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FGON based PON for Wired and Wireless Networks – A Review

1. M.Samayaraj Murali KishanLal, 2. Dr.A.Sivasubramanian, 3. Dr. A.Jawhar

1. Associate Professor St. Joseph's Institute of Technology, 2. Professor,

Vellore Institute of Technology, 3. Professor, SSN College of Engineering

Abstract

In this paper using the properties of Optical Networking concepts a (FGON) future generation optical network which can access both wired and wireless network using PON (Passive Optical Network) based on OFDM (Orthogonal Frequency Division Multiplexing) which seamlessly integrates ROF (Radio Over Fiber) in which the access technology used is OFDMA (Orthogonal Frequency Division Multiple Access is discussed and the review implementation of the various techniques available for FGON using PON are analyzed in detail and the architecture for the proposed FGON is discussed and the various parameters of significance are studied .

Introduction

The recent advances in communication field has given rise to many applications that require reconfiguration of the existing access network for obtaining maximum speed and eliminating the bottleneck created by the normal copper cables in the current access networks. One such alternative is to use Passive Optical Network [PON] and implement Fibre To Home [FTH] ie replacing the conventional cables by optical fibres and implementing them as a low cost simple effective network using passive optical elements so that the fibre connection in the network is extended till the users premises making the network bottleneck free and also imparting high speed to it. The Intial forms of PON was the Time Division Multiplexing based Gigabit Passive Optical Network using a non return to zero format signal which had a downstream of 2.5 Gbits/s and upstream of 1.25 Gbits/s [1]. To improve the speed of data movement in the network the OFDM modulating technique which uses multicarrier modulation formats and also reduces the bandwidth requirement of the optical and electrical components used in the network. A network can be popular if it has a wireless access for greater bandwidth and longer reach and also to be used in areas were the terrain is not so supportive one such solution to the problem is the use of ROF (Radio Over Fiber) ie to integrate radio signals in Optical Fibers by which we can also

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extend the area of the network using small sized remote antennas at the ONU (Optical Network Unit) ports of the receivers. But the usage of multiple antennas at the receiving end leads to a problem called as OBI (Optical Beat Interference). OBI is a special type of Interference problem which occurs when the frequencies of two or more laser sources are too close such that the frequency of the undesired product terms falls into the same bandwidth where the signal is actually is and so as a result the Interference occurs so if we use OFDMA (Orthogonal Frequency Division Multiple Access) the problem of OBI is reduced. In this paper we propose an architecture for FGON in which we integerate ROF signals along with OFDM signals and also analyze the existing techniques for such a network.

OFDM

OFDM is one of the predominant modulating techniques that can be used for future generation of optical wireless systems. The capacity of OFDM signals to encode digital signals in multiple carrier frequencies makes it suitable for Optical wireless systems. Since OFDM has multiple carrier frequencies it uses certain modulation techniques like PSK & QAM. The system capacity in a OFDM can be greatly increased by altering the spectrum of OFDM for which the sub carriers are modulated using special techniques like PSK and QAM as mentioned above which also creates a low symbol rate multilevel modulation technique which leads to the reduction of the spectrum width. OFDM also has parallel transmission in frequency domain and as a result ISI (Inter Symbol Interference) is cancelled because of the long symbols of the subcarriers of OFDM.

