Optik - International Journal for Light and Electron Optics 176 (2019) 357–365

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.com/locate/ijleo

Original research article

Performance analysis of CSRZ-DQPSK transmitter configurations for SBS tolerance in single mode fiber link

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ARTICLE INFO

Keywords:
Passive optical network (PON)
CSRZ-DQPSK (carrier suppressed return to zero- differential quadrature phase shift keying)
DD-MZM (Dual Drive Mach Zehnder Modulator)
Non linearity
Stimulated brillouin scattering SBS

ABSTRACT

This paper investigates the SBS tolerance of two reduced complexity Carrier Suppressed Return to Zero- Differential Quadrature Phase Shift Keying (CSRZ-DQPSK) transmitter configurations and comparison with conventional 3 MZM scheme is reported. One scheme utilizes a single DD-MZM (Dual Drive Mach Zehnder Modulator) and a MZM (Mach Zehnder Modulator). Another configuration uses a single DD-MZM (Dual Drive Mach Zehnder Modulator). The link performance is evaluated for 10 Gbps data rate in a 50 Km single mode fiber link. From the simulation results, it is observed that two and one MZM based configurations provide 3 dB improvement in SBS threshold compared to the standard three MZM based implementation. Also, the performance of 2 MZM is slightly better than the single MZM configuration. As the input power is increased beyond SBS threshold, the roll off of Q- Factor is found to be 0.3/dBm for 3 MZM scheme where it is 0.05/dBm and 0.1/dBm for the 2 MZM and 1 MZM schemes. The BER performance is better at higher power levels, for the one and two MZM cases.

1. Introduction

Recent research in optical communication aims to increase the capacity of the fiber link to satisfy the requirements of today's broadband applications. Many approaches for the implementation of cost effective, large bandwidth transmission systems have been attempted. Development of wideband optical transmitters with less complexity along with efficient modulation schemes is one approach. The most reliable modulation scheme for such an application is Carrier Suppressed Return to Zero- Differential Quadrature Phase Shift Keying (CSRZ-DQPSK) format. It provides better dispersion tolerance, robust towards non linearities and improves the spectral efficiency in high bit rate systems. Network providers are replacing traditional LANs (Local Area Networks) by PONs (Passive Optical Network) to serve large numbers of users with improved bandwidth. PON system uses Single Mode Fiber (SMF) along with a passive splitter that splits the downstream signals to many users. In the Upstream, the passive splitter acts as a combiner to connect all users to the same shared PON port. In the case of SMF over long lengths and at higher optical input powers, non linear effects have to be necessarily considered in the design of lightwave systems [1].

Optical sources with high power levels and narrow spectral distributions are required for the high capacity optical networks. However, Stimulated Brillouin Scattering (SBS) is a non linearity that restricts the amount of power launched into the fiber. It arises due to non linear interaction between the pump and the stokes fields through an acoustic wave. It backscatters the light signal by acoustic waves in the optical fiber. The transmitted power at the fiber output saturates at SBS threshold and barely increases with increasing input power. Further, it induces fluctuations in received optical power and increases photo detector noise. Hence it

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https://doi.org/10.1016/j.ijleo.2018.09.112
Received 4 July 2018; Received in revised form 16 September 2018; Accepted 19 September 2018

Table 1
Simulation Parameters.

S.No	Parameters	Values
1	Bit rate	2.5 and 10 Gbps
2	Wavelength	1550 nm
3	Laser Line width	10 MHz
4	Fiber Length (L)	50 km
5	Fiber Attenuation (α)	0.25 dB/km
6	Fiber Dispersion	17 ps/nm/km
7	Fiber Effective Area (A_{eff})	80 μm^2
8	Non linearity Refractive Index (n_2)	2.6e-20 m^2/W
9	Brillouin Gain	5e-011 m/W
10	Brillouin Linewidth	100 MHz
11	Frequency Shift	11 GHz

degrades the Q factor and consequently the bit error rate of an optical fiber link. This leads to careful design for maintaining appropriate power levels in optical systems with long fiber length. The system impairments due to SBS are discussed in detail in literature [2].

