Comparison of Optical Vector Signal Generation with oSSB Technique using Duo-Binary Modulation, oSSB Technique using EDFA and oVSB format based on SPM effect without using SOA.

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Abstract: - Recently, optical RF signal generations like single-sideband (SSB) using SOA, double-sideband (DSB), and double sideband with optical carrier suppression (DSBCS) modulation schemes have been demonstrated. SSB technique using SOA suffers from the polarization sensitivity problem which needs polarization controllers to overcome it. DSB modulation approach suffers from inferior sensitivity because the optical modulation index is limited & undergoes performance fading due to fiber dispersion. Although DSBCS modulation has excellent spectral efficiency and superior receiver sensitivity, the bandwidth requirement, power consumption & cost are high for DSBCS.

The following methods provide a novel modulation approach for generating optical vector signals: First approach is the Optical Vector Signal Generation with SSB Technique using Duo-Binary Modulation. Duo-binary modulation reduces the bandwidth and certain phenomena that lead to intersymbol interference (ISI). Second approach is the Optical Vector Signal Generation with SSB Technique using EDFA. The SSB technique using EDFA doesn't require any polarization controllers because EDFA is independent of polarization sensitivity. Third approach is the generation of optical vector signals with VSB modulation. The use of the VSB technique allows the reduction of the channel spacing by filtering the transmission pass band to reject either the upper or lower sideband. The resulting partial carrier suppression leads to narrower signal bandwidth and, hence, to a higher spectral efficiency. The VSB technique also reduces the crosstalk between adjacent channels.

Keywords: - oDSB, oSSB, oVSB, Vector signal generation, Duo-binary, OPTSIM Software.

1 Introduction

Several modulation techniques were used to generate optical vector signal. The DSBCS modulation [1] has been demonstrated to be effective in the millimeter-wave range with excellent spectral efficiency and superior receiver sensitivity following transmission over a long distance.

The use of the vestigial sideband (VSB) and single side band (SSB) [2] technique leads to narrower signal bandwidth and, hence, to a higher spectral efficiency.

2 Problem Formulation

DSB modulation approach suffers from inferior sensitivity because the optical modulation index is limited & undergoes performance fading [5] due to fiber dispersion. Moreover, for DSB, the bandwidth requirement, power consumption & cost are high.

Although DSBCS modulation has excellent spectral efficiency and superior receiver sensitivity, it cannot generate vector modulation formats, such as phase-shift keying (PSK), quadrature amplitude modulation (QAM), or orthogonal frequency division multiplexing (OFDM) signals, which are of utmost importance in wireless applications [1].

SSB technique using SOA suffers from the polarization sensitivity problem which needs polarization controllers to overcome it.

3 Problem Solution

The following methods provide a novel modulation approach for generating optical vector signals:

3.1 Optical Vector Signal Generation with SSB Technique using Duo-Binary Modulation

Duo-binary modulation reduces the bandwidth and certain phenomena that lead to intersymbol interference (ISI) [3].

The duo-binary modulation is an amplitude modulation case but here the bit stream is manipulated to reduce the bandwidth and certain phenomena that lead to intersymbol interference (ISI).

By modulating the phase of the one bit in a specific way, duo binary modulation produces a narrower spectrum compared to NRZ. ISI distortion is also reduced since bit patterns such as 101 are transmitted with the ones carrying an opposite phase.

In the Duo binary modulation the main lobe of optical spectrum is narrower than that of the NRZ signal, and side lobes are drastically suppressed [3] as shown in Fig.1.

