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Performance Analysis of WCDMA Radio over Fiber

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ABSTRACT
Wireless communications is one of the fastest media used worldwide today. However the wireless signals suffer from severe loss along the transmission as well as atmospheric attenuation. This paper proposes a solution to overcome this problem by using low-attenuation, electromagnetic interference free optical fiber. This can be achieved by using Radio Over Fiber (ROF) which is an integration of optical fiber for radio signal transmission within a network. This paper simulates a WCDMA Radio Over Fiber which results in a lower Bit Error Rate (BER) as compared to wireless transmission.

General Terms
Doppler shift, Gain, Bandwidth, Polynomial, Mobile Station (MS), Base Station (BS), Central Station (CS)

Keywords
AWGN, BER, BPSK, DBPSK, PSK, RAP, ROF, QPSK, QOS WCDMA

1. INTRODUCTION
Wireless communication has captured attention and imagination of many researchers as cellular systems has achieved exponential growth over decades [7]. New applications such as wireless sensor networks, remote telemedicine’s indicate a bright future for wireless networks. With the increase in demand for high speed data transfer capacities which require high microwave frequency, radio station antenna should always be smaller, less complex and more radio access point (RAP) is needed to cover a certain area [19]. To keep station cost under control, the base station (BS) should be simple and all the signal processing function should be at the central station. Adequate bandwidth is provided by ROF for this purpose.

Radio Over Fiber (ROF) has emerged as a cost effective approach as compared to wireless transmission cost because it simplifies the remote antenna sites(BS) and enhances the sharing of expensive radio equipment at central station (CS) [7,20].The main issue of the wireless radio communication is its limited available frequency spectrum and high-speed radio transmission. In addition, in case of wireless radio communication several radio access points are required to cover a certain area which makes the system costly and less reliable and hence the signal coverage is poor [8]. Radio over fiber system allows most of the signal processing (including coding, multiplexing [13], RF generation and others) to be done at the central station rather than the base station and hence base stations and hence base stations can be made simpler [10,11]. The signal transmitted in ROF system is optical and also base station comprises of optical to electrical convertor, antenna and some microwave circuitry which makes base stations in case of ROF system simpler and cheaper which decreases the overall cost of the system [14, 16].

2. RADIO SIGNAL USING FIBER
This paper aims at transmitting a radio signal with the help of the optical fiber instead of wireless transmission for providing large bandwidth and better coverage capacity.

2.1 WCDMA
WCDMA is well known as UMTS which is the third generation wireless personnel communication systems is far more efficient than the GSM system due to its characteristics and white band properties [2]. WCDMA combines both data and voice simultaneously and has a greater capacity and posse’s high-bandwidth applications and features such as greater quality of service, high security and for multi-media purpose [3, 4].

2.2 ROF
Radio over fiber technology [9] makes use of the optical fiber links to distribute the radio frequency signals from the central station to the base stations located at different points in a network area [1]. In a narrow band communication systems different signal processing is done at the base station which increases the complexity of the system. Whereas in case of ROF technology various signal processing is done at the central station and hence different base stations can be made simpler and cheaper. The centralization of radio frequency signal processing allows dynamic sharing of resources and simplify operation and of the system which deceases the complexity and increases the capacity of the system.

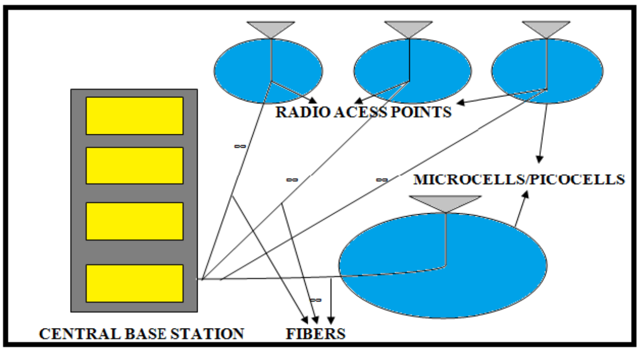

Fig1: ROF ARCHITECTURE

2.3 WCDMA using ROF
This paper combines WCDMA technology with ROF for efficient, fast and less error-proned data transmission.

