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STUDY OF PHASE SENSITIVE AMPLIFIER (PSA) CHARACTERISTIC FOR 80 GBIT/S DPSK DATA INPUT SIGNAL

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ABSTRACT

Simulation of phase sensitive amplifier (PSA) of differential phase shift keying (DPSK) data signal in dual pump is presented. The PSA is designed and simulated using OptiSystem software. A non-degenerate dual pump PSA of 80Gbit/s DPSK data signal is investigated in details on its gain and noise figure. Based on the results obtained, the gain is better, which lead to less noise, when the wavelengths are increased.

Keywords: Dual pump ・Gain ・ Noise figure

INTRODUCTION

The past decade has seen the rapid development of phase sensitive amplifier (PSA) in many designed to fulfill the increasing demand in communication. Generally, PSA is an interesting amplifier, but at the same time it is also impractical to implement.

PSA is a interesting remarkably powerful tool if carry out with a correct design - it allows amplification with a noise figure lower than quantum mechanics normally determine, and also allows the development of systems that clearly process the phase of their optical inputs (Da Ros et al. 2014) (Kakande 2012). PSA recently used to amplify signals in a certain phase. It can remove accumulated phase jitter, which is a critical function for an all-optical phase shift keyed network, and suppress the noise induced phase jitter.

However, PSA is considered impractical to implement as it requires precise phase-locking between the signal and the pump to get the stable low noise amplification. It is also not applicable to broadband transmission. However, Z. Tang et. al come out with the idea to overcome this issues by using non-degenerate PSA (Tong et al. 2012).

Previous studies have reported that, a PSA only amplifies the in-phase component and deamplifies the quadrature phase component, while a phase insensitive amplifier (PIA) such as an EDFA amplifies two orthogonal quadrature phase components equally (Asobe et al. 2012). Compared to PIA, PSA saturated input signal power is lower and the maximum attenuation still unaffected (Joseph Kakande et al. 2010).

PSA can be built using nonlinear media, such as highly nonlinear fiber (HNLF) (Malik et al. 2014), (André A. et. al 2015), silicon waveguides (Albuquerque et al. 2015), semiconductor optical amplifier and periodically poled lithium niobate (PPLN) (Albuquerque et al. 2015). Nonetheless, most researchers are tend to use HNLF as the nonlinear media in PSA (Marhic et al. 2015).

This paper shows simulation work in OptiSystem software that used dual pump insteed of the single pump. Dual pump can avoid idler spectral broadening due to pump modulation if the pumps are counter phase modulated, as well as requiring lower peak pump powers reducing susceptibility to stimulated Brillouin scattering (SBS). In this simulation, we investigate the gain and the noise figure when 80Gbit/s DPSK data signal was injected.

NON-DEGENERATE DUAL PUMP

Non-degenerate dual pump scheme has the potential for WDM regeneration but requires three waves phase-locked with the signal. The PSA scheme considered in this work is based on the dual-pump degenerate FWM in fibers where the two pumps and the signal have the same polarization state. The conceptual scheme of this amplifier is shown in Figure 1. In the same figure, the pump amplitude and phase noise effect on parametric gain is highlighted as well (Bogris et al. 2010). Under this condition, the idler coincides with the signal, and their interaction becomes dependent on the input signal phase (McKinstrie & Radic 2004).

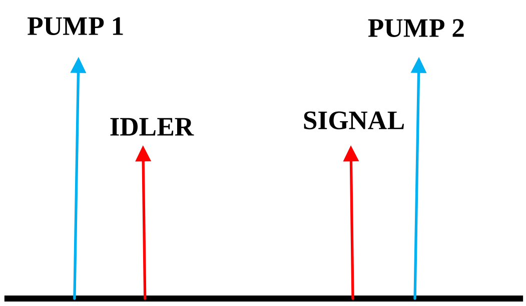

Figure 1: Non-Interferometric Fiber Based PSA (Non-Degenerate Dual Pump)