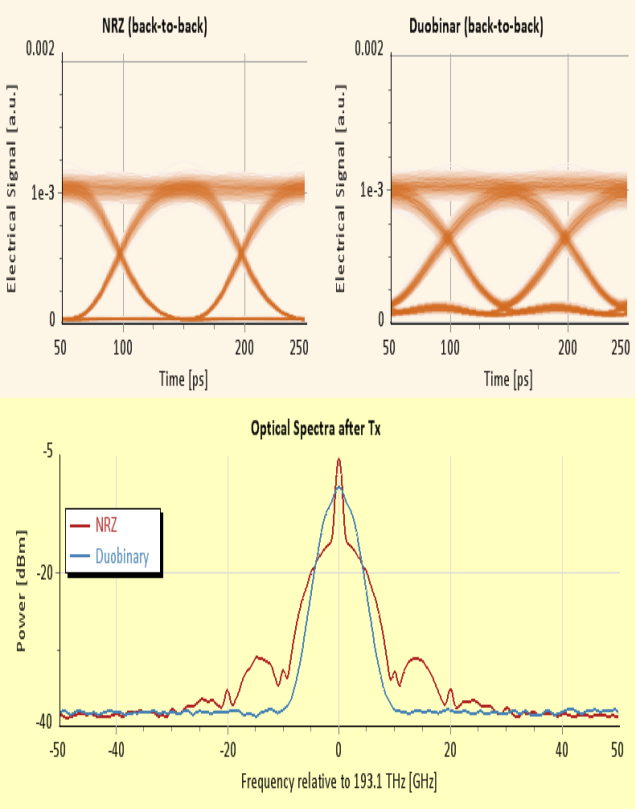

Fig. 1: Comparison of NRZ with Duo binary

The experimental set up is shown in Fig.2.

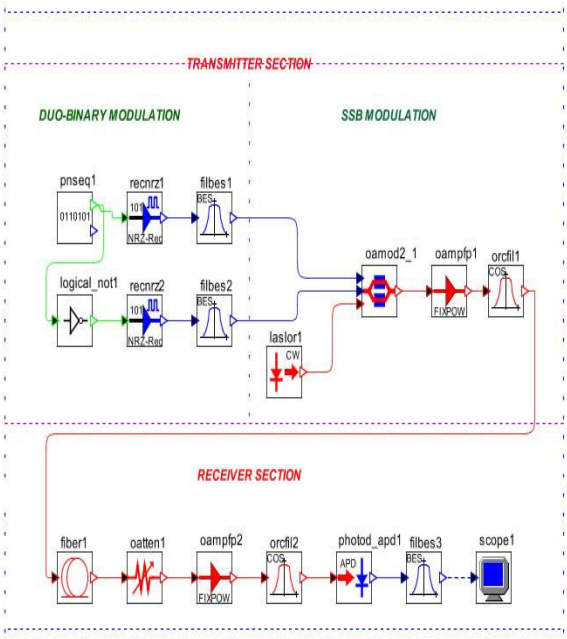

Fig. 2: Experimental setup

The data bit stream is modulated using Duo-Binary modulation & is applied to amplitude modulator $\sin^2$.This modulator converts electrical duo-binary modulated signals into optical DSB signals. The Fig.3 shows the eye diagram of Duo binary sample at I/P Bessel filter1. The oDSB signal is generated with an amplitude modulator. A raised cosine optical filter (OF1) is used at the optical amplifier output to produce the oSSB signal. This O/P is transmitted via a SMF fiber. The resultant signal is detected by a pre-amplified receiver section.

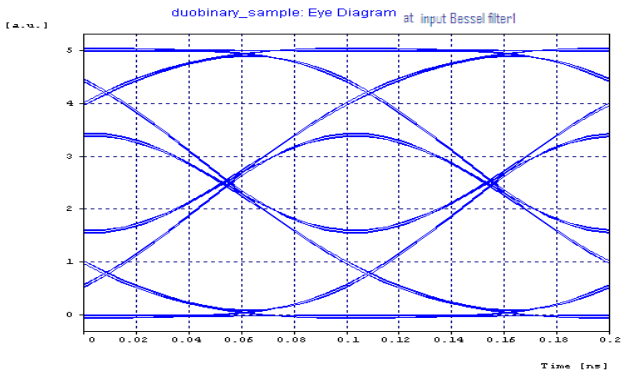

Fig. 3: Eye diagram of I/P Bessel filter1

The electrical signal at O/P Bessel filter highlights the PM-AM conversion as shown in Fig.4.