WCDMA technology makes use of microcells and picocells for providing better coverage and high bandwidth services to the customers [5]. The main aim of combining WCDMA with ROF is extremely important because it meets the demand of high frequency and large bandwidth requirements for efficient data transmission [12, 15, 17, 18].

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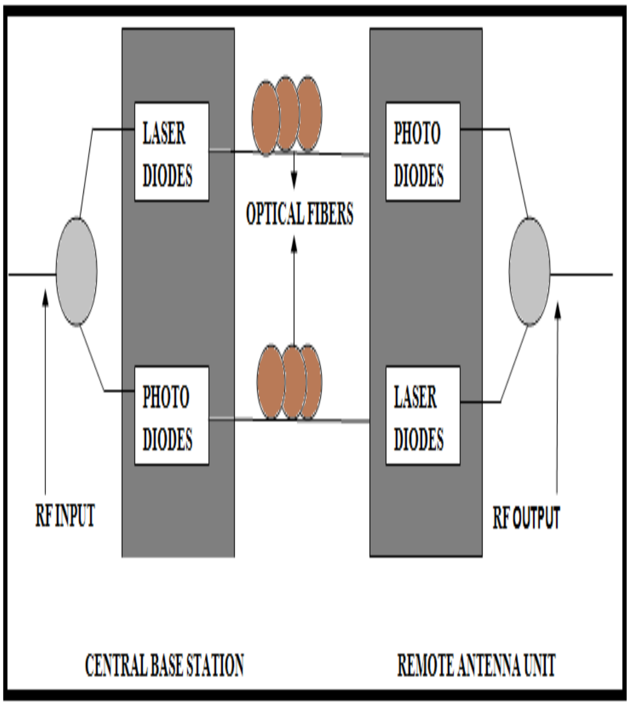

Fig 2: Modulation of laser diodes

In each direction the input RF signal is applied to a laser diode which modulates the intensity of the output light and its converts an electrical signal into optical light and this light will have a wavelength of either 1300 or 1550 nm for low transmission loss in silica fiber which may be multimode or single mode according to the requirements of the user. Latter is preferred for links spans of more than a few tens of meter.

A p-i-n photodiode, which provides an RF power output that is proportional to the square of the optical power input and converts the optical signal back to the electrical signal and performs the function opposite to that of the optical source such as laser diode.

This optical link is known as intensity modulated-direct detection (IM-DD) which is used for cellular applications for its simplicity and cost. The length of the optical fibers used may be varied according to the requirements of the user.

3. BER COMPARSION OF WCDMA WITH AND WITHOUT ROF

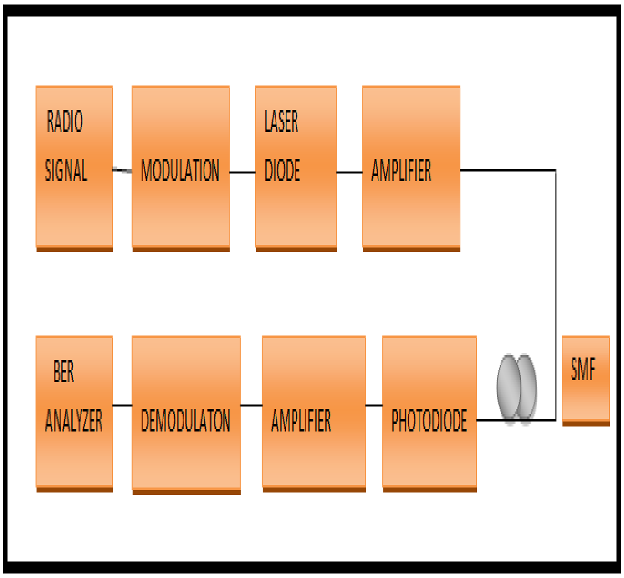

Fig 3: Simulation block of downlink WCDMA ROF

Figure3 shows the basic simulation block diagram of WCDMA system to observe the parameter's effect on the system Processing data in multiple smaller sets and looping over a set of values such as Eb/N0, the alphabet size, or the over sampling rate to reduce the memory requirement.