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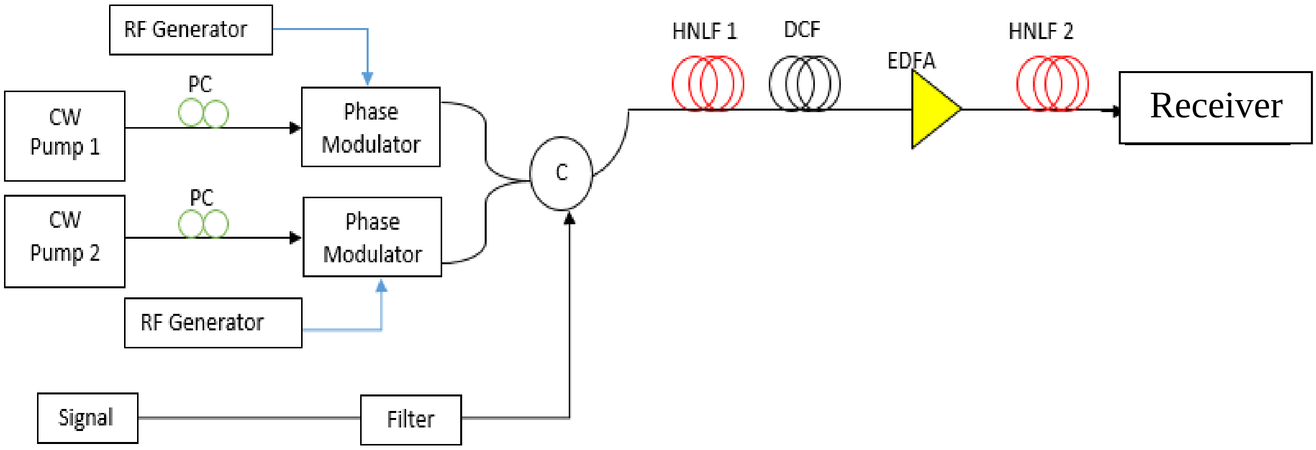

Figure 2: Phase Sensitive Amplifier Simulation Design, CW – tuneable laser source, PC – Polarisation Controller, PM – Phase Modulation

NOISE FIGURE

Noise figure (NF) for PSA can obtaine from:

$$NF = \frac{1}{G} + \frac{P_{in}\,(S_{out} - S_{in})}{2h\nu I_{out}^{2}} \quad (1)$$

P_{in} is the input signal power, S_{out} and S_{in} are the noise power spectral density measured at the input and output of the amplifier, respectively, and I_{out} is the detected output signal photocurrent (Tong et al. 2010).

SIMULATION SETUP

The configuration of simulation setup showed in Figure 2. Using two tuneable laser as pump connect to the phase modulator to suppress the SBS. These two pump are connected using 3 dB pump attenuation coupler and amplifier to provide pump at 1540 and 1560 nm.

The pump was phase modulated with three RF frequency, 100MHz, 300 MHz, and 600 MHz. All RF frequency are choosen outside the range of amplitude modulation frequency imposed on the pump. It is because in order to not impact the result. Circulator was used to combine the signal and pumps. It is nonreciprocal multiport passive that direct light sequentially from port to port in one direction.

The dual pump and signal were launched into a highly nonlinear fiber, HNLF 1, to generate an idler, which is phase locked to the signal and pumps. The HNLF 1 act as Phase Insensitive Amplifier (PIA) was 0.4 km long using 0.8 ps/nm^2/km. Then its followed by Dispersion Compensating Fiber (DCF) 0.4km long, act as balancing between HNLF1 and HNLF2. Polarizer was connected between DCF and HNLF2 to ensure that alignment of polarization is similar. Erbium Doped Fiber Amplifier (EDFA) is use to boost the signal from DCF. The amplified signal then connected to the HNLF 2 was 0.4 km long.

