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Control of Bandwidth & OSNR using Higher Modulation Schemes with Coherent Detection

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***Abstract*— In order to transmit over a long distance and to meet the demand of data transmission in long haul communication, it is necessary to use the optical spectrum by increasing the bit rate on each channel. As narrow pulses occupy higher Bandwidth, so in order to avoid this problem higher order modulation schemes such as QPSK, QAM can be used to modulate the bit, which increases the efficiency. For this type of modulations, coherent receivers place an important role over direct detection. For a given BER, the received optical signal requires to have minimum OSNR.**

In our study, in this paper, we analyze for different modulation schemes using coherent detection, the OSNR requirement. Our analysis shows that as we decrease the BER, the OSNR is high for coherent receiver, whereas it is low for direct detection. Also we analyzed the OSNR vs. BER in synchronous and asynchronous detection of different types of modulation over a long distance with coherent detection. **Keywords—OSNR,WDM, Coherent System, Heterodyne System, Nyquist**

I. INTRODUCTION

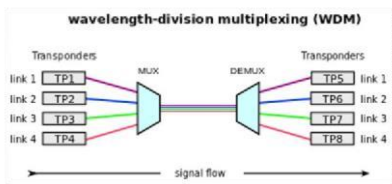
Fiber optics connects the world ,carrying calls and data .With bandwidth demand growing ,manufacturers are working up to transmission rates, cut costs and otherwise improve product performance .However, achieving these goals may require changing long - and short-haul fiber, while at the same time overcoming manufacturing related challenges . It's the many tera bits, or thousands of gigabits, travelling to and from data centers, that are influencing where long haul fiber is being installed. Moving that, much data around demands higher transmission rates, so the industry will be transition to 400Gb/s data links over the next few years.

.WDM coherent optical fiber systems with Nyquist spectral shaping known as Nyquist WDM systems , can reduce the channel spacing close to the symbol rate by upgrading the transmitter in a conventional single carrier coherent optical fiber system

This paper provides an overview of detection & modulation methods, which emphasis on coherent detection & digital compensation of channel impairments .Here we review signal detection methods, including direct and coherent detection with synchronous & asynchronous detection. We presented the BER performance of different modulation formats in presence of additive white Gaussian noise, also found OSNR.

II. REALIZE OF WDM SYSTEM

WDM (wave length division multiplexing) coherent optical fiber systems with Nyquist spectral shaping, known as Nyquist WDM systems, can reduce the channel spacing close to the symbol rate by upgrading only the transmitter in a conventional single carrier coherent optical fiber systems. This Nyquist WDM system can reduce the channel spacing close to the symbol rate with negligible cross talk between channels and ideally zero ISI.Optical filters aren't flexible to generate accurate



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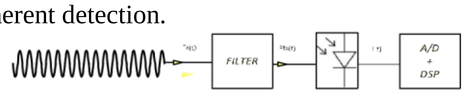
III.REALIZEOF COHERENT DETECTION

In optical communications there are two major kinds of detectors: direct detection and coherent detection.



Direct detection receiver scheme.

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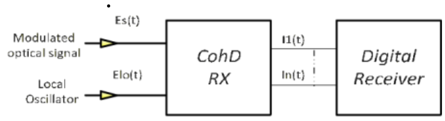

In an optical coherent system, the use of balanced photo detectors allows reducing or eliminating the noise from the electrical signal, as well as it enables to maximize the use of the optical power generated by the local oscillator.

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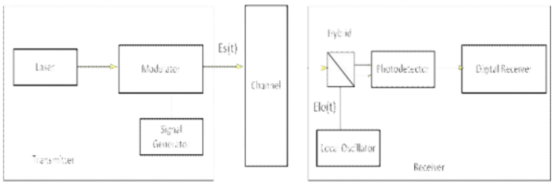
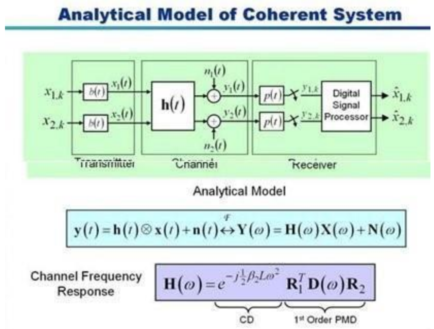
IV. GENERIC BLOCK SYSTEM FOR THE COHERENT SYSTEM

The most basic idea on a coherent system is that, in the reception stage, the modulated optical signal is mixed with a local oscillator.



(BLOCK DIAGRAM FOR COHERENT OPTICAL SYSTEM

V. ANALYTICAL MODEL OF COHERENT SYSTEM



VI. EVOLUTION OF OPTICAL MODULATION FORMAT

About a decade ago, the bandwidth provided by optical amplifiers was sufficient to carry the capacity demand in optical transport networks and spectral efficiency was of little concern. Binary Intensity modulation (on/off keying OOK) had dominated fiber –optic transport its beginning, since it is the simplest of all modulation formats. OOK was the first modulation format used .and was taken all the way to 100gb/s in research demonstrations using optical equalization to make up for the limited bandwidth of optoelectronic components.

