Modelling the Frequency Response of an Optical Modulator

A Photonic Integrated Circuit (PIC) is a device which combines the functionality of multiple optical components onto a single chip. Today PICs are being deployed in data centres across the world to enhance the data transmission capacity of broadband optical networks. The data transmission capabilities that have been demonstrated by PICs will mean that companies such as Facebook, Google and Netflix will be able to improve the services they offer.

In Photonic Systems Group (PSG) we're working with a PIC which combines the capabilities of a laser, modulator and amplifier in a single device. A modulator is a device for converting optical power into a string of binary digits "0" and "1" used to optically encode data which is then transmitted over optical fibre. A key performance indicator for a modulator is its bandwidth: a modulator with high bandwidth can be operated at high frequency and can therefore enable more data in the form of optical "0" and "1" to be transmitted in unit time. The transition between "0" and "1" is enabled by high frequency (~10 GHz) AC signals.

When electronic components are driven at high frequency they exhibit physical characteristics not seen under DC operation such as frequency dependent reflection and transmission. The most effective way to model effect of high frequency AC signals being applied to a device is to use RF circuit theory which can predict high frequency behaviour of a component to a high degree of accuracy [1].

In photonics it is often the case that complex photonic components can be approximated by an equivalent electronic circuit comprising resistors, capacitors and inductors [2]. The equivalent circuit approach greatly simplifies the modelling of a component and provides excellent quantitative insight into measured data.

We're interested in finding out which electronic circuit most closely matches the measured frequency response of the modulator in our PIC. Are there leakage paths in the circuit which can help explain certain features observed in the modulator frequency response spectrum? What improvements can be made to the equivalent circuit that could enhance the modulator bandwidth?

As part of this project the student will learn about photonics, optical modulators and RF circuit theory. The project will combine analytical and numerical analysis in order to obtain a model that best approximates real frequency response data measured on a state of the art PIC.

Interested students should contact Dr. Fatima Gunning (fatima.gunning@tyndall.ie) or Dr. Robert Sheehan (robert.sheehan@tyndall.ie) for further details.

[1] D. M. Pozar, "Microwave Engineering", Wiley, 2012

[2] G. K. Li et al., "Concise RF Equivalent Circuit Model for Electroabsorption Modulators", Electron. Lett., 36 (9), 2000

Modelling the Optical Properties of a Photonic Integrated Circuit

A Photonic Integrated Circuit (PIC) is a device which combines the functionality of multiple optical components onto a single chip. Today PICs are being deployed in data centres across the world to enhance the data transmission capacity of broadband optical networks. The enhanced data transmission capabilities that have been demonstrated by PICs will mean that companies such as Facebook, Google and Netflix will be able to improve the services they offer.

In Photonic Systems Group (PSG) we're working with a PIC which combines the capabilities of a laser, modulator and amplifier in a single device. The laser generates light, modulator digitises light and the amplifier increases the optical power being emitted from the device. The operating characteristics of the device are well known, the PIC emits around 1 mW of optical power at a wavelength of 1321 nm, making it highly suitable for data centre applications.

We're interested in in constructing a model that qualitatively replicates the behaviour of the PIC. It's envisaged that a model for the PIC can be constructed using a scattering matrix approach [3], for the purposes of this project the modulator would be treated as an absorbing section. The scattering matrix approach to optical modelling represents sections of a PIC with a 2*2 matrix. By appropriately combining the 2*2 matrices you can get a very accurate model of the physics of a complex optical structure.

We're interested in learning more about the optical properties of the interaction between our laser and the amplifier. Does the reflectivity of the amplifier section change with applied current? Does the reflectivity of the amplifier change with optical input power? Is it possible for the optical reflections from the amplifier to influence the operation of the laser?

As part of this project the student will learn about photonics, semiconductor lasers and semiconductor optical amplifiers. The project will combine analytical and numerical analysis in order to obtain a model that reproduces the observed properties of the state of the art PIC.

Interested students should contact Dr. Fatima Gunning (fatima.gunning@tyndall.ie) or Dr. Robert Sheehan (robert.sheehan@tyndall.ie) for further details.

[3] L. A. Coldren et al, "Diode Lasers and Photonic Integrated Circuits", Wiley, 2012