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Digital Signal Processing For Optical OFDM Based Future Optical Networks

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Abstract

Digital signal processing (DSP) is widely exploited in the modern world to enable a vast array of high performance services and devices that were unimaginable several years ago. As a highly pervasive technology, DSP considerably enhances everyday life by enabling applications ranging from anti lock breaking systems to satellite navigation and sophisticated medical imaging. DSP has also been an enabler for many of the highly successful communications technologies over the last20 years. It is only in recent years that advanced DSP has been utilized in optical communications to realize commercial long-haul optical systems in the form of DSP-enable coherent optical receivers, which not only offer high transmission capacities of the order of 100 Gb/s per wavelength, but achieve ultra sensitive receivers for radically increasing unrepeated transmission distances.

Index Terms: Digital signal processing,OFDM,Passive optical networks.

I.INTRODUCTION

I have an idea about this paper is the wide use of DSP in other areas of optical communications, there is growing interest in the exploitation ofDSP to solve the challenges facing the future optical accessnetworks. The passive optical network (PON)has beenwidely adopted as one of the main fiber-to-the-home (FTTH)solutions capable of meeting the low-cost demands of the accessnetworks. PON technologies are expected to deliver anaggregate capacity of 40 Gb/s in the near future and the NGPON2standardization work has addressed this by the decisionto adopt a time-division multiplexing/wavelength-division multiplexing(TDM/WDM) approach, this maintains the use ofconventional on-off keying (OOK) modulation with transmissionspeeds preserved at 10 Gb/s per wavelength. It is widelyaccepted that in the long term the future generation PON technologiesmust exceed the 10 Gb/s per wavelength threshold tofurther increase network capacity throughput. It is technicallyhighly challenging to achieve this with the conventional binaryOOK modulation. DSP-enabled PON technologies on the otherhand offer far greater flexibility in signal generation and decodingallowing compensation of signal distortions and/or utilizationof advanced modulation formats which are inherently moretolerant to the fiber distortion effects. DSP can also allow theuse of spectrally efficient modulation techniques, which networks can thus potentially provide network administratorswith on-demand adaptability down meansincreased network capacity can be achieved through efficientexploitation of component bandwidths, thus great commercialbenefits may be attained if the established, mature optical componentsources for NG-PON1 and NG-PON2 can be exploited.DSP can also enable adaptive modulation techniques which canadapt to the varying spectral characteristics of the network dueto the natural variations in optical fiber, optical component, andradio frequency (RF) component characteristics

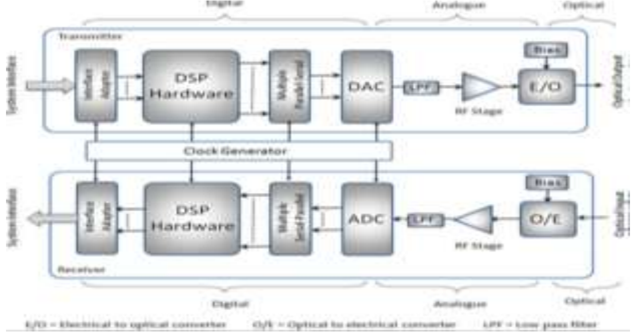

Figure 1 : System elements of optical OFDM

II. STATE OF THE ART

I Express the state of art of this paper is an increase in demand for high data rates has been an important factor in the emergence of OFDM in the optical domain, with a wide variety of solutions developed for different applications both in the core and access networks. This emergence has been facilitated by the intrinsic advantages of OFDM such as its high spectral efficiency ease of channel and phase estimation and robustness against delay. In this section, an overview of optical access networks is presented, covering state-of-the-art technologies, recent progress and different application scenarios. OFDM is also presented as an effective solution to the major problems of today's optical access networks. The structure of this chapter is as follows:It provides an overview of next-generation broadband access networks. In this section, we highlight optical fiber as probably the most viable means of meeting the ever-increasing bandwidth demand of subscribers. The various state-of-the-art optical technologies currently being deployed for shared fiber multiple access such as time division multiple access (TDMA), wavelength division multiple access (WDMA), and orthogonal frequency division multiple access (OFDMA) are explained.

III.PROPOSEDMETHOD

This paper presents a tutorial on real-time DSP for optical access networks, first exploring general implementation aspects of any DSP-based optical transceiver and then providing an in-depth examination of real-time DSP for OOFDM basedtransceivers based on the world first real-time end-to-end OOFDM transmission systems .

