# Polytechnique Montréal CAP7001E Ensuring a successful doctorate

Instructor: Michel Perrier 1 credit, Fall 2015

## Research proposal

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**Investigation and Implementation of Full Duplex Multi-Function 5G Transceiver**

*Summery:*

The investigation of a multi-functionally integrated multi-band full-duplex transceiver architecture for 5G and future wireless systems. This topic will cover a wide range of research activities including how to devise full-duplex technique that can be used to support both radar and radio functions. In addition, a scheme to improve dynamic range with reconfigurable dual-band for both wireless and millimetre-wave transmission will be developed. Theoretical modelling and experimental validations will be carried out and also substrate integrated waveguide design techniques will be deployed to implement the proposed transceiver systems integrated with dual-band antenna array.

*Trigger:*

The advent of cell phones, tablets and other wireless devices in recent years and their exponential expansion on one hand, and elevation of data quality such as videos and images over internet on the other hand, all indicate that bandwidth requirement is increasing day by day. One important scope for next generation of wireless systems is to manage to exchange large amount of data, and this will not be possible unless more efficient methods for usage of current bandwidth are introduced.

Full duplex transceivers have set a promising horizon to nearly double the bandwidth by simultaneous transmission and reception of signal in the same channel i.e. same frequency and same time. Besides bandwidth elevation, due to simultaneous transmission and reception of signal, full duplex transceivers have the potential to solve other kind of problems associated with current transceivers such as long end to end latency, hidden terminal problem and loss of throughput in congested nodes.

On the other hand by growth and advancement of wireless devices, new features are expected to be added to these devices. One charming capability is the ability of multi-functionality, like coexistence of radio and radar systems in a transceiver, which can enhance the capacity of devices communication with its neighbours.

*Frontier of Knowledge:*

The idea of full duplex as a realizable system has been established and researched roughly in last 5 years and there are basic problems which make full duplex systems hard to be realized. One basic problem with full duplex systems is “self-interference”, for which researches are trying to propose their own techniques, however up to now a single convincing solution has not been found. On the other hand integration of full duplex systems into multi-function systems and finally realization of such systems with SIW structures is a completely new idea.

*Questions/Objectives:*

First, we need to introduce a self-interference cancelation method to suppress the interference signal by 100 dBs. Different methods will be proposed and their capability will be tested. Second the MAC layer needs to be redesigned to meet new capabilities and specifications proper for full duplex systems. Third, the feasibility of integrating full duplex into multi-function systems should be investigated and proper theoretical and experimental validations should be derived.

*Strategy:*

The main strategy is to first find the proper solution for full duplex system. Full duplex system will be realized in microwave and wireless frequencies. Then we will investigate the integration of multi-function system into full duplex one. And finally we will translate and deploy the low frequency system into millimetre wave frequencies which is challenging.

*Expected Results:*

First, realization of FD transceiver which successfully increases the throughput in comparison to conventional transceivers. The realized transceiver should be prototyped to work smoothly within a network with tolerable error rate. Second, we should be able to integrate the multi-function system which can do their radio and radar functions in a prototype system. Finally the mentioned system should work within accepted results after translation into millimetre waves.

*Originality:*

The self-interference cancelation method in full duplex systems and integration of full duplex and multi-function systems, and finally their realization in millimetre wave frequencies with SIW structures will be original and for the first time.

*Anticipated impact:*

The 5G generation of transceivers will be launched on 2020 if definite solutions have been reached. This work if meets satisfactory results, can hugely impact the fabrication of next generation of transceivers or contribute to new designs depending on the level of satisfactory results obtained from tests and practical prototypes.

*Anticipated risks and approach to manage/mitigate:*

Device impairments is one the biggest obstacles in realization of such systems. To mitigate these problems we first anticipate them in our design and try to mitigate them, secondly we will have more than one solution and we will use other solutions if one did not work in practice.

On the other hand to minimize the risk of failure we will first simulate our designs with best numerical simulation software which yield results corresponding to practical results within tolerable errors.

*Required Resources:*

On one hand, all the recent researches in last few years on FD architecture, experiments of people working on multi-function systems. On the other hand, hardware equipment’s such as different microwave measurement systems in low to high frequencies which are all available in Poly Grames research centre. Further a SDR platform to prototype the proposed transceivers.

*Proposed Time line:*

January 2017: Realization of Full Duplex system which works robustly in a network.

January 2018: Realization of integrated multi-function full duplex system in wireless frequencies.

January 2019: Realization of goal transceiver in millimetre waves where SIW structures are deployed.