

Gennaro Di Meo

Tutor: Davide De Caro

XXIX Cycle - I year presentation

Digital cancellation techniques
toward Full-Duplex radios



Outline

- Background
- Digital cancellation techniques toward Full-Duplex radios
- My research activity
- My Products
- Next year



Background

- Graduation at University of Naples “Federico II” in March 2018
- Master Degree Thesis: Design and Simulation of Adaptive Filters for Full-Duplex Radios in FinFET 14 nm CMOS Technology
- Collaboration with University of Pavia and University of Milano “Bicocca”
- PhD Student at the “Information Technology and Electrical Engineering” Department
 - Ministerial scholarship



Digital cancellation techniques toward Full-Duplex radios

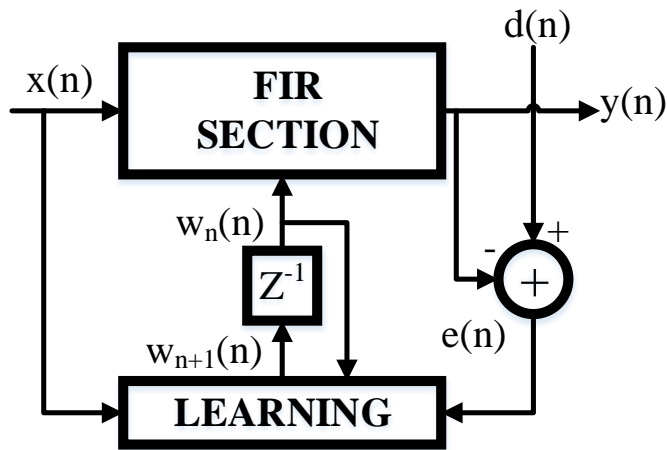
- This research activity deals with the study of digital cancellation techniques with the possibility of application in the In-Band Full-Duplex communication.
- Full-Duplex communication challenge
 - Signals transmitted and received using, in the same time, the same bandwidth and the same antenna (improvement of channel capacity)
 - Strong interference due to superimposition of TX signal on RX signal in the transceiver
- Analog solution
 - Use of circulator or hybrid transformer to isolate TX and RX path
 - Poor circuits linearity and/or impedance balancing issues, non-flat frequency response
- The proposal
 - Use of Adaptive Filters to reduce TX leakage in the transceiver
- In the same time research activity is focused also on low-power implementation of Adaptive Filters exploiting Approximate Computing paradigm

My research activity

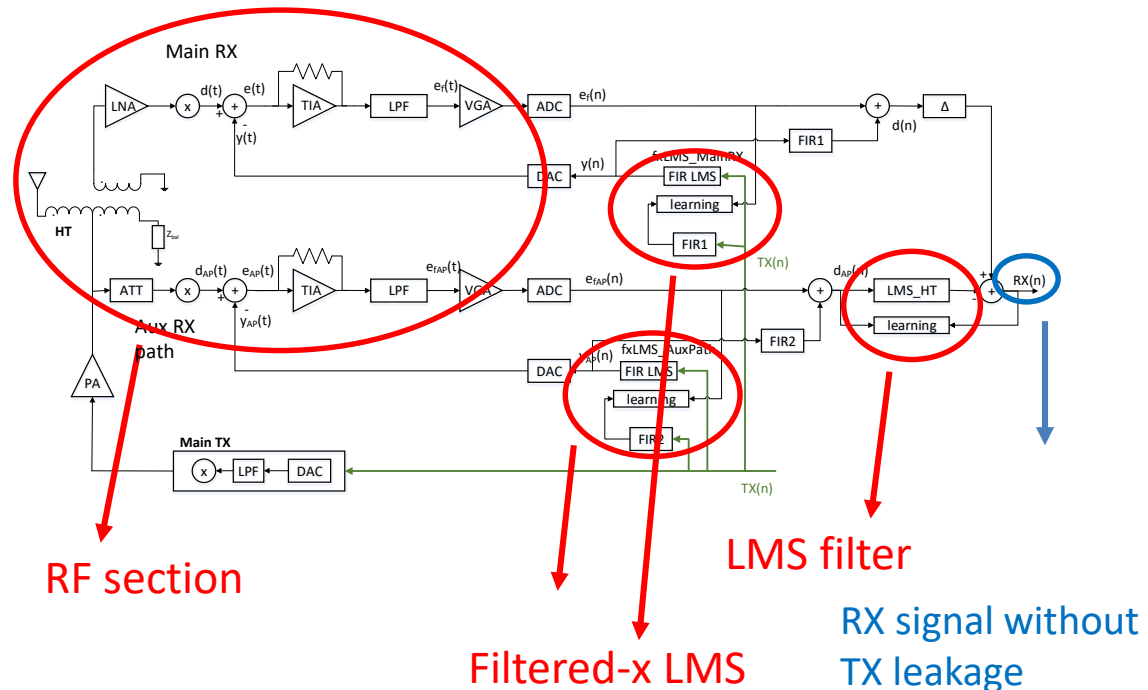
- Study of different topologies of Adaptive Filters, convergence and cancellation capability
 - LMS filters, filtered-x LMS filters, Normalized LMS filters, Delayed LMS filter
- Description of Full-Duplex system in Matlab and Simulink
 - RF Section in Simulink
 - Particular attention to quantization noise, EVM and phase noise
 - Baseband digital section using matlab scripts
- Introduction of filtered-x LMS filters
 - Possibility to overcome ADC quantization noise and related non-linearity
 - Reduction of signal power for analog circuits (linear behavior)
- Introduction of a LMS filter for TX leakage cancellation
 - Verify the cancellation of TX leakage, phase noise and EVM form the RX path

