DESIGN OF SYSTEMS FOR BREAKTHROUGH RADIO SYSTEMS

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2018 WORKSHOP PhD STUDENT PROGRESS

MOTIVATION OF THE WORK

Quantum technologies offer a promise to simulate other quantum systems in ways that are intractable with classical computation, to solve certain problems with quantum computers for which no efficient classical algorithms are known and to guarantee secure communications through quantum key distribution (QKD). These emerging large capacity systems demand novels systems that can afford unforeseen features.
This proposal will develop a QKD transmitter based on classical optical communication devices, manufactured in an integrated photonic circuit (PIC).

Three objectives: transmitter, interfaces (antenna), analysis of quantum transmission for radar purposes.

In this research work we have focused on Three main topics .

- **Millimeter, THz and Microwave** wave frequency band antennas : As the radiating element for the Quantum photonic transmitter.
- **Theoretical analysis** of the **interfacing** between the photonic transmitter and the electromagnetic radiating antenna.
- **Design fabrication and measurement** of the Quantum transmitter in an InP foundry.

THESIS OBJECTIVES

The objectives to be acquired during the development of this thesis are, in terms of knowledge, skills and competences:

1. Solid knowledge about the current state of the art and simulation skills on antennas, radio systems and photonic transmitters and their applicability to future emerging technologies (5G, THz, CV QKD).
2. **Acquire software simulation skills** for designing new models of CV photonic transmitters using standard foundries platforms for quantum applications (CV QKD, quantum radar).
3. Definition of technical requirements and functional parameters of the **CV photonic transmitter** devised for emerging applications: linewidth, noise, attenuation, power budget …
4. **Manufacturing, characterization and prototyping** of the Quantum transmitter.
5. Theoretical analysis of the **interfacing** between the photonic transmitter and the electromagnetic radiating antenna and theoretical analysis of **quantum transmission for radar** purposes.

COMPLETED WORK & NEXT YEAR PLANNING

In the present work, the following tasks have been completed:

- **RF interfaces (antenna):**

1. **Analysis and characterization** of the **substrate and manufacturing process** in the coplanar microstrip design of millimeter and THz band antennas. **Simulation of an antenna design** for millimeter band using coupled microstrip line feeding. **Analysis and characterization** of the Graphene for its use in the design of millimeter and THz band antennas. **Simulation of an antenna design** with Graphene for THz band.

- **Quantum transmitter:**

1. **Quantum Transmitter Circuital simulation**.

The next year planning includes the following tasks to be completed:

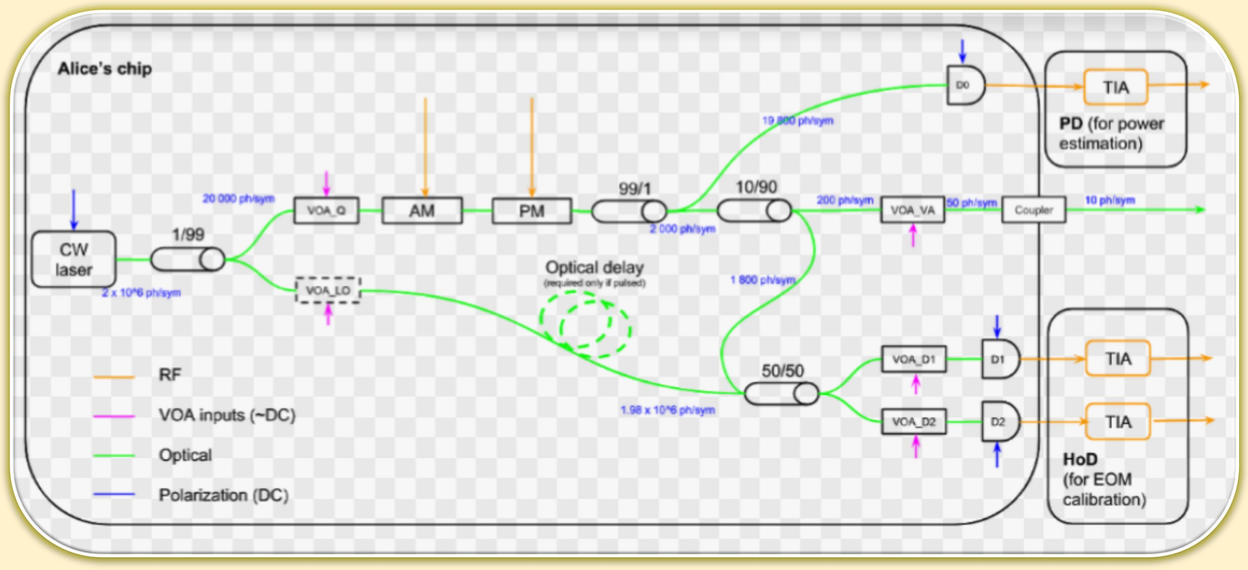
1. **Quantum Transmitter layout.**
2. **Design fabrication and measurement** of the Quantum transmitter.
3. Selection of an antenna prototype and analysis of quantum transmission for radar purposes.