The downlink model of WCDMA using fiber has been shown and it explains that the radio signal after being received is modulated. The modulation used should be such that it gives a better signal to noise ratio. The modulated signal is provided to the optical source so that it can produce a optical signal from an electrical signal.The optical source used here is the laser diode which provides electrical-optical conversion of the signal which is then amplified to increase the signal level so that a better SNR can be produced.

The amplified version of the optical signal is sent through the optical fiber. At another end of optical fiber, there is a photodiode or a photo detector which provides optical-electrical conversion of the signal and an optical signal is then converted into electrical form which is then again given to the amplifier to increase the signal level so that the losses occurred through the fiber can be compensated .The amplified signal is then demodulated with the help of the demodulator to demodulate the signal to produce the signal into its original form.

The demodulator scheme used should be the same as used for the modulation to provide better quality signal at the receiver end which is then given to the ber analyzer to measure the bit error ratio of the received signal at the destination.

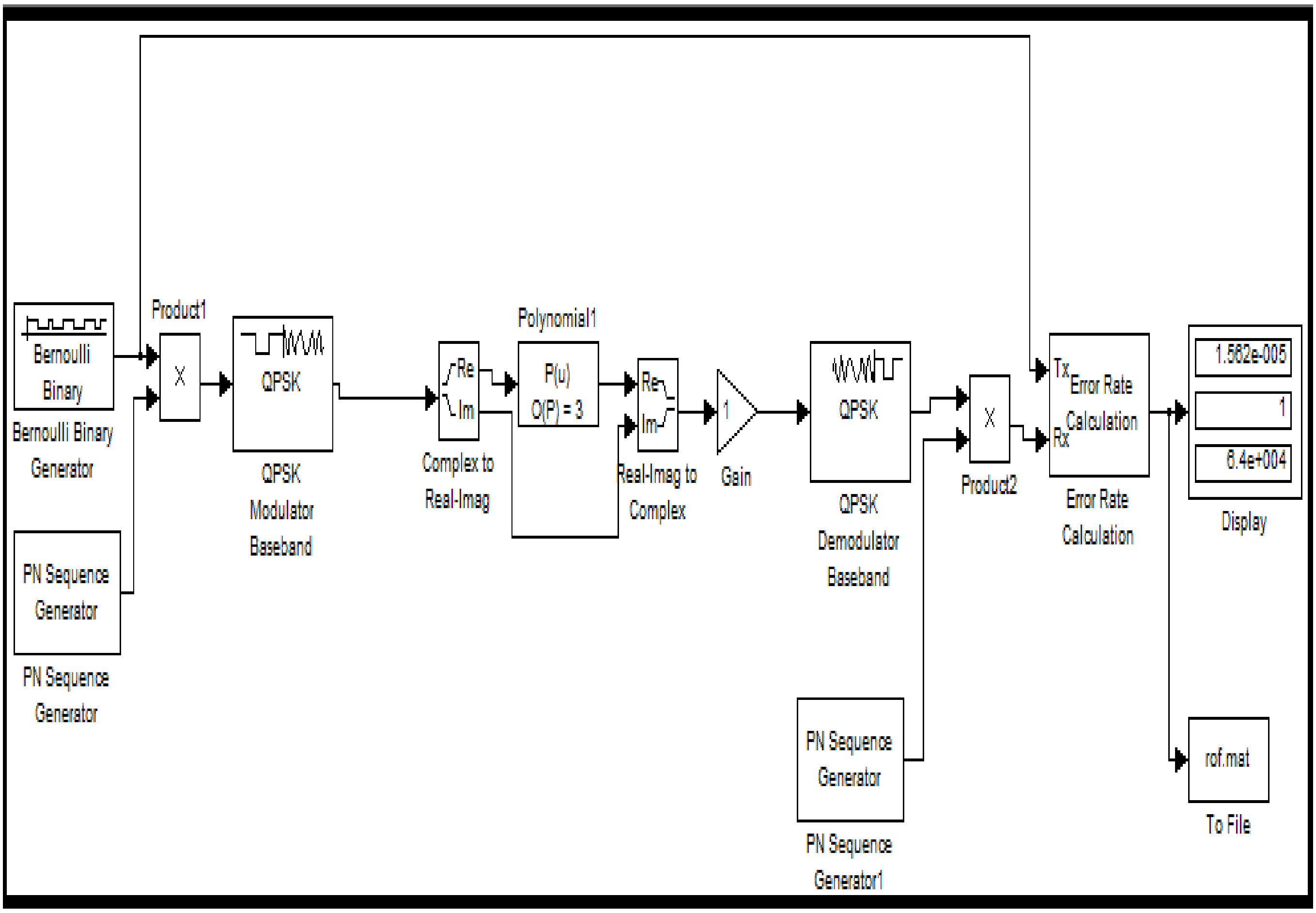

Fig 4: Simulation of WCDMA with ROF

Figure4 shows the simulated model of WCDMA with ROF using Bernoulli binary generator, pn sequence generator, a product block,QPSK modulator baseband and a polynomial for representing a laser diode which is essential for converting an electrical signal into optical signal, a gain block which represents fiber, a QPSK demodulator, error rate calculation block and a display.

