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Hammerstein Type Decision Feedback Equalizer For Compensating Wiener Type Nonlinear Channels

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ABSTRACT

ROF, where an optical signal is modulated at radio frequencies & transmitted via an optical fiber, provides for an excellent link allowing for high band-width communication of several channels. In this scenario, there is an intermediate stage between the central base station and the mobile units. The intermediate stage is the optical fiber & the radio access point (RAP). The RAPs provide wireless access instead of the conventional base station and are connected to the central base station via the ROF links. Optical fiber based wireless access schemes have become very popular recently because of their potential to increase system capacity. A Fiber – Wireless uplink consists of a wireless channel followed by ROF link. Optical fiber has some advantageous properties such as low attenuation, longevity, and low maintenance costs which will eventually render fiber the medium of choice in wired first / last mile access networks.

KEYWORDS RAP, ROF, UV, PDA

I. INTRODUCTION

(a)FIBER OPTIC SYSTEM

Fiber-optic communication is a method of transmitting information from one place to another by sending pulses of light through an optical. The light forms an electromagnetic carrier wave that is modulated to carry information. First developed in the 1970s, fiber-optic communication systems have revolutionized the telecommunications industry and have played a major role in the advent of the Information. Because of its advantages over electrical transmission, optical fibers have largely replaced copper wire communications in core networks in the developed world.

The process of communicating using fiber-optics involves the following basic steps: Creating the optical signal involving the use of a transmitter, relaying the signal along the fiber, ensuring that the signal does not become too distorted or weak, receiving the optical signal, and converting it into an electrical signal.

An optical fiber consists of a core, cladding, and a buffer (a protective outer coating), in which the cladding guides the light along the core by using the method of total internal reflection. The core and the cladding (which has a lower-refractive-index) are usually made of high-quality silica glass, although they can both be made of plastic as well. Connecting two optical fibers is done by fusion splicing or mechanical splicing and requires special skills and interconnection technology due to the microscopic precision required to align the fiber cores.

Two main types of optical fiber used in optic communications include multi-mode optical fibers and single-mode optical fibers. A multi-mode optical fiber has a larger core (≥ 50 micrometers), allowing less precise, cheaper transmitters and receivers to connect to it as well as cheaper connectors. However, a multi-mode fiber introduces multimode distortion, which often limits the bandwidth and length of the link. Furthermore, because of its higher dopant content, multi-mode fibers are usually expensive and exhibit higher attenuation. The core of a single-mode fiber is smaller (<10 micrometers) and requires more expensive components and interconnection methods, but allows much longer, higher-performance links.

In order to package fiber into a commercially viable product, it typically is protectively coated by using ultraviolet (UV) terminated with optical fiber connectors, and finally assembled into a cable. After that, it can be laid in the ground and then run through the walls of a building and deployed aerially in a manner similar to copper cables. These fibers require less maintenance than common twisted pair wires, once they are deployed. Specialized cables are used for long distance subsea data transmission, e.g. transatlantic communications cable. New (2011–2013) cables operated by commercial enterprises (Emerald Atlantis, Hibernia Atlantic) typically have four strands of fiber and cross the Atlantic (NYC-London) in 60-70ms. Cost of each such cable was about $300M in 2011.

Another common practice is to bundle many fiber optic strands within long-distance power transmission cable. This exploits power transmission rights of way effectively, ensures a power company can own and control the fiber required to monitor its own devices and lines, is effectively immune to tampering, and simplifies the deployment of smart grid technology.

(b) WIRELESS COMMUNICATION SYSTEM

Wireless communication is the transfer of information between two or more points that are not connected by an electrical conductor. The most common wireless technologies use electromagnetic wireless telecommunications, such as radio. With radio waves distances can be short, such as a few meters for television remote control, or as far as thousands or even millions of kilometers for deep-space radio communications. It encompasses various types of fixed, mobile, and portable applications, including two-way radios, cellular telephones, personal digital assistants (PDAs), and wireless networking. Less common methods of achieving wireless communications include the use of light, sound, magnetic, or electric fields.