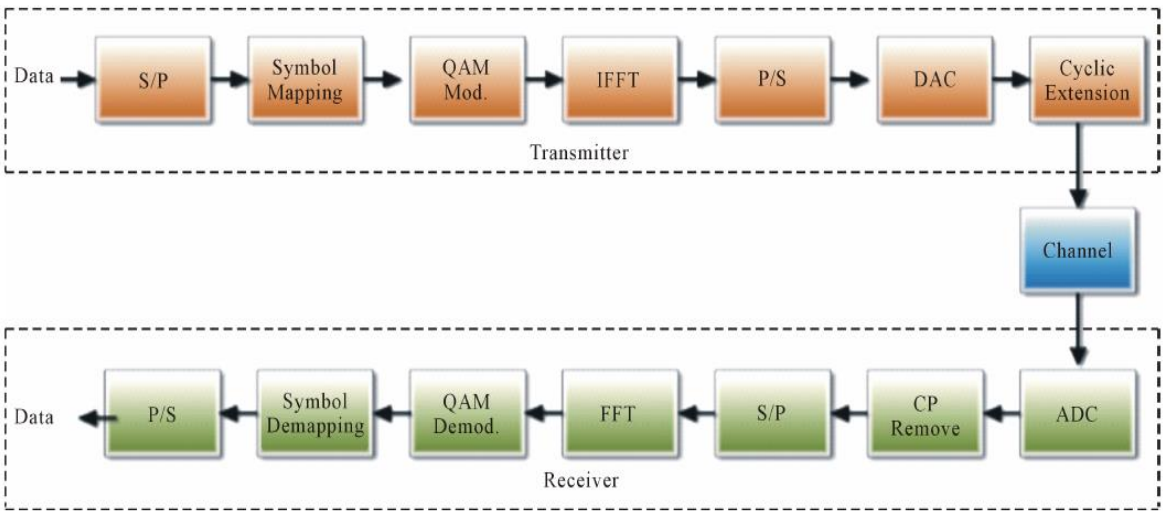

Figure 1. OFDM System

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Transmitter Section

From the above diagram we understand the process of how an OFDM system works, the upper part of the diagram depicts how an signal is converted into OFDM output and the lower part of the diagram shows how an OFDM signal is converted back into the original form at the receiver end. The PRBS signal generator first generates a stream of bits of data which is passed on to the symbol mapping process in which the NRZ pulse generator for generating a Non return to Zero pulse is then obtained and then the signal is undergoing an special modulation scheme where in the subcarriers are individually modulated using a QAM modulator as discussed earlier then the modulated signal under goes IFFT block which converts the signals into time domain and also one more important function that takes place in the IFFT block is the summation of the n sidebands which are then passed to the next DAC block for the required conversion process.

Receiver Section:

In the receiver section the signal first under goes analog to digital conversion process then followed by a FFT process which performs the inverse operation of the IFFT ie the summed signals are then separated and converted back to frequency domain. After the signals pass the demodulation process the original signals are obtained and when these are plotted in a complex plane the constellation diagram is obtained which helps us to analyze the output obtained.

ROF (Radio Over Fiber)

ROF is an technique in which microwave and millimeter waves can be transmitted using optical fiber for long and short distances which can also support WLAN and mobility networks. In an ROF based system due to the integration of RF signals and optical signals the channel capacity of the system is increased and mobility is enhanced. Small antennas can be easily deployed with low maintenance and power consumption methods. The typical architecture of a ROF based system has a central base station which is connected to the main office and the base station in turn is wirelessly connected to the other mobile units which in turn has a small area called as micro cell area which has the signal range of the mobile unit and by this mechanism the signals can be connected even to geographical difficult areas. Some of the important applications of the ROF are used in the areas of satellite communication, mobile radio communication etc.