Architecture

Orthogonal Frequency Division Multiplexing

FFT and IFFT

Coder and Decoder

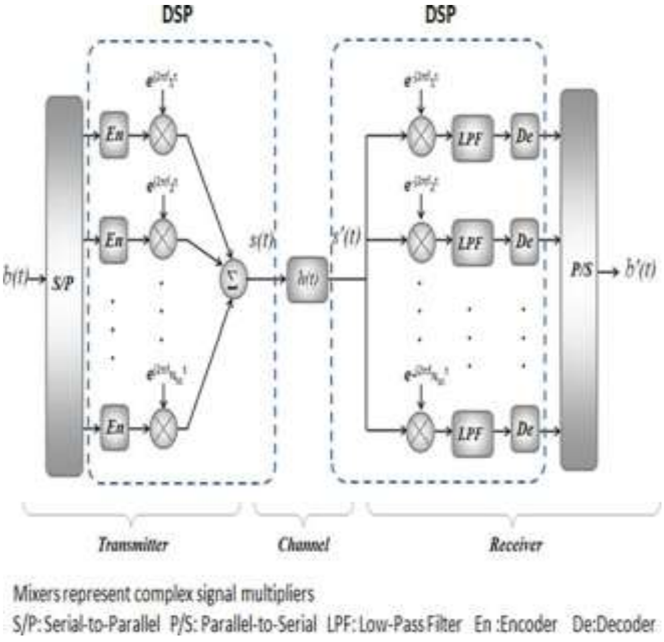

FIG 2:BLOCK DIAGRAM OF GENERIC MULTICARRIER SYSTEM

OFDM is a multicarrier modulation (MCM) technique firstproposed in the 1960s but at that time its implementationwas impractical. Salz and Weinstein first proposed theuse of the discreet Fourier transform (DFT) for the generationof OFDM signals in 1969. It was not until semiconductorelectronics achieved sufficient processing power, however, thatimplementation of OFDM with the DFT was feasible. Today theOFDM modulation technique is widely adopted in numerouscommunication standards such as digital subscriber line (DSL)and its many variants, wireless local area networks (WLAN)and digital audio and video broadcast (DAB, DVB). OFDM isnow widely recognized as a potential modulation technique forapplication in future optical access networks authors provide an extensive coverage of OFDM inoptical communications. The following sections, of this paper,provide an overview of the key principles of OFDM and adaptive OFDM, pertinent to the real-time OOFDM implementation presented in this paper.

The spreading effect associated with a dispersive channel causes adjacent received symbols to overlap, a phenomenon known as inter symbol-interference (ISI).

IV.FFT AND IFFT

To explicitly compute xn and X from the definitions of an Npoint IDFT and DFT, as given in (5) and (6) respectively, wouldrequire N2kcomplex multiplications and N2–*N* complex additions.For a hardware-based implementation of the transforms,it is highly advantageous to minimize computational complexityin order to minimize design complexity. Furthermore, theextremely high IDFT/DFT real-time computational throughputinherent to OOFDM implies that a highly parallel and pipelinedarchitecture is necessary. This makes it difficult to reuse complexfunctions for more than one calculation during one transformcycle. Therefore, minimizing the number of discrete instancesof complex functions in the algorithm is vitally important ifchipcost and power consumption targets are to be emt.

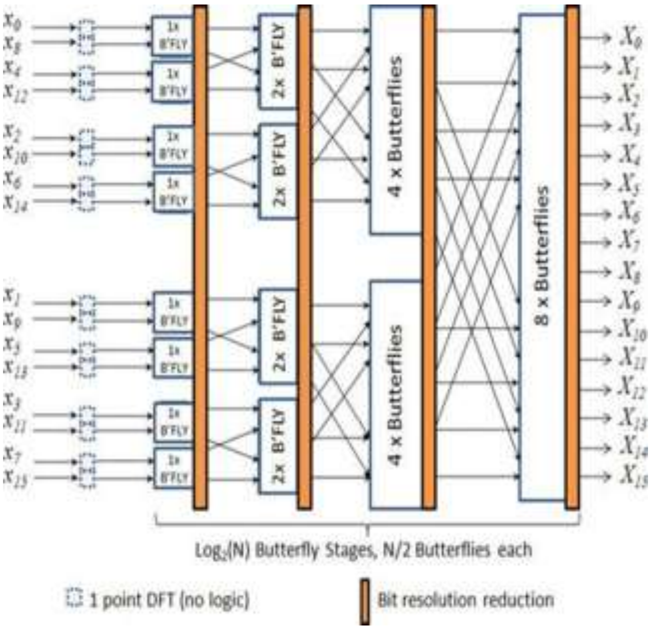

FIG 3: FFT AND IFFT PROCESS

. The fast Fourier transform (FFT) and inverse FFT (IFFT) are highlycomputationally efficient algorithms for computing the DFTand IDFT, respectively. The FFT was first introduced by Tukeyand Cooley in 1965 in their seminal paper “An algorithm forthe Machine Calculation of Complex Fourier Series” Thedrastic reduction in computational complexity offered by theFFT and IFFT makes them highly appropriate for implementationin physical hardware and thus ideal for use in real-timeOOFDM transceivers. The IFFT can be created from an FFT bysimple modification. Therefore, the following discussions willconcentrate on the FFT although they are equally applicable tothe IFFT.