Wireless operations permit services, such as long-range communications, that are impossible or impractical to implement with the use of wires. The term is commonly used in the telecommunications industry to refer to telecommunications systems (e.g. radio transmitters and receivers, remote controls etc.) which use some form of energy (e.g. radio waves, acoustic energy, etc.) to transfer information without the use of wires. Information is transferred in this manner over both short and long distances.

Wireless networking (e.g., the various types of unlicensed 2.4 GHz WiFi devices) is used to meet many needs. Perhaps the most common use is to connect laptop users who travel from location to location. Another common use is for mobile networks that connect via satellite. A wireless transmission method is a logical choice to network a LAN segment that must frequently change locations.

Microwave communication, for example long-range line-of-sight via highly directional antennas, or short-range communication, light, visible and infrared (IR) for example consumer IR devices such as remote controls or via Infrared Data Association (IrDA)sonic, especially ultrasonic short range communication electromagnetic induction short range communication and power. Applications may involve point-to-point communication, point-to-multipoint communication, broadcasting, cellular networks and other wireless networks. The term "wireless" should not be confused with the term "cordless", which is generally used to refer to powered electrical or electronic devices that are able to operate from a portable power source (e.g., a battery pack) without any cable or cord to limit the mobility of the cordless device through a connection to the mains power supply.

Some cordless devices, such as cordless telephones, are also wireless in the sense that information is transferred from the cordless telephone to the telephone's base unit via some type of wireless communications link. This has caused some disparity in the usage of the term "cordless", for example in Digital Enhanced Cordless Telecommunications.

(c) RADIO OVER FIBER

Radio over Fiber (RoF) refers to a technology whereby light is modulated by a radio signal and transmitted over an optical fiber link to facilitate wireless access, such as 3G and WiFi simultaneous from the same antenna. In other words, radio signals are carried over fiber optic cable. Thus, a single antenna can receive any and all radio signals (3G, Wifi, cell, etc..) carried over a single fiber cable to a central location where equipment then converts the signals; this is opposed to the traditional way where each protocol type (3G, WiFi, cell) requires separate equipment at the location of the antenna.

Although radio transmission over fiber is used for multiple purposes, such as in cable television (CATV) networks and in satellite base stations, the term RoF is usually applied when this is done for wireless access.In RoF systems, wireless signals are transported in optical form between a central station and a set of base stations before being radiated through the air. Each base station is adapted to communicate over a radio link with at least one user's mobile station located within the radio range of said base station. The advantage is that the equipment for WiFi, 3G and other protocols can be centralized in one place, with remote antennas attached via fiber optic serving all protocols. It greatly reduces the equipment and maintenance cost of the network.RoF transmission systems are usually classified into two main categories (RF-over-Fiber ; IF-over-Fiber) depending on the frequency range of the radio signal to be transported.

a) In RF-over-Fiber architecture, a data-carrying RF (Radio Frequency) signal with a high frequency (usually greater than 10 GHz) is imposed on a light wave signal before being transported over the optical link. Therefore, wireless signals are optically distributed to base stations directly at high frequencies and converted from the optical to electrical domain at the base stations before being amplified and radiated by an antenna. As a result, no frequency up/down conversion is required at the various base stations, thereby resulting in simple and rather cost-effective implementation is enabled at the base stations.

