Introduction

Since the birth of internet in the 60^{th} decade, the required information capacity has increased following the Moore's law, consequently communication systems have had to adapt to these constantly growing necessities. Such a characteristic has induced the constant development of transmission technologies which allowing transmission bandwidth satisfying high capacity constraint. At the same time, to satisfy the requirements on long distances, the communication channel must have very low loss. Reducing the latter while increasing the bandwidth of communication channels is therefore essential for future telecommunications systems.

In the same period, glass fibers were studied to be used for transmitting light. However, these fibers exhibited enormous propagation losses, so that the transmission distance was severely limited. Therefore long-distance optical data transmission with fibers, now called optical fiber communications, were not feasible. After any appreciable distance, the optical power would be attenuated to levels too low to be detected.

Despite these discouraging circumstances, the 2009 Nobel Prize in Physics, Charles K. Kao had a closer look at the prospects for reducing propagation losses of fibers. He realized that the losses of existing fibers were orders of magnitude above the fundamental physical limit, which is set by Rayleigh scattering in a glass. Further, Kao searched for ways to get close to this limit improving the purity of the silica. Already in 1970, a company called Corning developed a silica fiber with a propagation loss of 20 dB/km. Thereafter, the progress remained rapid, leading to even 100 times lower loss levels around 0.2 dB/km (in the 1550 nm spectral region), very close to the fundamental limit.

Due to these last mentioned attenuation characteristics in conjunction with high bandwidth features, optical fibers have proved to be the most promising of the many different types of available communication technologies, also by allowing simultaneous propagation of multiple channels of different wavelengths in the same transmission media.

The development of erbium-doped fiber amplifiers (EDFA's) operating in the 1550 nm region has extended the transmission distance as limited by fiber loss in optical fiber transmission systems. The transmission distance without regenerative repeaters is extended, fiber chromatic dispersion becomes an important factor limiting the reach. For systems running at 2.5 Gb/s the capability to cover distances of about 1000 km with only a 1 dB power penalty due to chromatic dispersion has been demonstrated, whereas at 10 and 40 Gb/s, the maximum propagation distance is reduced to only 60 and 4 km respectively.

In order to compensate fiber chromatic dispersion several techniques have been developed in the recent years. These techniques can be divided into two families: Optical fiber dispersion compensation, able to compensate chromatic dispersion in an optical way but showing high costs and difficulty of tuning, and electrical dispersion compensation cheaper and tunable, but presenting lower performance.

In the present project, we aim to study fiber chromatic dispersion compensation, by exploiting tunable predistortion realized in the microwave domain at the transmitter side. In particular we design and realize a chirped delay line centered at 20GHz and with a bandwidth of 20GHz, with a group delay able to compensate 130km of fiber chromatic dispersion. Then, by introducing dielectric perturbers to the last mentioned microstrip line, we will experimentally demonstrate the capability to tune the dispersion of such a line, and therefore the capability to adapt the transmitter to different uncompensated propagation fiber lengths.

In the first chapter, the propagation of an optical short pulse propagation inside an optical fiber is studied, in order to understand pulse distortion due to fiber chromatic dispersion. Then we review and compare the state of the art of the most important chromatic dispersion compensation techniques.

In the second chapter we will describe an analog technique to compensate chromatic dispersion by using a microwave Chirped Delay Line, which is a non uniform microstrip line. Along this chapter we will describe the equations allowing us to design and experimentally realize a Chirped Delay Line. Then, in the next chapter are described and compared the most important techniques able to tune a microwave waveguide.

The last three remaining chapters are dedicated to the design and experimental realization of a tunable microstrip line able to compensate fiber chromatic dispersion. In chapter 4 a new microstrip line capable to compensate the residual dispersion accumulated over 125 km of standard fiber by a 10 Gb/s NRZ signal is designed, simulated and experimentally realized. Then, thanks to a Tektronix(R) TDR sampling module we will measure the scattering parameters of the designed microstrip line, comparing them with the simulative results. In chapter 5 the relative position of dielectric perturbers is studied in order to tune the microstrip line and achieve the desired chromatic dispersion value. We will describe the realization of an experimental setup for the measurements of the tunability of the microstrip line. At the end of this chapter the experimental results are shown and discussed.

The last chapter aims to verify the effectiveness of the predistortion experimentally demonstrated by the realized tunable microwave device in terms of dispersion tolerance and transmission reach in a whole optical fiber system. This evaluation is done simulatively, by introducing in our simulation the real behavior of our developed compensator experimentally characterized in the previous chapter. Propagation of standard NRZ signal and predistorted NRZ signal is compared. Finally the conclusions are presented.