Hadjifotiou and Hill [3] have reported the suppression of Stimulated Brillouin scattering using Phase Shift Keying (PSK) at 1320 nm. They have carried out experiments to initiate SBS, suppress it and studied the effect of coding. They observed a linear relation between the input power and the forward power since SBS threshold depends on the signal statistics.

Similarly Ref. [4,5] also has reported the influence of SBS on Phase modulated signals in the optical fibers. Also, they have simulated the suppression of SBS with an increased bit rate.

The input power limitation due to SBS was experimentally studied by Yasuhiro et al. [6], for ASK, FSK and PSK Signals. It is observed that the PSK modulated wave has a SBS threshold which is 2.5 times the threshold of an unmodulated CW wave.

In [7,8], the authors have experimentally investigated the optical noise induced by SBS in single mode fiber. The noise is caused by the random nature of spontaneous Brillouin scattering induced in the transmitted wave as well as in the reflected Brillouin wave (anti stokes signal).

Jone M Genie et al. [9] have simulated the impact of non linear effects, phase noise and chromatic dispersion on a 10 Gbps optical differential quadrature phase shift keying system. It is inferred that the limiting factor is the phase noise, even for very low linewidth.

It is understood that CSRZ modulation formats can provide better tolerance to non-linearity and dispersion in optical fibers. It is normally implemented with standard 3 MZM based transmitters. However, cost effective But cost effective and simple means of transmitter implementation may deviate from standard performance. Hence, it becomes necessary to investigate the non linearity and dispersion tolerance in the case of simple and cost effective implementation of CSRZ transmitters.

In this paper, we investigate the SBS tolerance of two cost effective 10 Gbps CSRZ-DQPSK transmitter schemes. The SBS threshold

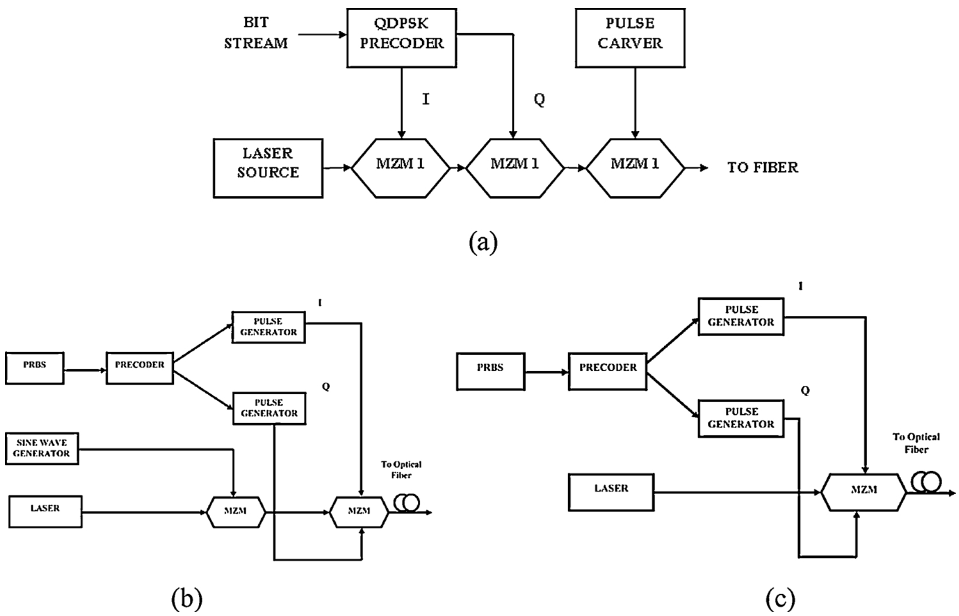

Fig. 1. Transmitter Configuration for CSRZ-DQPSK Format (a) Three MZM Based Transmitter. (a) Two MZM Based Transmitter (c) Single DDMZM Based Transmitter.