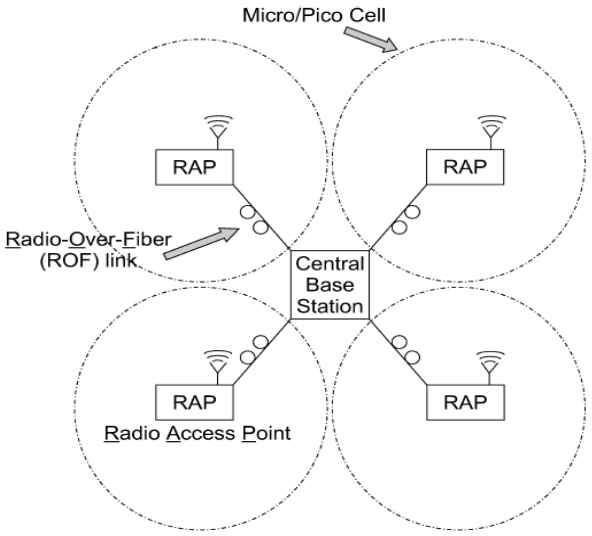
b) In IF-over-Fiber architecture, an IF (Intermediate Frequency) radio signal with a lower frequency (less than 10 GHz) is used for modulating light before being transported over the optical link. Therefore, before radiation through the air, the signal must be up-converted to RF at the base station.

II.SIMULATION RESULTS AND DISCUSSION

With the evolution of internet & computer technology, people are using various mobile technologies. The high data rate and broadband demands of wireless & wired line networks have rapidly increased in recent years. New wireless subscribers are signing up at an increasing rate demanding more capacity whereas the radio spectrum is limited. One scheme that has become increasingly popular to alleviate this demand is radio-over-fiber (ROF).ROF, where an optical signal is modulated at radio frequencies & transmitted via an optical fiber, provides for an excellent link allowing for high band-width communication of several channels. In this scenario, there is an intermediate stage between the central base station and the mobile units. The intermediate stage is the optical fiber & the radio access point (RAP). The RAPs provide wireless access instead of the conventional base station and are connected to the central base station via the ROF links. Optical fiber based wireless access schemes have become very popular recently because of their potential to increase system capacity. A Fiber – Wireless uplink consists of a wireless channel followed by ROF link. Optical fiber has some advantageous properties such as low attenuation, longevity, and low maintenance costs which will eventually render fiber the medium of choice in wired first / last mile access networks.

Simulations were performed in an asynchronous multiuser environment. The simulation package used for all simulations herein was MATLAB with SimulinkTM. The SimulinkTM model was used mainly as a means to gather the input-output data of the system. All the initializations and identification calculations (i.e., correlations) were performed in MATLAB by sending the Simulink inputs/outputs to the MATLABTM workspace. Although the simulations were performed in an asynchronous environment, the cross correlation properties of

PN (i.e., partial cross correlations) still hold and the algorithm is able to successfully identify both systems.



(i)SIMULATION PARAMETERS

CIR and polynomial channel: all CIR'S used in the simulations satisfied the property of unit energy,

i.e. $\sum_n |h(n)|^2$ = 1, to ensure no amplification from the wireless channel. The gain of each path was selected using the Rayleigh fading model. The optical channel was modeled using a third order memoryless nonlinearity,

$$y = c_1 x^3 + c_2 x$$

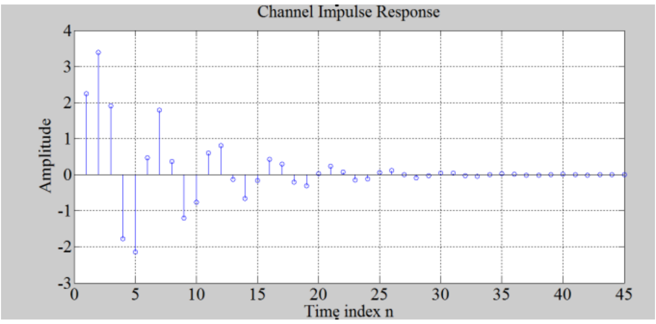


Fig 1.Channel impulse response

Note:

This channel impulse response mainly determines the channel to downlink characterstics of the system.

2.Number of users and PN sequence length: The effect of including additional users will also be shown. Simulations were performed with a PN sequence length of 4095 based on several trials. Compared to the single user case identification in a multiuser environment requires a longer sequence length because there is MAI in addition to ISI.