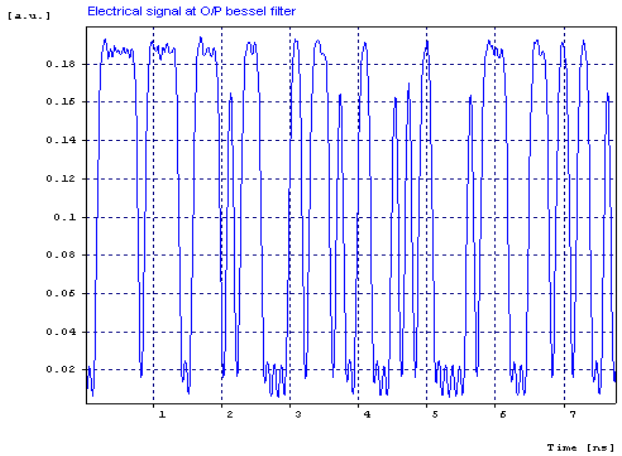

Fig. 4: Electrical Signal at O/P Bessel filter

The electrical spectrum at O/P Bessel filter highlights the Optical Vector Signal Generation with SSB Technique using Duo-Binary Modulation as shown in Fig.5.

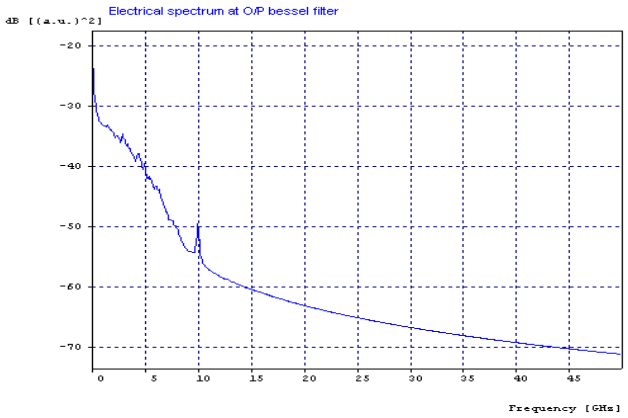

Fig. 5: Electrical Spectrum at O/P Bessel filter

3.2 Optical Vector Signal Generation with SSB Technique using EDFA

The SSB technique using EDFA doesn't require any polarization controllers because EDFA is independent of polarization sensitivity. The experimental setup of Fig. 6 is employed to convert an oDSB signal in to oSSB signal. This set up is similar to the set up shown in fig.2, except that NRZ modulation is used instead of duo-binary modulation. An optical filter (OF2) which is used to reduce the amplified spontaneous emission (ASE) noise spectral bandwidth.

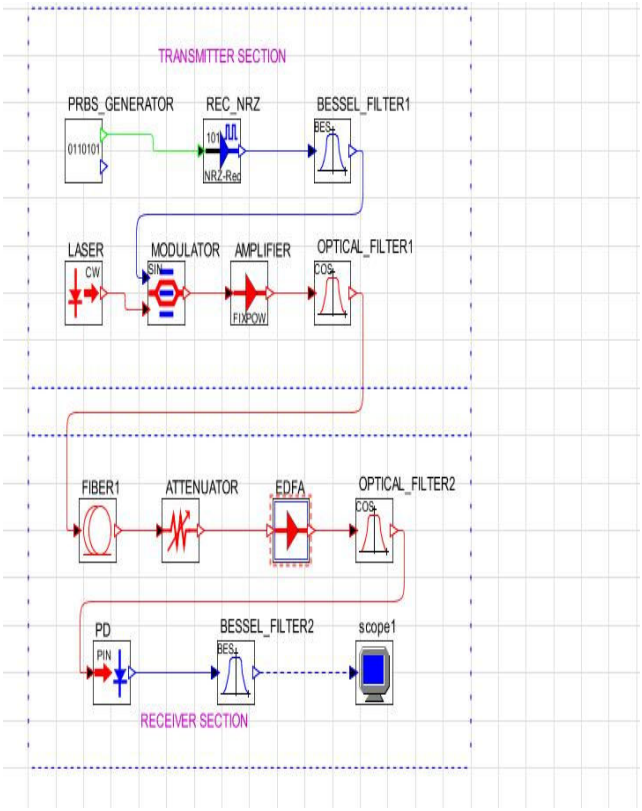

Fig. 6: Experimental setup

The Fig.7 shows that the optical spectrum of EDFA contains amplified spontaneous emission (ASE) noise which is removed by OF2.