The Bernoulli binary generator block generates random binary numbers using binary distribution. The pn sequence generator block generates a sequence of pseudorandom binary numbers using a linear feedback shift register, the pseudonoise sequence can be used as a scrambler for spreading the data sequence at the transmitter end using the product block by multiplying the binary data with the pseudonoise sequence. This spreaded data is then given to the QPSK modulator which uses quaternary phase shift keying method to produce the modulated signal, The complex to real-imag block accepts the complex valued signal and it outputs the real-imag part of the input signal depending on the setting of the output parameter. The signal is then given to the polynomial block which uses a coefficients parameter to evaluate a real polynomial for the input value, it has been used as a laser diode for electrical optical conversion of the signal The signal is then given to real-imag to complex block which converts real or imaginary inputs to a complex valued output signal, then the signal is given to the gain block which represents the optical fiber whose length can be varied accordingly by changing the parameter values. Finally the signal is then demodulated using a QPSK demodulator which uses quaternary phase shift keying method to demodulate the signal. The input to this block is a baseband block whose input is a baseband representation of the modulated signal.

The demodulated signal is then despreaded by using another pn sequence generator and a product block at the receiver, the product block performs multiplication of its inputs to produce the descrambled data. The number of inputs to a product block can be varied according to the requirements. The scrambled signal is then given to the error rate calculation block and a Bit Error Rate (BER) is calculated using the error rate calculation block which compares input data from a transmitter with the input data from a receiver which is then given to the display block to show the final result. The amount of data displayed and the time steps at which the data is displayed are determined by the decimation block parameter and the sample time property.