1. Pilot Detection, Channel Estimation, and Equalization

The frequency response of the transmission channel introduces subcarrier amplitude and phase changes during transmission.The received signal is therefore no longer a direct representationof the transmitted signal.

2.Symbol Synchronization

Symbol timing offset (STO) is the difference between thecorrect symbol start position and the estimated symbol start position.Symbol synchronization is necessary to minimize STO,which is ideally zero, as nonzero STO leads to degraded BERperformance if the processed samples do not all originate fromthe same symbol. It should be noted, however, that if the CPlength exceeds the ISI length by y samples, an STO of up to y samples can be tolerated without performance degradation.STO tolerance can thus be improved by increasing CP length.A DSP-based symbol synchronization method has been experimentallydemonstrated that is highly suitable for applicationin OOFDM multiple access-based passive optical networks(OOFDMA-PONs). This is because the technique can achievesymbol, timeslot, and frame alignment of an optical networkunit’s (ONU’s) upstream and downstream signals without theneed to interrupt existing ONU traffic.

3.*Clock Synchronization*

Accurate synchronization of the OOFDM receiver and transmitter sampling clocks is essential to minimize their sampling frequency offset (SFO) [6]. SFO induces inter channel interference (ICI) which produces increasing received signal distortion with increasing SFO. ICI results from the loss of subcarrier orthogonality due to the mismatch between the discrete subcarrier frequencies in the receiver compared to those in the transmitter. SFO also induces a drift in symbol alignment necessitating periodic symbol re-alignment. Due to the noise-like nature of the OOFDM signal clock recovery is not straightforward

V.CODER AND DECODER

The IFFT algorithm then takes the OFDM symbol frame to the time domain, and the CP is added, just before DAC and anti-aliasing filtering. A training symbol insertion that is known OFDM symbol frames can be sent before each data packet for receiver synchronization. In general case, two signals corresponding to the real and the imaginary parts of the OFDM symbol are obtained from the baseband OFDM coding, which hare fed to the optical modulation stage. At the baseband decoder module, the reverse process is taken place in order to post-process and recover data sent.

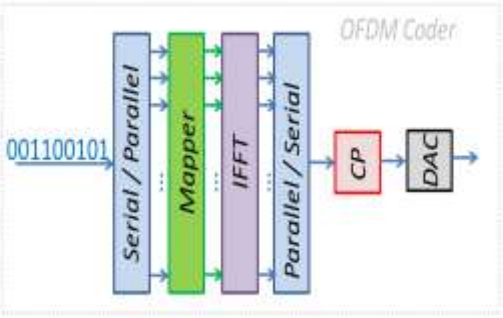

FIG4.OFDM CODER

The real and imaginary parts, of the received baseband OFDM signal provided by the optical demodulation stage at the receiver are firstly low filter to avoid the alias at high frequencies and sent to a pair of ADCs in order to be digitalized. The complex valued electrical signal is then synchronized with the preamble added in the transmitter and CP extraction takes place. The sequence is then converted from serial to parallel and demodulated with a fast Fourier transform (FFT). Afterwards, zero-padded subcarriers and pilot tones are extracted. The channel estimation using pilot tones and training sequence is taken place whose output is equalizer coefficients. Each subcarrier is then demodulated according to the corresponding modulation Format and, finally the restored bit sequences are serialized to recover the information sequence sent.

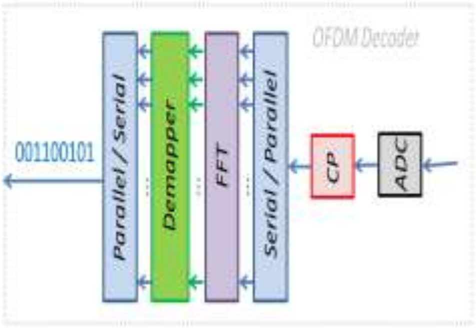

FIG5.OFDM DECODER

VI.APPLICATIONS

- In tele communications
- Military
- In Speech Processing
- In Image Processing

VII. CONCLUSION & FUTURE WORK

An overview of the implementation aspects associated with DSP-based optical transceivers for future access networks by examining the optical transceiver structure and the key transceiver constituent elements. This paper focuses on DSP functionality and architecture of OOFDM-based optical transceivers.the high equipment volumes associated with opticalaccess networks can inevitably lead to cost-effective electronics.OOFDM is one of the leading DSP-based optical accesstechnologies which is perceived by many as one of the maincontenders for future optical access networks due to its potentialfor high cost-effectiveness, data capacity per wavelengthfar beyond 10 Gb/s, adaptiveness to varying network characteristics,and flexibility in terms of bandwidth allocation.Giventhe exponentially growing demand for data capacity and theoperators' need for flexible cost-efficient access networks, it isbelieved that DSP-based optical access networks will emerge inthe future.

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