RESEARCH PLAN

	2017			2018				2019				2020			
	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Literature review															
Millimeter and THz Antenna															
Quantum prototype															
Quantum transmission for radar purposes															
Thesis results															

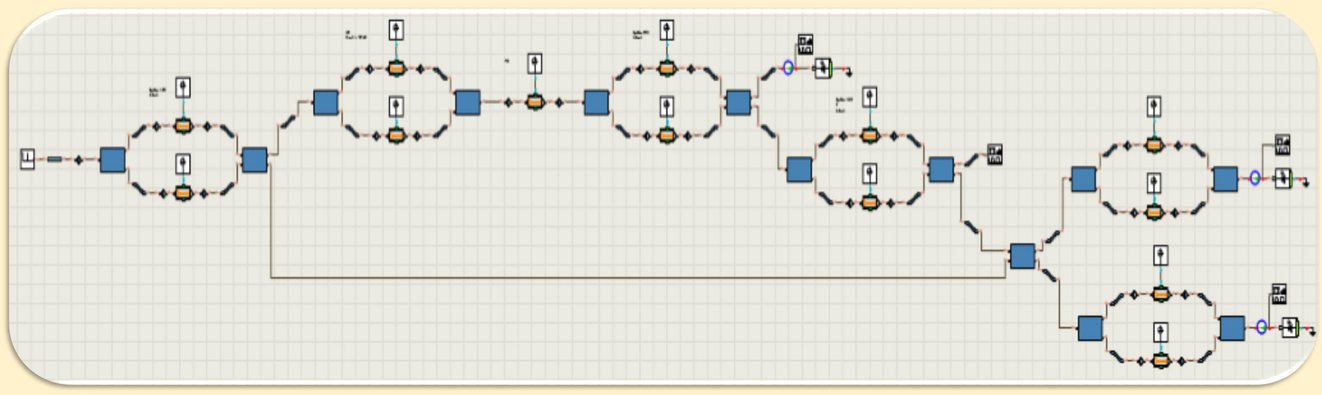
RESULTS & DISCUSSIONS

Proposed Quantum Transmitter design



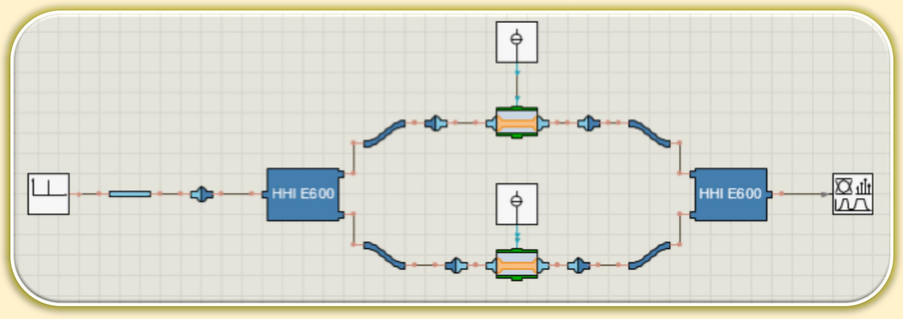
The photonic Quantum Transmitter is composed by a CW DFB laser as light source, this light is splitted on two branches. The upper branch is highly attenuated and modulated in amplitude and phase in order to have only a few photons at the output (Quantum Signal). The bottom branch carries the pilot signal that is mixed with the quantum signal at the end.