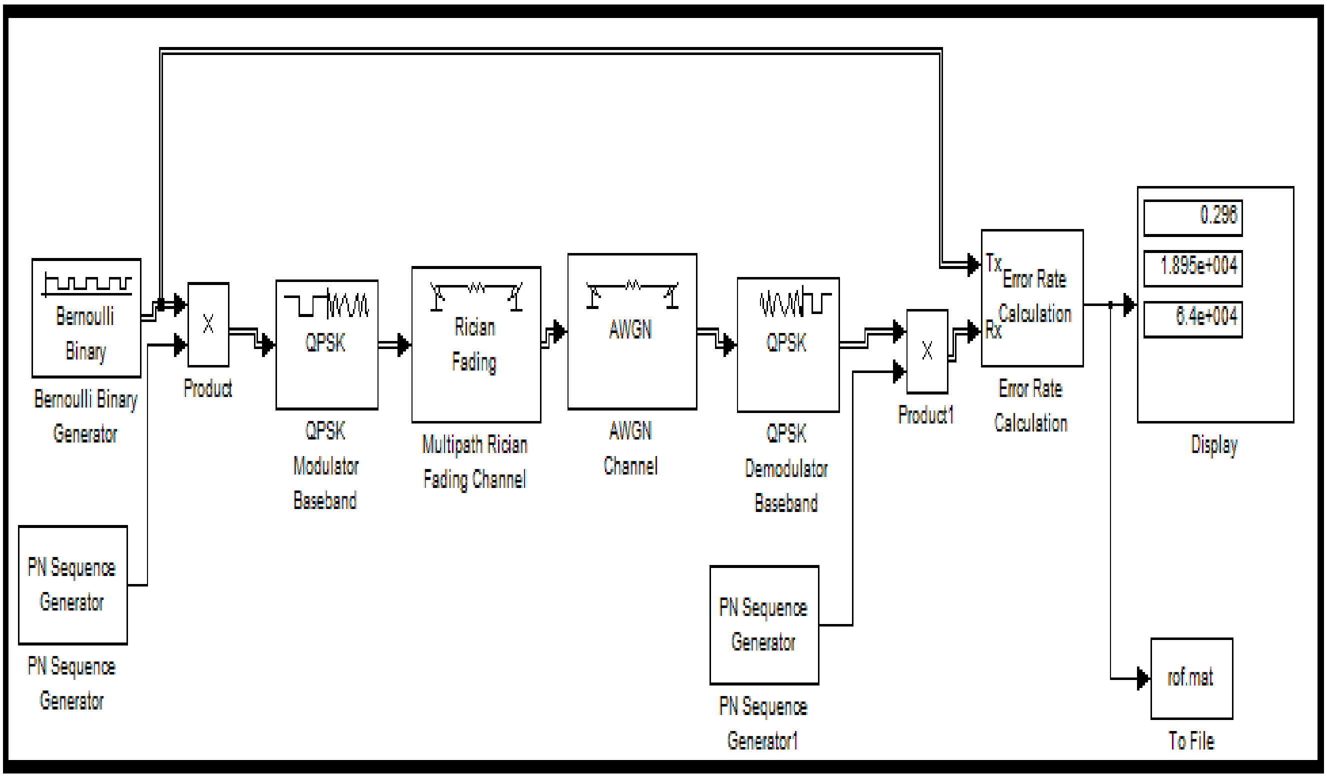

Fig 5: Simulation of WCDMA without ROF

The simulated model of WCDMA without ROF, has been shown and it has been constructed using MATLAB 7.6.0 The. ROF has been replaced by a rician fading channel and a AWGN channel between modulator and the demodulator. The details of each and every block used and the parameters are set accordingly.