My research activity

LMS Adaptive Filter structure

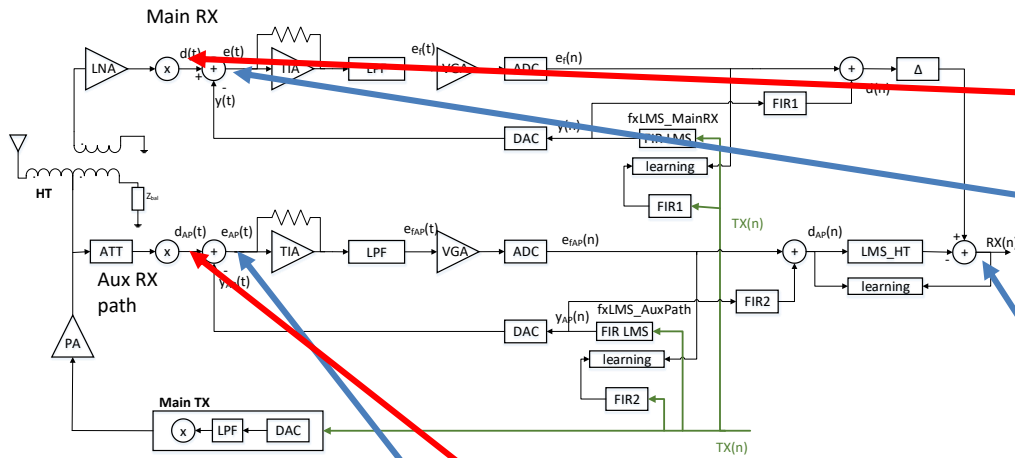


Full-Duplex System overview

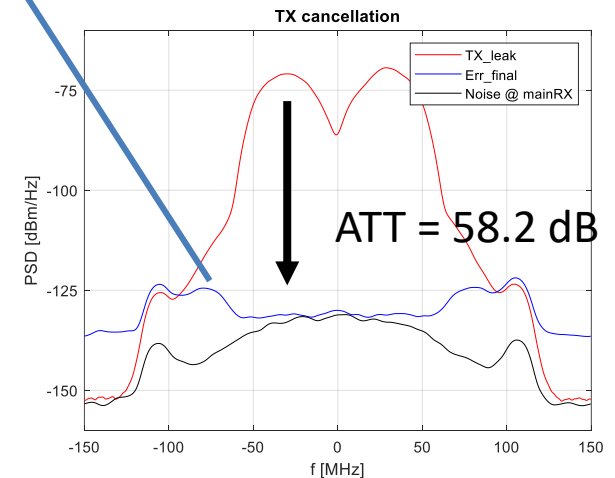
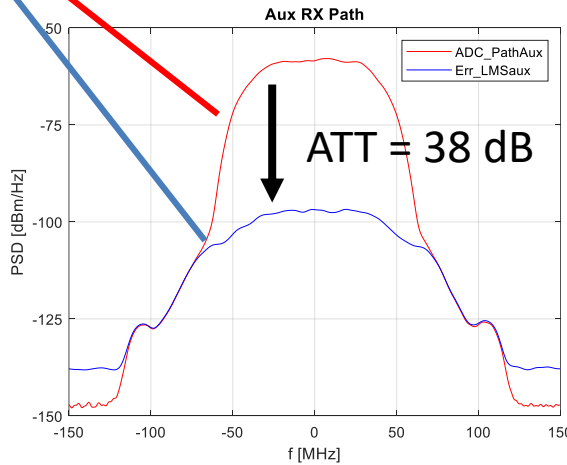
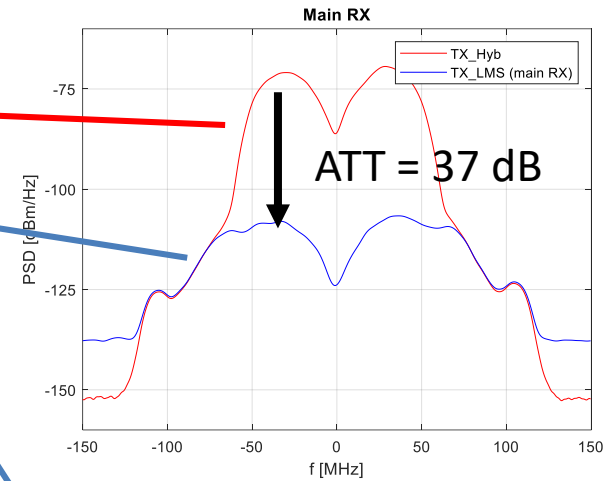


