Modeling of Polarization Insensitive Phase Sensitive Amplifier for Phase Regeneration

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Abstract

This thesis describes a novel configuration which implements a polarization insensitive phase sensitive fiber optic parametric amplifier for phase regeneration. The proposed design can be used to address the inherent gain degradation issue in a polarization insensitive phase sensitive amplifier when polarization diversity loop is incorporated. This research investigates the possibilities for a significant gain enhancement when the polarization diversity loop is implemented.

At first, a baseline for a phase sensitive amplifier scheme is developed by taking different parameters into consideration. In this case, an extensive characterization is carried out to identify the variations of phase sensitive fiber amplifier gain associated with the parameter changes. Once the baseline is developed, the polarization diversity loop is implemented in the phase sensitive amplifier in order to make the phase sensitive fiber amplifier insensitive to polarization state variations of the input signals. Moreover, the existing issues in the polarization diversity loop are identified.

Finally, a strategic design is developed to overcome one of the major issues that persists in the existing polarization diversity loop configurations. It is the degradation of maximum achievable gain due to not being able to utilize the total pump power for parametric amplification process as only half of the pump power is available after polarization splitting at the input of the loop. The proposed design includes the concatenation of fiber pieces together to explore the possibility of gain enhancement of the diversity loop. To assess the performance of the proposed design, an extensive analysis is carried out. The gain enhancement introduced to the existing system is presented and suggestions are made for further improvements in the future.

Index terms— FOPA, PSA, FWM, polarization diversity, cascaded fiber

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D.R.Munasinghe

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List of Abbreviations

Abbreviation	Description
WDM	Wavelength Division Multiplexing
DFA	Doped Fiber Amplifier
EDFA	Erbium Doped Fiber Amplifier
SOA	Semiconductor Optical Amplifier
OEO	Optical-to-Electrical-to-Optical
ASE	Amplified Spontaneous Emission
SNR	Signal to Noise Ratio
SRS	Stimulated Raman Scattering
FOPA	Fiber Optic Parametric Amplifier
FWM	Four Wave Mixing
HNLF	Highly Nonlinear Fiber
PI-FOPA	Phase Insensitive Fiber Optical Parametric Amplifier
PS-FOPA	Phase Sensitive Fiber Optical Parametric Amplifier
PIA	Phase Insensitive Amplifier
PSA	Phase Sensitive Amplifier
M-QAM	M-ary Quadrature Amplitude Modulation
M-PSK	M-ary Phase Shift Keying
NF	Noise Figure
SOP	State of Polarozation
PMD	Polarization Mode Dispersion
PDM	Polarization Dependent Modulation
PDL	Polarization Dependent Loss
PDG	Polarization Dependent Gain
BER	Bit Error Rate
SBS	Stimulated Brillouin Scattering
SPM	Self Phase Modulation
XPM	Cross Phase Modulation

CME	Coupled Mode Equation
NLSE	Nonlinear Shrödinger Equation
GVD	Group Velocity Dispersion
ZDF	Zero Dispersion Frequency
ZDW	Zero Dispersion Wavelength
NOLM	Nonlinear Optical Loop Mirror
PM-HNLF	Polarization Maintaining Highly Nonlinear Fiber
PBS	Polarization Beam Splitter
PBC	Polarization Beam Combiner
DSF	Dispersion Shifted Fiber
PC	Polarization Controller
PRBS	Pseudo Random Bit Sequence
QPM	Quasi-Phase Matching
PS-FBG	Phase Shifted-Fiber Bragg Grating
GER	Gain Extinction Ratio
SSFM	Split Step Fourier Method
DCF	Dispersion Compensating Fiber
HPL	Half Passed Loop
OSNR	Optical Signal to Noise Ratio
OSA	Optical spectrum analyzer
OBSF	Optical Band Stop Filter
OBPF	Optical Band Pass Filter
FSK	Frequency Shift Keying
BPSK	Binary Phase Shift Keying
QPSK	Quadrature Phase Shift Keying
MI	Modulational Instability
FPU	Fermi-Pasta-Ulam recurrence