Bernoulli generator generates the binary signal to be transmitted from the transmitted end. Pn sequence generator which generates the pn sequence value which is used as the spreading code for spreading the transmitted binary data. The products block which is used for combining the input transmitted data with the pn sequence. In the product block two inputs has been taken which can be varied according to the requirements. QPSK modulator which modulates the input signal using the quaternary phase shift key methods and produces the output modulator waveform. The modulated signal is then given to a rician fading channel block which implements a baseband simulation of a multipath rician fading propogation channel this block is useful when a transmitted signal can travel to the receiver along a dominant line of sight or direct path. Fading can cause the signal to spread and become diffuse and decreases the strength of the signal considerbly. The signal after the fading channel is then passed to the AWGN channel which adds white gaussian noise to the input received signal which is then given to the QPSK demodulator baseband block which uses quaternary phase shift keying method to demodulate the signal. The input to this block is a baseband block whose input is a baseband representation of the modulated signal. The demodulated signal is then despreaded by using another pn sequence generator and a product block at the receiver, the product block performs multiplication of its inputs to produce the descrambled data. The number of inputs to a product block can be varied according to the requirements The scrambled signal is then given to the error rate calculation block and a Bit Error Rate (BER) is calculated using the error rate calculation block which compares input data from a transmitter with the input data from a receiver and produces the bit error rate which is then given to the display block to show the final output value. The simulated model of WCDMA without ROF does not give better performance in comparison to the simulated model of WCDMA using using ROF.

4. MODULATION TECHNIQUES FOR WCDMA WITH AND WITHOUT ROF

Table1: Results for various modulation techniques

MODULATION TECHNIQUES	BER WITH ROF	BER WITHOUT ROF
DBPSK	1.562e-005	4.687e-005
BPSK	0.003891	0.1012
OQPSK	0.5	0.5594
PSK	1.562-005	0.4659

Figure below shows BER versus different modulation techniques:

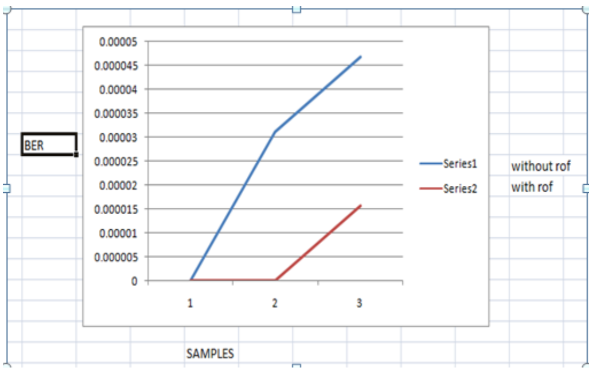

Fig 6: Results for DBPSK modulation .