VII. SPECTRAL EFFICIENCY AND ADVANCED OPTICAL MODULATION FORMAT

Modern optical communication systems fulfilling optical networking functionalities and operating at data rates of about 40Gb/s are now commercially available due to the rapid development of high-speed electronics and optical component technologies in recent years . In wavelength division multiplexing (WDM) systems the increase of system reach and capacity and, at the same time, the reduction of the cost per transported information bit are achieved by sharing optical components among many WDM channels.

$$SE = \frac{1}{\ln 2}\left(SNR - {SNR^2}/{2}\right)$$

The above represents relation between spectral efficiency & SNR.

VIII. OSNR CALCULATION

Optical Signal to Noise Ratio (OSNR)

The Optical Signal to Noise Ratio (OSNR) is defined as the average optical signal power divided by the ASE power, measured in both polarizations and in a reference bandwidth fixed to 0.1nm corresponding to the resolution bandwidth of optical spectrum analyzers at 1550nm. The OSNR is :

$$\text{OSNR} = \frac{P}{2N_{ASE}B_{ref}}$$

where P is the total average signal power summed over the two states of polarization, N_{ASE} is the spectral density of the ASE in one polarization and the reference bandwidth B_{ref} fixed to 0.1nm (10GHz).

IX. RELATION BETWEEN SNR & OSNR

SNR is defined as Signal-to-noise ratio which is defined as

$SNR = {E_s}/{N_o}$ *which is defined in terms of symbol*

$SNR_b = {E_b}/{N_o}$ *which is defined in terms of bit*

Now, $OSNR = {2R_s}/{2B_{ref}}$ SNR where R_s is the symbol rate & B_{ref} is the bandwidth considered.

Similarly, in terms of bit, OSNR can be defined as:

$OSNR = R_b/2B_{ref}\, SNR_b$ *where* Rb *the bit rate*

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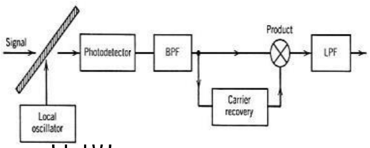
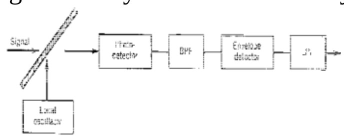
X. SYNCHRONOUS & ASYNCHRONOUS RECEIVER



(Block Diagram for Synchronous Heterodyne Receiver)



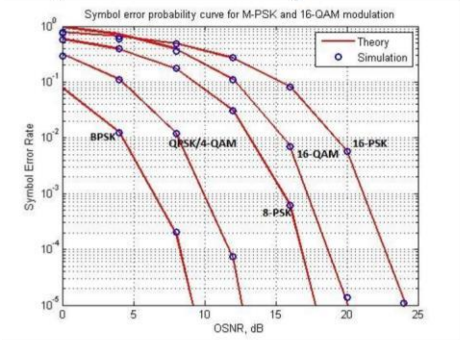
(Block Diagram for Asynchronous Heterodyne Receiver)

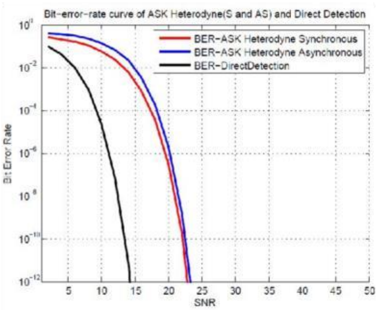
XI. SIMULATION USING MATLAB

Here we simulated with MATLAB for different modulations i.e. BPSK,M-PSK,16 QAM where

Symbol error probability vs. Optical Signal to Noise Ratio is analysed. We simulated it using

$R_s = 40\ GB = \text{Symbol rate} \quad \text{and} \quad B_f = 10GHz = \text{Bandwidth}$





XII. CONCLUSION

Coherent optical fiber communication systems potentially offer improved receiver sensitivity and channel selectivity over direct-detection techniques. High per-fiber capacities at an attractive cost per transported information bit are enabled by spectrally efficient WDM transport on flexible, optically. routed networks. Advanced modulation formats play an important role in design of such networks. We have discussed the generation and detection of the most important optical modulation formats for multi gigabit/s per-channel data rates, where limits of available RF technology place important restrictions in the implementation. It is also shown that BER performance becomes more sensitive against ISI as the level of modulation increases.

Sl No.	Type of Modulation	BER	OSNR(dB)
1	BPSK	10^-3	8
2	QPSK	10^-3	10
3	8-PSK	10^-3	16
4	16-PSK	10^-3	22
5	16-QAM	10^-3	18

Sl No.	Type of Modulation	BER	OSNR(dB)
1	Heterodyne Synchronous ASK	10^-3	16
2	Heterodyne Asynchronous ASK	10^-3	17
3	Direct Detection	10^-3	8

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