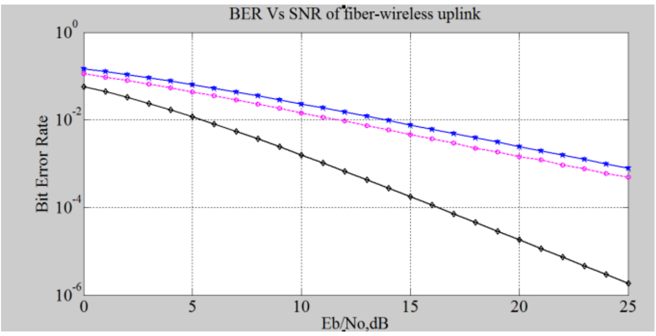


Fig 2.BER Vs SNR

To determine the input and output amplifier difference & to determine the linearity for different users. Each of the multiple PN sequences was generated from a separate maximal-length linear feedback shift register (LFSR) polynomial. This is in contrast to the common technique (used in current CDMA systems) of using delayed versions of a single PN sequence to represent different users. The 'delay' technique requires a priori knowledge of the channel memory and is therefore undesirable. If the PN sequence offset is not longer than the memory, there will be multiple identifications. All simulations were performed with the inclusion of wireless ((n)) and optical ($n(n)$) Gaussian noise with different initial seeds to ensure statistical independence. The SNR between each mobile user and the RAP was set to 25 dB, and the optical noise power was set equal to the wireless noise power. Quality of fit: The quality of fit of the estimated CIR to the actual CIR was measured by defining a normalized estimation error parameter,

$$\rho = \frac{\sum_{k=0}^{L} [h_{actual}(k) - h_{est}(k)]^2}{L_{\max}}$$

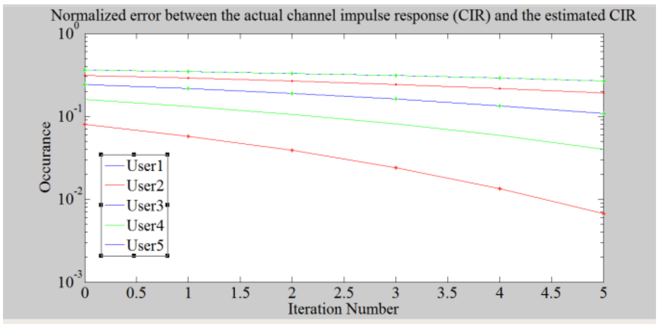


Fig 3.Normalized error between the actual channel impulse response (CIR) and estimated CIR

This Normalized error between the actual channel impulse response and the estimated channel impulse response determines uplink to channel (i.e)wired communication, without downlink.

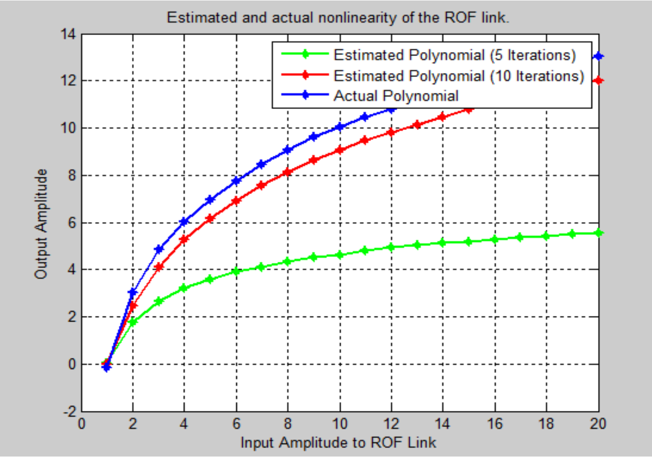


Fig 4.Estimated and actual nonlinearity of the ROF link

Note:
This curve determines the estimated and actual nonlinearity of the ROF link for different iterations.

