Microwave Photonics

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Abstract: The interdisciplinary field microwave photonics have drawn a lot of attention due to the inherent advantages of photonics such as low loss, high bandwidth, immunity to electromagnetic interference (EMI), tunability and reconfigurability which can be used for the processing of microwave and millimeter-wave signals. Signal filtering was one of the most important signal processing function which expected to be implemented in photonics domain, in results the idea of microwave photonics filter (MPF) was proposed and developed. The main function of MPF is similar to ordinary electrical signal filter which is remove unwanted signals but keep the target signals remain untouched, the difference is MPF only process optical signals which are modulated by radio frequency (RF) signals instead of process the RF signals directly. The present of MPF in an electrical signal processing system can effectively relief the high requirements on the electrical and digital signal processing equipments. Various ideas had been proposed to build a feasible MPF; basically all of these designs have a common structure which consists of optical source, electro-optic modulator (EOM), optical delay line and photodiode.
Keywords: Microwave photonic, radio frequency,electro-optic modulator.

I. INTRODUCTION

Microwave photonics (MWP) , a discipline which brings together the worlds of radiofrequency engineering and optoelectronics, has attracted great interest from both the research community and the commercial sector over the past 30 years and is set to have a bright future . The added value that this area of research brings stems from the fact that, on the one hand, it enables the realization of key functionalities in microwave systems that either are complex or even not directly possible in the radiofrequency domain and, on the another hand, that it creates new opportunities for information and communication (ICT) systems and networks. While initially, the research activity in this field was focused towards defense applications, MWP has recently expanded to address a considerable number of civil applications, including cellular, wireless, and satellite communications, cable television , distributed antenna systems , optical signal processing and medical imaging . Many of these novel application areasdemand ever-increasing values for speed, bandwidth and dynamic range while at the same time require devices that are small, lightweight and low-power, exhibiting large tunability and strong immunity to electromagnetic interference. Despite the fact that digital electronics is widely used nowadays in these applications, the speed of digital signal processors (DSPs) is normally less than several gigahertz (a limit established primarily by the electronic sampling rate) so in order to preserve the flexibility brought by these devices and their limit constraints there is a need for equally flexible front-end analog solutions to precede the DSP.