RESULT AND ANALYSIS

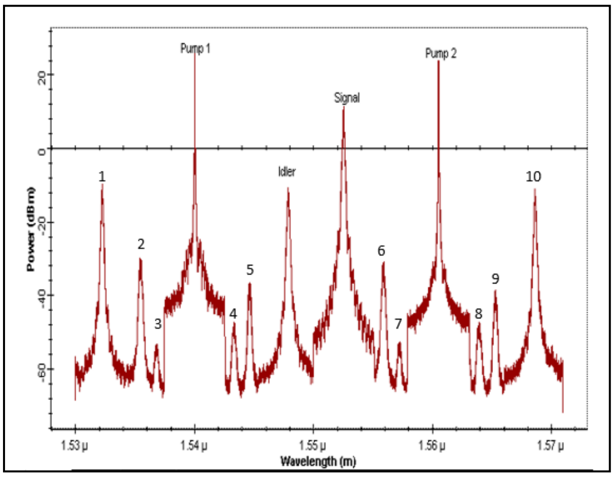

Figure 3: Output Specta for dual pump PSA

Figure 3 show the output spectral of this simulation. It show that the combination between signal and two pump after passes through HNLF 1. The degraded data signals are applied as the pump in the FWM processes. The input signal is parametrically amplified by the strong pump and a phase conjugate new idler field is generated in the process. The pumps are combined with the signal and delivered to a length of highly nonlinear fiber (HNLF) and idler is typically generated at frequency. All idlers act as wavelength shifted replica of the signal and exhibit much less noise compared with the signal. It also show sidebands labelled 1-10 that produce or generated at HNLF 2. This sideband will become larger then the signal and it can affect the amount of signal attenuation achievable by adding noise to the signal. This sideband can remove by using low gain operation (J. Kakande et al. 2010).

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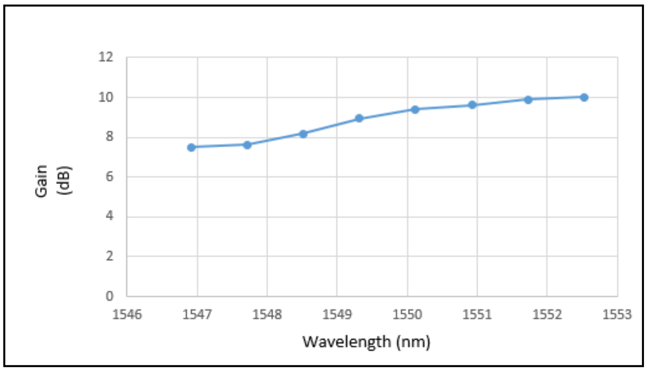

Figure 4: PSA gain for dual pump at 1540 nm and 1560.5 nm using 20 dBm power pump.

Figure 4 show the obtained gain achieve of 80Gbit/s DPSK signals in a non-degenerate dual pump PSA. Once can be observed that the frequency increase and the gain also increase. Gain is variation at different channel. The gain became better which lead to less noise. Frequency at 1552.52 or 193.1 THz produced higher gain while frequency 1547.72 nm or 193.7 THz produced lowest gain; it is 10.00919 dB and 7.518379 dB respectively.

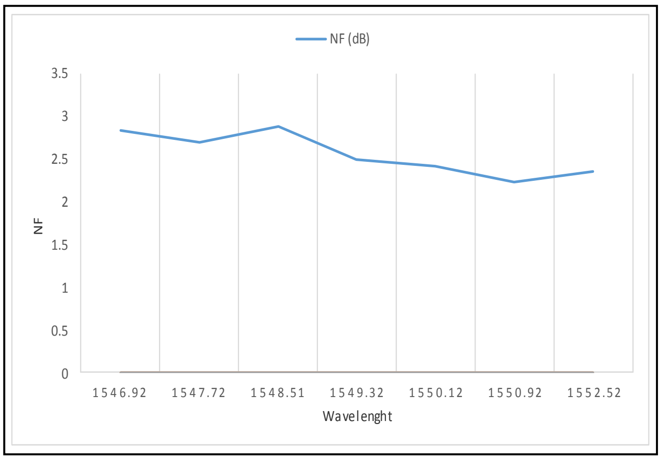

Figure 5: Noise Figure PSA for dual pump at 1540 nm and 1560.5 nm using 20 dBm power pump.

Figure 5 show the noise figure for PSA. It show that the noise figure is fluctuated and still below 3dB. It is prove that PSA noise figure lower than quantum mechanics PIA.

CONCLUSION

In conclusion, this simulation has proposed the PSA dual pump design. By using 80 Gbits/s Differential Phase Shift Keying (DPSK) data signal, it achieved the increasing gain due to increasing wavelength. The noise figure of this simulation setup closer to 0 dB.

ACKNOWLEDGEMENT

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