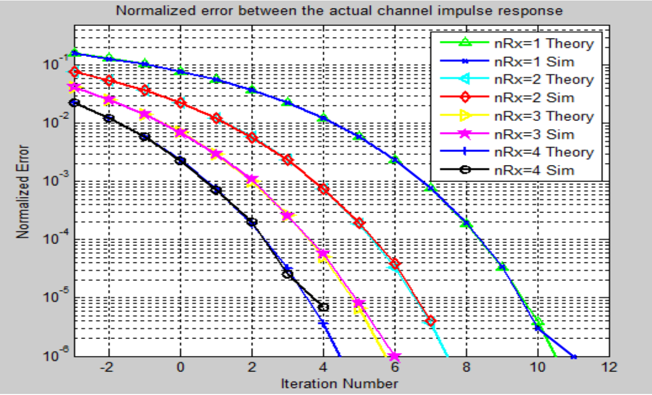


Fig 5.Normalized error between estimated and actual channel impulse response this curve determines the error between estimated and actual channel impulse response for channel estimation.

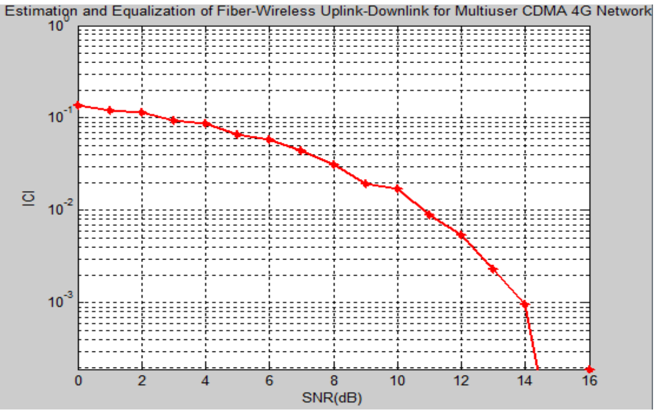


Fig 6. Estimation and equalization of fi-wi uplink –downlink for multiuser CDMA 4G networks This curve determines the uplink –downlink for multiuser CDMA mainly to avoid the error reduction.

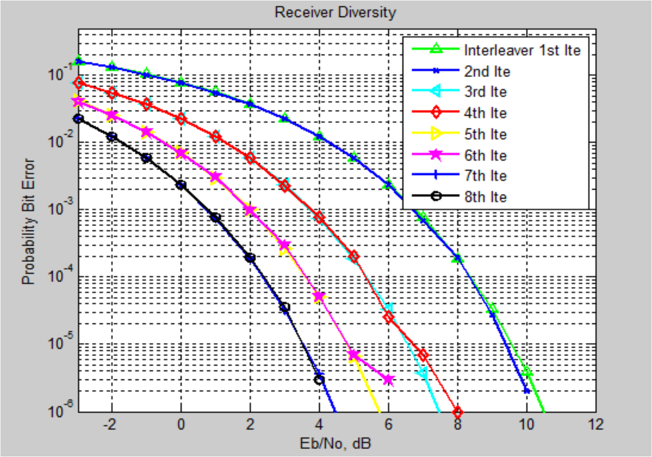


Fig 7. Recevier Diversity

Note:
This curve determines the receiver diversity characteristics mainly to reduce the bit error rate.

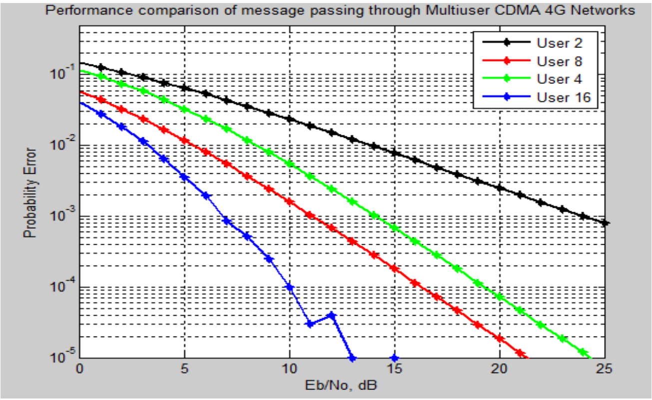


Fig 8.Performance comparison of message passing through Multiuser CDMA 4G Networks

This curve determines the performance comparison of message passing for multiuser CDMA 4G Networks without interference.