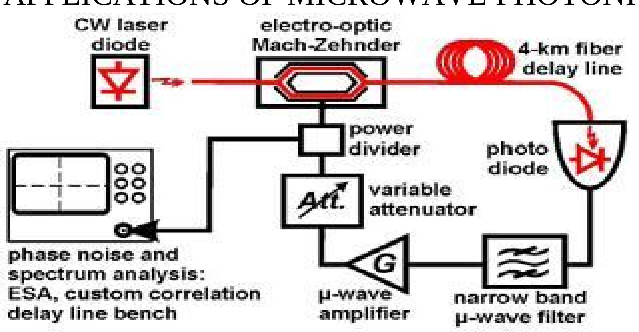
II. BASIC PRINCIPLES

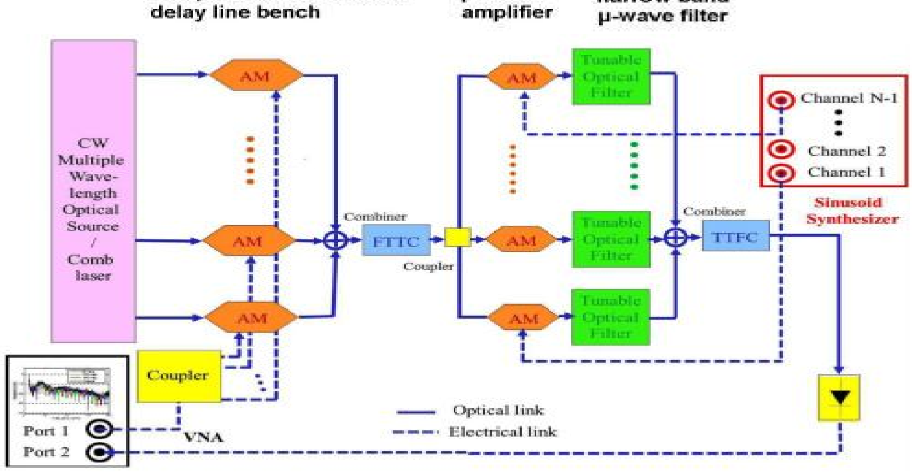
One of the main driving forces for MWP in the middle term future is expected to come from broadband wireless access networks installed in shopping malls, airports, hospitals, stadiums, power plants and other large buildings. The market for microwave photonic equipment is likely to grow with consumer demand for wireless gigabit services. For instance, the IEEE standard WiMAX (the Worldwide Interoperability for Microwave Access) has recently upgraded to handle data rates of 1 Gbit s–1, and it is envisaged that many small, WiMAX-based stations or picocells will soon start to spring up. In fact, with the proliferation of tablet devices such as iPads, more wireless infrastructure will be required. Furthermore, it is also expected that the demand for microwave photonics will be driven by the growth of fibre links directly to the home and the proliferation of converged and in-home networks . To cope with this growth scenario, future networks will be expected to support wireless communications at data rates reaching multiple gigabits per second. In addition, the extremely low power consumption of an access network comprised of pico- or femtocells would make it much greener than current macrocell networks, which require high-power base stations. Up to now, MWP signal processors and links have relied almost exclusively on discrete optoelectronic devices and standard optical fibres and fibre-based components which have been employed to support several functionalities . These configurations are bulky, expensive and power-consuming while lacking flexibility. Furthermore, the design of MWP systems is very much application-oriented and no general models have been developed which could be employed to develop general design rules, in particular for the evaluation of their performance metrics. In this context, ITEAM research activities in the field of MWP are being carried to address these important topics. On one hand, the issue of bulky MWP system configurations can be overcome by integration of MWP functionalities on a photonic chip and also, by reducing the interconnection complexity by means of using more efficient designs of optical fibers, which can provide the desired feature of parallelism and long range signal distribution with low losses. Integrated microwave photonics and the use of multicore optical fibers are cornerstones of these two novel paradigms respectively while analog filtered links recently proposed by ITEAM researchers providesd a unifying modelling approach of the different applications of MWP systems.

III. DEVICES

MWP applications of multicore fibers 3.1 Rationale Multicore Fibers (MCFs), invented three decades ago , have been recently the subject of considerable attention and research as they enable the increase in the transmission capacity of optical fiber links by spatial division multiplexing (SDM). Reported research has mainly addressed digital transmission systems in several contexts as long haul transmission , combined polarization, wavelength and spatial multiplexing domains and passive optical networks (PONs) . The inherent parallelism offered by MCFs with potential low or negligible signal coupling between their inner cores make them an ideal candidate for bandwidth extension in future telecommunication systems. A vast majority of the research activity reported so far is based on the so-called homogeneous MCFs where identical cores are disposed in the fiber cross-section following different profiles in order to either suppress or have a given control over mode coupling.. There is an obvious interest in increasing the number of cores in MCFs, which requires the drastic reduction of mode coupling between the cores so they can be placed more tightly spaced within the cladding cross section. To this end, heterogeneous MCFs have been recently proposed . In these, non-identical cores, which are singlemode in isolation of each other are arranged so, due to the absence of phase matching conditions, the crosstalk between any pair of cores is very small and thus can be more closely spaced. Although preliminary results have only been presented , MCFs with and more cores are feasible and a broad field of design alternatives is expected to be proposed, both in terms of geometric designs as well as of material compositions, which will require a thorough analysis using coupled-mode theory models for MCFs . In this section we describe the proposal for the potential application of MCFs to the implementation of a sampled discrete true time delay line for radiofrequency (RF) signals, which is the basis of multiple functionalities in the field of Microwave Photonics We concentrate in particular on heterogeneous MCFs, where cores can be designed to have different dispersion profiles.

IV. APPLICATIONS OF MICROWAVE PHOTONICS





V. CONCLUSIONS

The paper has described the progress in three main areas, including the general modelling of MWP systems by means of the so-called analog filtered links, the use of novel multicore fibers for the implementation of sampled RF optical delay lines and finally recent advances in the emergent and hot topic of integrated microwave photonics.