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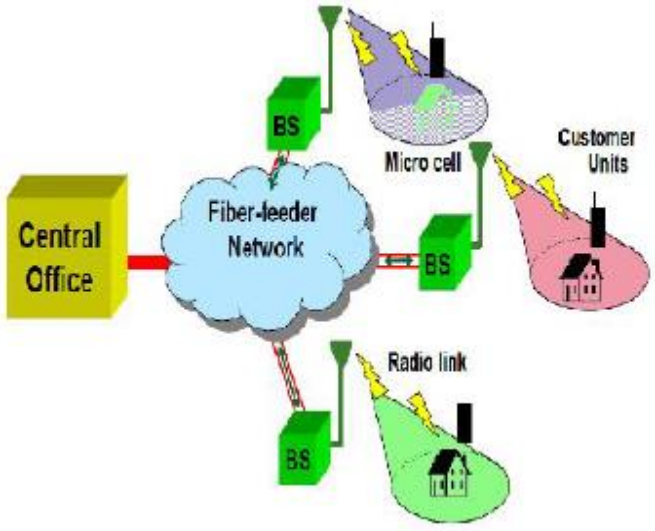
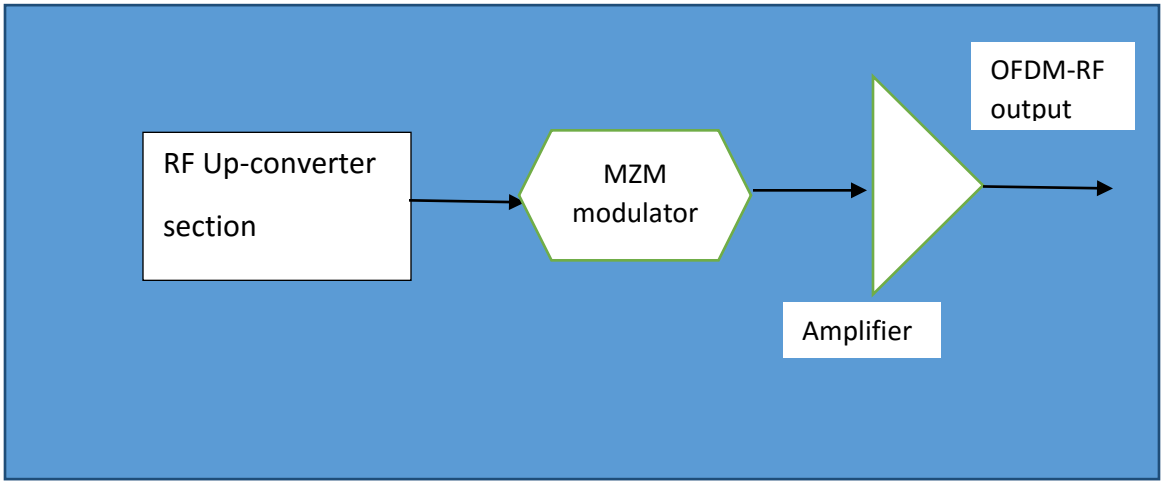


Figure 2. ROF based architecture

OFDM – ROF BASED SYSTEM

This section describes about the integration of the broadband optical OFDM signal in the optical fiber mentioned above and the high frequency RF signal which has the following components RF up converter section, CW laser, Mach zender Modulator, amplifier whose architecture is shown in the diagram



The OFDM signal is given as input to the RF up converter section which converts the signal to a high frequency components and from which the signal is given to a Mach zender modulator which performs the E-O-E and O-E-O conversions at the transmitter and the receiver sections from which the signal is fed to the amplifier before it is being fed to the optical link for transmission of the signal.

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Existing Methods of various OFDM – ROF PON System:

AuthorName	Objectives	Tools &Parameters	Results	Remarks
AyoobAlateeq, MohammadMatin (March-2013)	To maintain high bit rate andprovidehigh bandwidth using OFDM as amodulation format inRoF. BER performance of OFDMusing QAM and PSK modulation.	OptiwaveV.11 8-PSK, 16-PSK,16-QAM with 20Gb/s & 30Gb/son OFDM signal at20GHzmicrowave carrierover 40km SMFused.	Both cases (20Gb/s&30Gb/s) OFDMsignalon 20-GHzmicrowave, 16-PSK &16-QAM sameBER.	BER when16-PSK used might refersto the difficultyin maintainingtheorthogonality intheOFDM.
Fahad Almasoudi, KhaledAlatawi, MohammadA. Matin (June-2013)	Investigates OFDM-RoF techniquein PON. RoF-OFDM-PON systemprovideflexible for cost effective and highdatarate at last mile of wirelessnetworks.	OptiwaveV.11 Laser source1500nmwavelengt h was usedwith 100km, 140km,288km 4-QAM modulationfor 7.5GHz carrierfrequency and 10 and Bitrate 10Gbits/sused.	From theconstellation diagram, 4-QAMis clearly that thequality of the signal ismuch improved afterusing	In this studysuggests that this system isnotonly flexible andcosteffective, butalso provides asignificanthigh datarate.
M. Mahros,M. Tharwat(Dec-2012)	RoF-OFDM based physicalperformance of IEEE 802.11ausing various channelmodel.	MATLABSIMULINK model of IEEE802.11aoptical OFDMsystem. Modulation Bandwidth20MHz.	Here, OFDMwith differentmodulation formats wassimulated and analyzed. TheBERperformance output signalfor differentlength.	16-QAMmodulation only used. AndBERperformancewas analyzed forgiven input andoutput signal.
Toon-Khang Wong, S.M.Idrus, andI.A.Ghani (Oct-2012)	Performance OFDMmodulation technique forRoF OFDMhasdifferentmodulationfo rmat. 16QAMused.	OptiSystem8.0/9.0 16QAM, 7.5GHzcarrier frequency, bit rate10Gbps, 10-50kmdistance. RF signal, opticalfiber channel, RF powerlevel, formatused.	OFDM-RoFsystemmodel usefulto improved theperformance qualityof the current RFsignals.	OFDM-RoF systemto providevarious advantagesin wideband cellular systems.
R.Karthikeyanand Dr. S.Prakasam(June-2013)	OFDM signal into RoFsystem. Up-converting 10 Gb/s OFDMsignalon 7.5 GHz carrier frequency over60 km SMF was applied usingQAM modulation.	OptiSystemand OptiPerformer. Applying 4-QAMRF Signal at 7.5 GHzcarrier frequency. Upto60KmSMF	Resultingof OFDM-RoF, the RF signalimproved compare with inputRFsignal.	Easily maintaintheorthogonalityat 4-QAM. In futureitwill increasedifferentmodulationform atsuch as PSK,BPSK and16-QAM.
Mohammad ShaifurRahman, Jung HyunLee, Youngil Parkand Ki-Doo Kim(2009)	To transmit data of RoF deploymentfor WiMAX with intensitymodulated direct detection RoFtechnology. RoFtechnologytocarryWiMAXsi gnalbetween base station andRAU.	Simulinksoftware. Channel bandwidth –3.5 GHz. OFDM symbol –2 Modulation –QPSK, 16-QAM,64-QAM	Result producewith transmit diversityand withouttransmitdive rsity fromthesimulation for BERVs SNRvalues. BER is 64-QAM.	RoF is thesuccessfultechnologyfor transmittingWiMAX signal.