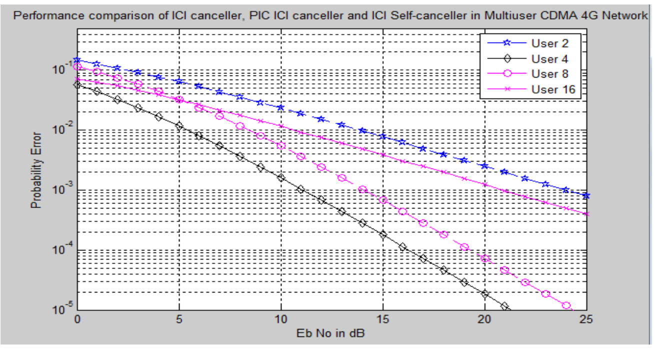


Fig 9.Performance comparison of different canceller in Multiuser CDMA 4G Network This curve determines the performance comparison of different canceller in CDMA networks for different users.

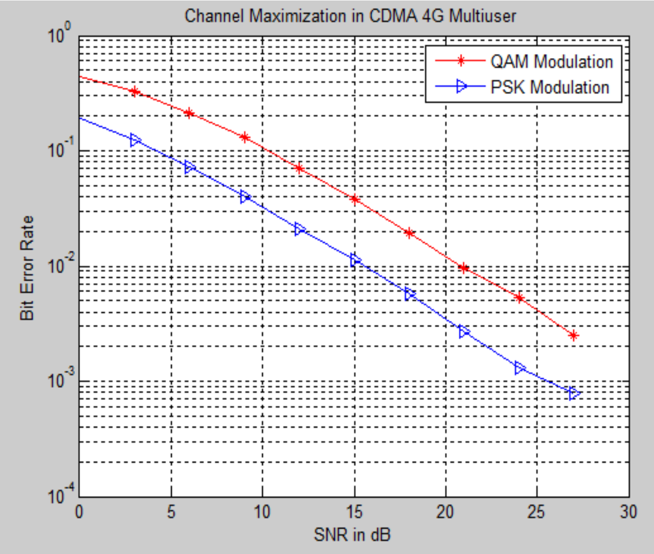


Fig 10.Channel Maximization in CDMA 4G Multiuser This curve determines the channel maximization in CDMA 4G multiuser in which QAM modulation has better performance than the PSK modulation to reduce the bit error rate.

III.CONCLUSION AND FUTURE SCOPE

In this paper we have proposed a Hammerstein type decision feedback equalizer, for compensating wiener type nonlinear channels. Although the motivation is triggered by the fiber-wireless uplink, the equalizer is effective against any general Wiener type nonlinear channel that consists of a time dispersive linear system followed by a memory less static nonlinear system. These type of channels are frequently encountered in communication systems. The HDFE architecture has the advantage that when the linear dynamic system is a fast changing wireless channel, it enables updating only the linear filter coefficients, leaving the nonlinearity compensation unchanged. Furthermore, this architecture is especially useful when multiple users share a single nonlinear link such as the fiber channel. This paper also presented an efficient algorithm for the identification and equalization of the uplink in a multiuser CDMA Fi- Wi network. Estimation was performed using the correlation properties of PN sequences and equalization was performed using a unique equalizer that has separate linear and nonlinear modules. The algorithm also mitigates MAI with little iteration. This technique works in an asynchronous CDMA environment, which is ideal for a 4G uplink. A key advantage of this approach is the separate estimation and equalization of the linear and nonlinear portions.

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