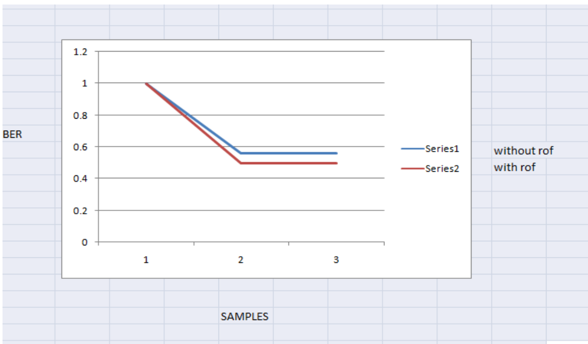

Fig 7: Results for BPSK modulation

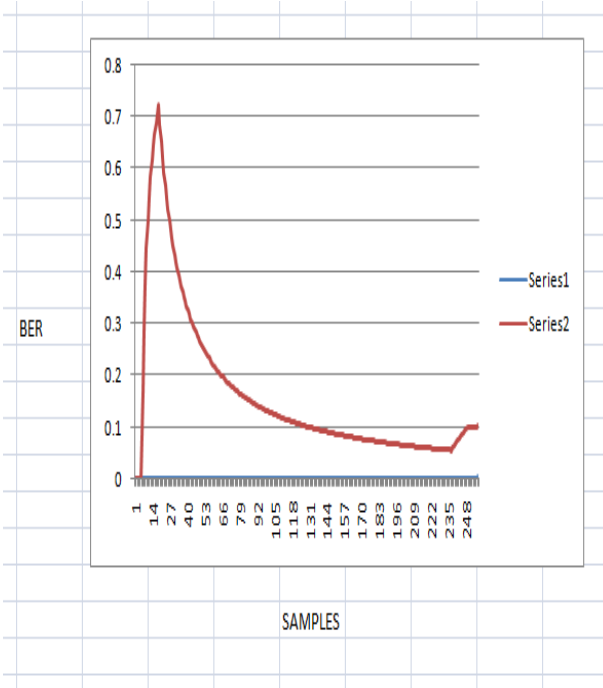

Fig 8: Results for OQPSK modulation

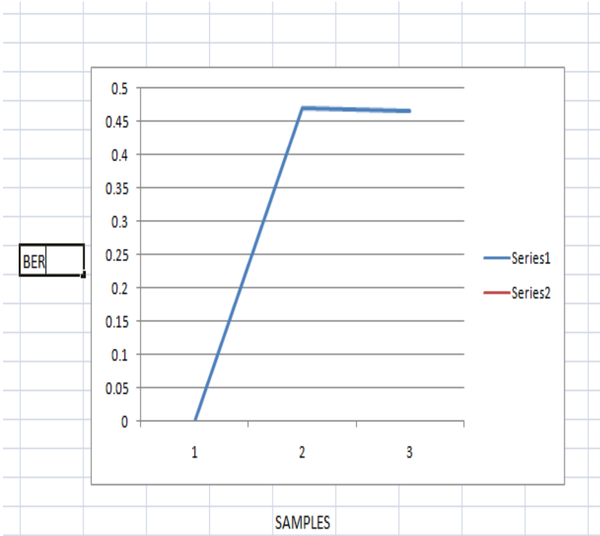

Fig 9: Results for PSK modulation

The above graph shows the results for different modulation techniques using ROF and without ROF. It can be seen from the above graph that Bit Error ratio is better in case of ROF as compared to without ROF for all the modulation schemes that have been used above.

Results clearly shows that Radio Over Fiber is much advantageous to use as it reduces the errors occurring in the received signal and hence it improves signal quality, thereby giving a better signal to noise ratio at the output, All the modulation techniques that have been used above gives better results when used with ROF as compared to when used without ROF and this has been verified by simulation and the results shown above.

Table 2: BER for different Doppler shift without ROF

DOPPLER SHIFT	BIT ERROR RATE (BER)
2HZ	0.3354
6HZ	0.4099
10HZ	0.4472

There is no doppler shift in case of WCDMA ROF as there is no fading channel present between the transmitter and the reciever.

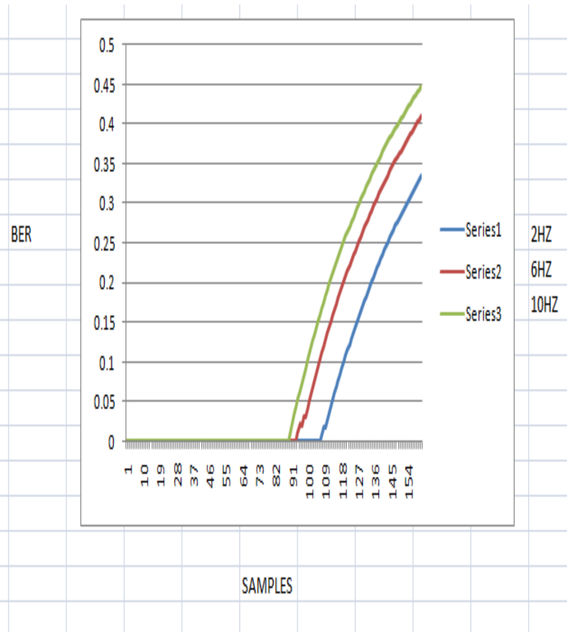

Fig 10: Results for different Doppler shifts

Table 3: BER versus SNR without ROF

SNR	BIT ERROR RATE (BER)
10DB	0.4769
20DB	0.3846
60DB	0.3692

In case of ROF BER doesnot depend on the AWGN channel SNR as the signal is transmitted through the fiber.