Quantum Transmitter Circuit Simulation

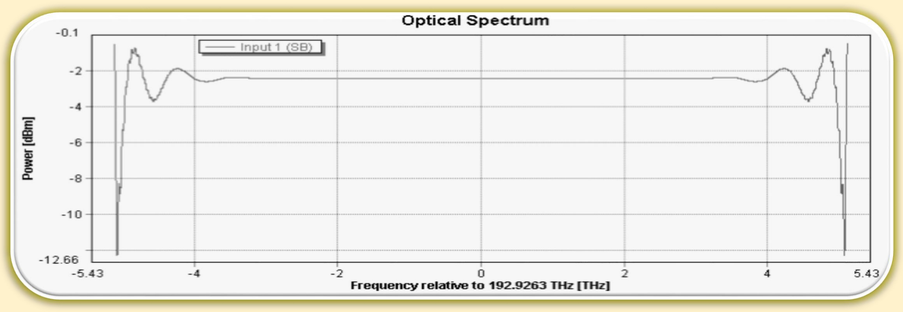


Circuital schematic of the Quantum Transmitter using VPI photonics simulator and building blocks. All elements and dimensions have been optimized in order to have the best response in frequency and at his tuning range for the **VOAs , AM, and adjustable splitters**. All modules are based on the same structure, a balanced Mach Zehnder with two phase modulator as tuning.

Main structure

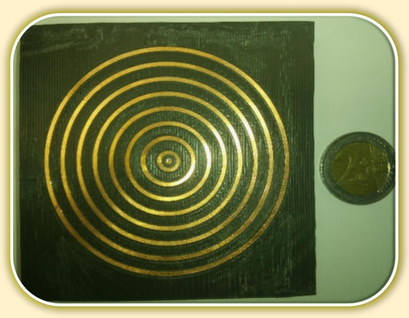


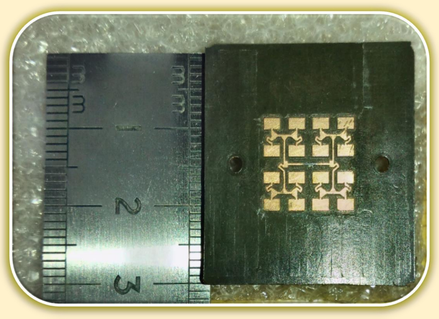
Balanced Mach Zehnder with two phase modulator as tuning.

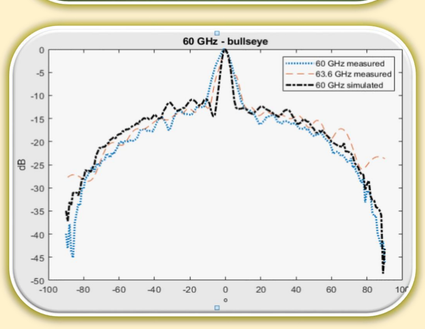


Typical flat impulse response of the balanced Mach Zehnder.

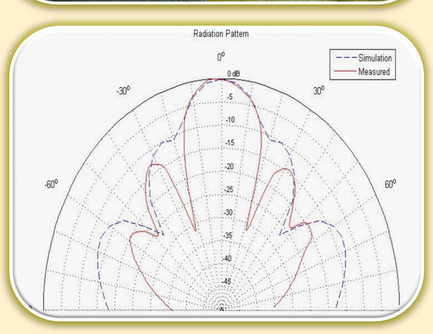
Antenna prototypes







Bulls eye antenna prototype.



16 elements Array prototype.

PUBLICATION WORKS

1. **David Alvarez Outerelo**, Ana Vazquez Alejos, Manuel Garcia Sanchez, "Microstrip Phased Array Antenna With Reduced Radiation Sidelobes at 60GHz for 5G applications", *submission pending*.
2. **David Alvarez Outerelo**, Ana Vazquez Alejos, "Graphene modeling for antenna applications: Issues for millimeter 5G antenna design", *submission pending*.
3. **David Alvarez Outerelo**, Ana Vazquez Alejos, "Graphene modeling for antenna applications: Issues for millimeter 5G antenna design", *XXXI Simposium Nacional de la Unión Científica Internacional de Radio*, URSI, Madrid (Spain), 5-7 September 2016.
4. **David Alvarez Outerelo**, Ana Vazquez Alejos, Manuel Garcia Sanchez, "Microstrip Antenna for 5G Broadband Communications: Overview of Design Issues", *IEEE APS-URSI*, Vancouver (Canada), July 2015.

5. L. Pedrosa-Rodriguez, **D.A. Outerelo**, R. Gomez-Alcala, F.I. de Vicente, F.J. Diaz-Otero, Design, Development and Testing of a Helical Resonator for Trapping Sr+ ions for Frequency Standards and Sensing Applications, Measurement (2018), doi: https://doi.org/10.1016/j.measurement.2018.04.086