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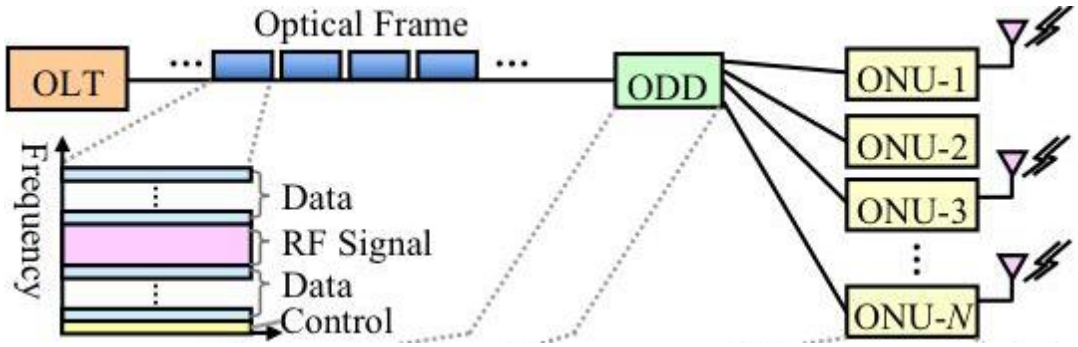
Proposed FGON architecture:



FGON architecture consists of three important structures namely the OLT (Optical Line terminal) the ODD (Optical Distribution Node) and the ONU (Optical Network Unit). The OLT is the main terminal which broadcasts and receives data both upstream and Downstream in the form of optical frames to the ODD which is the point from which the individual connections are given to the clients places which have an ONU for receiving and retransmitting the data if needed. The downstream data and the upstream data use different frequencies for transmitting and receiving data from the OLT to ODD and vice versa. The optical frames which travel in this network consists of various components such as the data RF signal and the control signal. The proposed architecture is to design a 30 GB/s an 40 GB/s OFDM signal on a 40 GHZ microwave carrier over a 80 Km, 160 km, 240 km length fibre SMF with QAM as the modulation technique and analyze the important parameters such as attenuation, scattering, dispersion, bit error rate, and signal to noise ratio are to be analyzed.

Conclusion

In the above discussion the review of the OFDM – ROF based system was carried and analysed so from the above analysis the implementation of the OFDM based ROF system is to be implemented using QAM and also to try the various forms of QAM such as 16QAM, 32 QAM, 64 QAM are to be carried out and the various parameters which were mentioned above are to be tested.

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