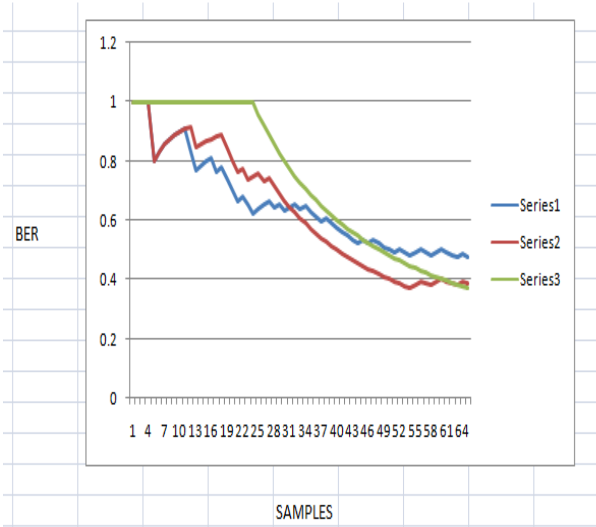

Fig 11: Results for different AWGN SNR values without ROF

Different fiber length has been represented by different value of gain as the fiber length increases attenuation loss gets increased and hence the gain decreases. So as we increase the value of gain, the BER gets decreased because the losses present in the fiber gets reduced which has been shown in the results above and have been proved by simulation.

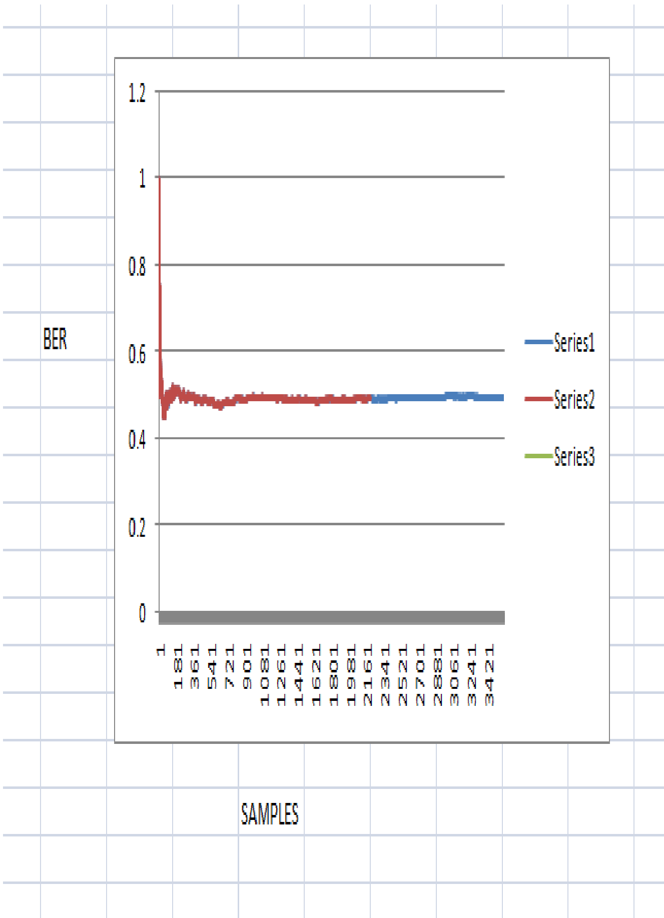

Fig 12: Results for different length of the fiber (ROF)

RESULTS AND CONCLUSION

Results shows that WCDMA system with ROF provides less BER as compared to WCDMA without ROF. Different modulation techniques have been used above and results shows that for all the modulation techniques the WCDMA when used with ROF gives better performance and lower BER as compared to WDMA without ROF. Variation in BER has also been noticed when Doppler shift is varied and it has been noticed that BER gets increased when Doppler shift is increased.

3. ACKNOWLEDGMENT

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