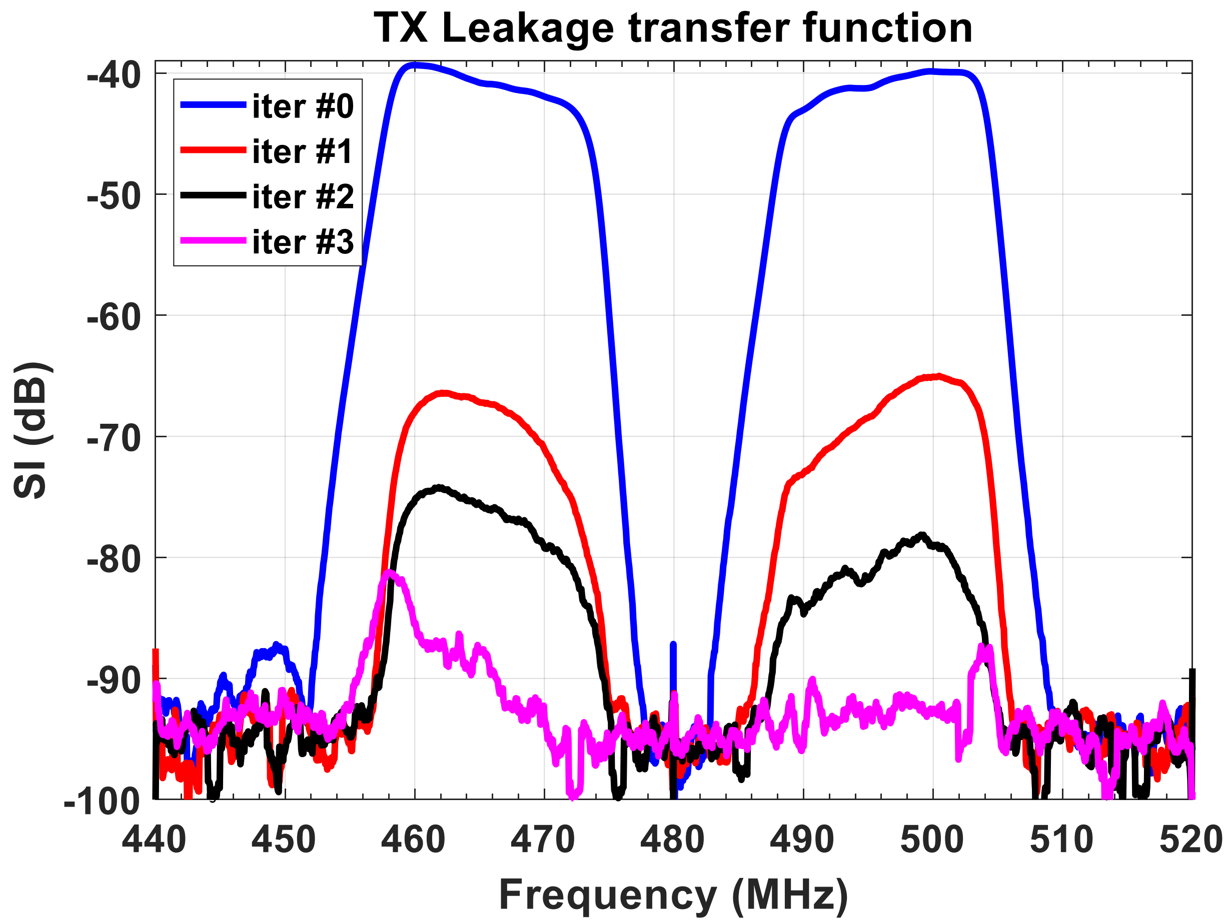


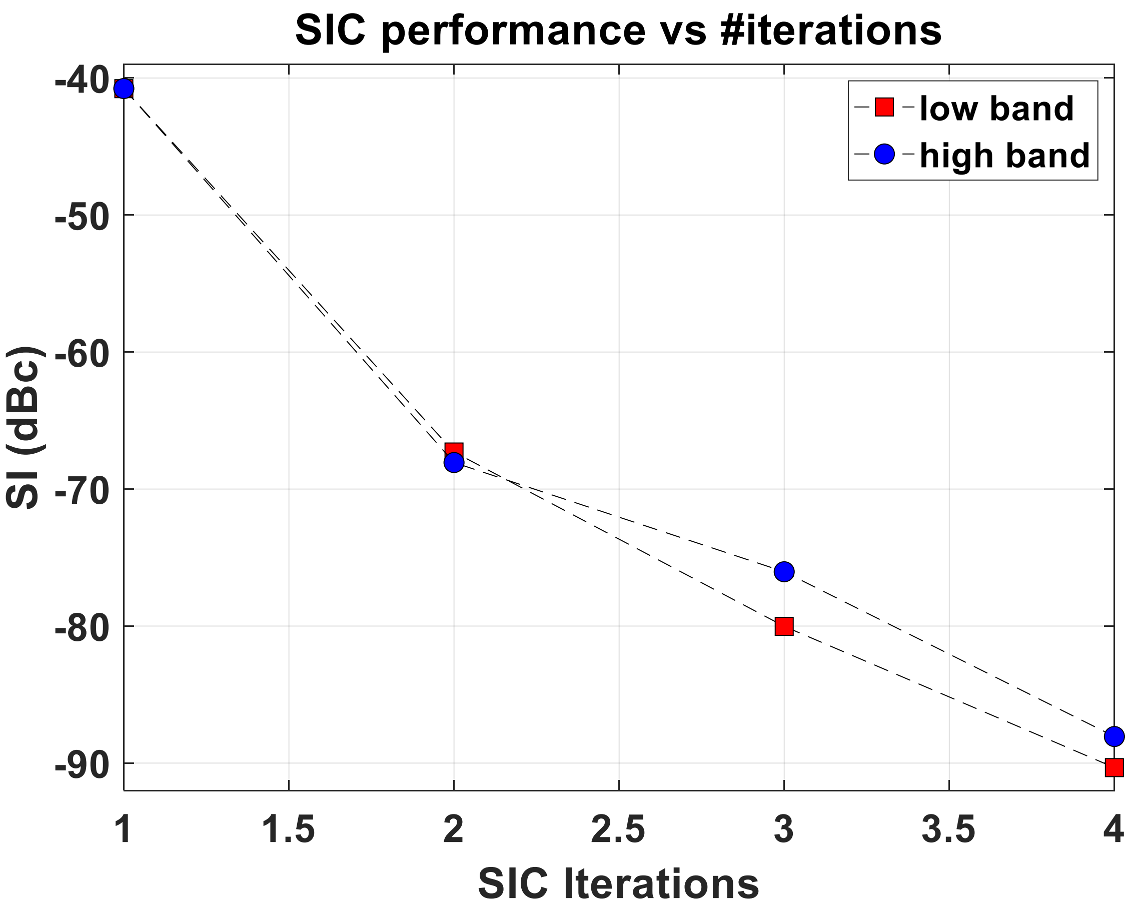
Measurement Results – RF Tap



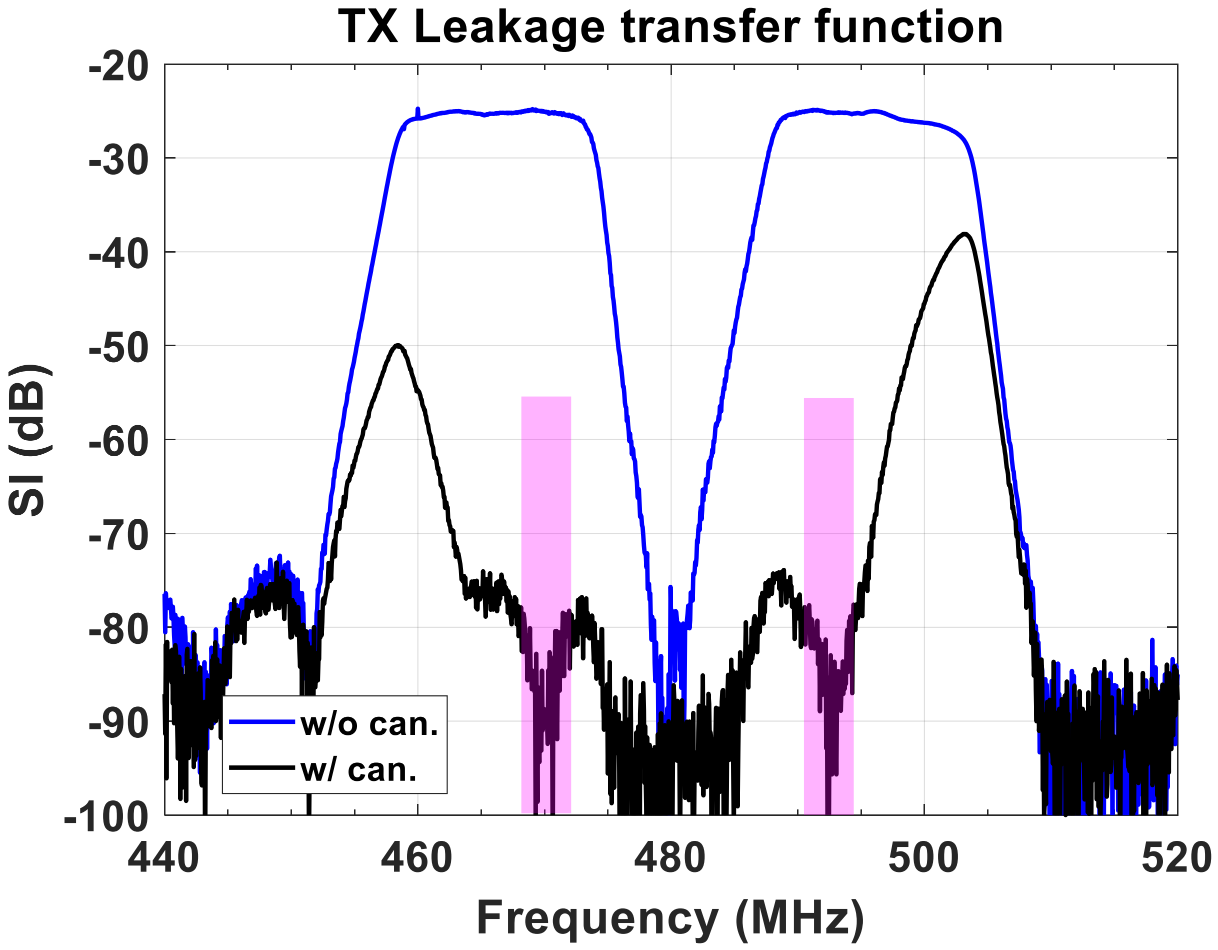


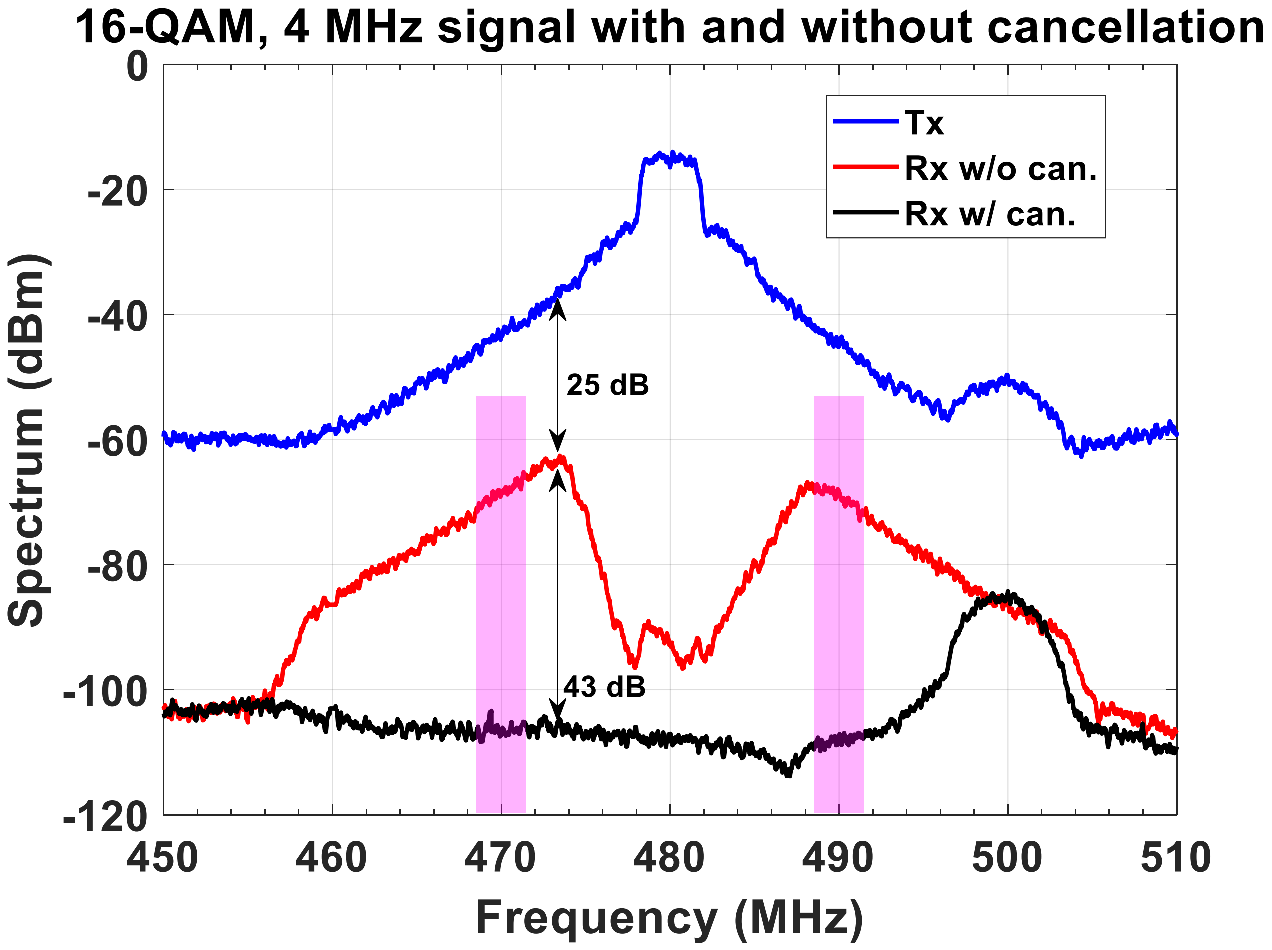
Measurement Results – Analog FIR





Measurement Results – Narrow Band





Conclusions

- The proposed architecture takes the advantage of FDD Operation and split the cancellation problem to:
  - Main lobe leakage by using RF Tap
  - Side lobe leakage by using analog adaptive FIR filter
- This architecture alleviates the need to sample the entire FIR baseband bandwidth
- Efficiently compute two narrow band SIC according to the frequency of interest

Q & A

Thank You