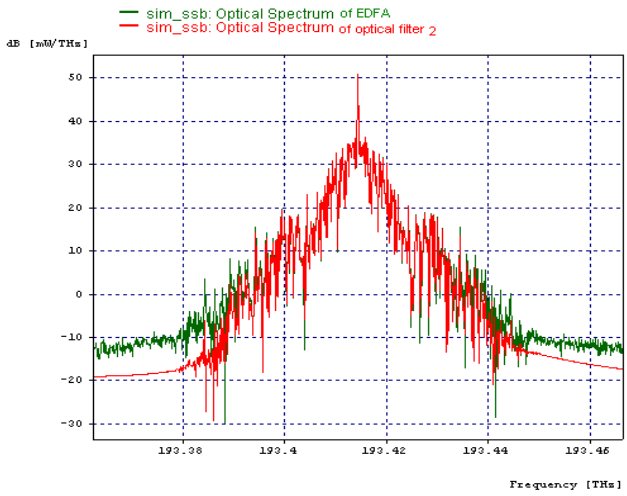

Fig. 7: Optical Spectrum of EDFA & optical filter2

The electrical spectrum at O/P Bessel filter highlights the Optical Vector Signal Generation with SSB Technique Using EDFA as shown in Fig.8.

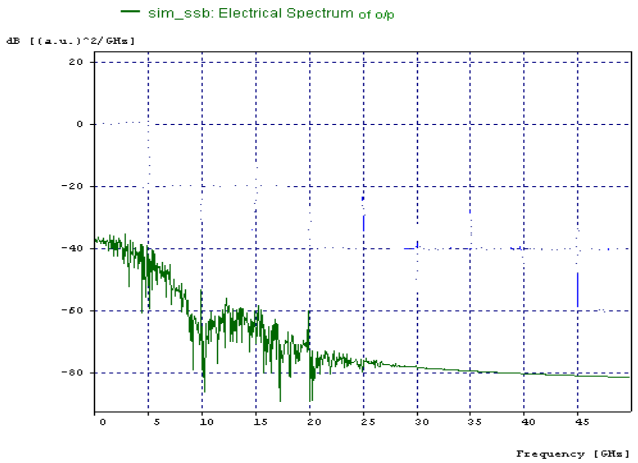

Fig.8: Electrical Spectrum of O/P Bessel filter

It was realized that this system has provided low bandwidth requirement & low power consumption.

3.3 Optical Vector Signal Generation with VSB Modulation Technique by means of Self Phase Modulation

An all-optical method based on self phase modulation (SPM) non-linear effect to convert oDSB signals to the oVSB format is proposed. Here, SPM effect is produced to obtain VSB without using SOA. Experimental set up is similar to the set up shown in fig.6 except that the optical filter properties are varied to get a VSB O/P.

The use of the VSB technique [4] allows the reduction of the channel spacing by filtering the transmission pass band to reject either the upper or lower sideband.

4 Conclusion

An all optical method to generate the optical vector signal was realized using various approaches.

In the first approach the optical vector signal was generated with SSB Technique using Duo-Binary Modulation. Duo-binary modulation has reduced the bandwidth and certain phenomena that led to intersymbol interference (ISI).

In the second approach the optical vector signal was generated with SSB Technique using EDFA. The SSB technique using EDFA doesn't require any polarization controllers because EDFA is independent of polarization sensitivity.

In the third approach the optical vector signal was generated with VSB modulation. The use of the VSB technique has allowed the reduction of the channel spacing by filtering the transmission pass band to reject either the upper or lower sideband. The resulting partial carrier suppression has led to narrower signal bandwidth and, hence, to a higher spectral efficiency. The VSB technique has also reduced the crosstalk between adjacent channels.

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