My research activity

Achieved results



Power reduction due to filtered-x LMS filter



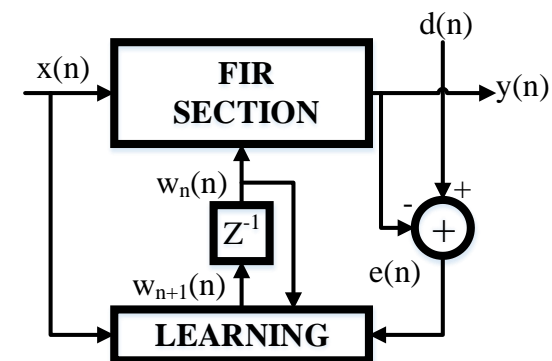
Power reduction due to filtered-x LMS filter

Digital cancellation of LMS filter



My research activity

- Reduction of power consumption in Adaptive Filters
- Approximate Computing paradigm to save power
 - Adaptive algorithms are inherently imprecise, thus it is possible to reduce signal precision to diminish power consumption
- Dynamic reduction of input precision for coefficients learning
 - Switching activity of multipliers reduced and power consumption saving up to 27% with respect to a standard implementation
 - Negligible area overhead due to dedicated logic for signals analysis (only +1.8%)
 - Negligible regime performance degradation
- Module per Sign Multiplier for coefficient updating and input approximation
 - Power consumption saving up to 48%
 - Area increase of 29%
 - Negligible regime performance degradation
- Last solution realized in TSMC 28 nm CMOS technology
- Testing phase in next months



My Products

- Paper
 - Variable-Rounded LMS Filter for Low-power Applications, “Application in Electronics Pervading Industry, Environment and Society” Conference, 2019
 - Low-power implementation of LMS Adaptive Filter Using Scalable Rounding, “IEEE International Symposium on Circuits and Systems” Conference, 2020 (submitted)
- Conference
 - 25th International Conference on Electronics, Circuits and Systems, Bordeaux, 9-12 December 2018. Presentation of paper: Quality-Scalable Approximate LMS Filter
 - “Application in Electronics Pervading Industry, Environment and Society” Conference, Pisa, 11-13 September 2018. Presentation of paper: Variable-Rounded LMS Filter for Low-power Applications
 - 51th Annual Meeting of the Associazione Italiana di Elettronica (SIE), Rome, 26-28 June 2019. Poster Session: Design of Adaptive Filters for In-Band Full-Duplex Application

Next Year

- Testing of chip in TSMC 28 nm CMOS technology for low-power LMS filter
- Realization of first In-Band Full-Duplex radio in FinFET 16 nm CMOS Technology

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	Credits year 1							Credits year 2							Credits year 3							Total	Check			
	Estimated	1	2	3	4	5	6	Summary	Estimated	1	2	3	4	5	6	Summary	Estimated	1	2	3	4			5	6	Summary
Modules	20	0,4	5	0	10	6	0	21	10							0								0	21	30-70
Seminars	5	0	0	1,5	1,4	0	0,4	3,3	5							0								0	3,3	10-30
Research	35	9,6	5	8,5	0	4	9,6	37	45							0								0	37	80-140
	60	10	10	10	11	10	10	61	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	61	180

Thank you for your attention!