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The transmission of symmetric 40 Gb/s TWDM-based NG-PON2 utilizing delay interferometer (DI) for RSOA bandwidth enhancement

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ABSTRACT

Time and wavelength-division multiplexed passive optical network (TWDM-PON) has been finally selected as the pragmatic solution for the next-generation passive optical network stage 2 (NG-PON2). In this paper, we propose a symmetric 40 Gb/s TWDM-PON system with low cost reflective semiconductor optical amplifier (RSOA) for both downstream and upstream directions. A single bi-pass delay interferometer (DI), deployed in the optical line terminal (OLT), is used to enhance the poor performance of the RSOA with respect to the low bandwidth induced by laser chirp. With the help of the 40 GHz free spectrum range (FSR) DI, we show a successful transmission of the proposed work through simulation study where an aggregate capacity of 40 Gb/s is transported over 40 km transmission distance with 32 splits. The TWDM-PON system at BER of 10^{-6} has shown a minimum receiver sensitivity of −22.78 dBm and −22.71 dBm for both downstream and upstream, respectively with maximum power penalty of 2 dB for downstream channel and 2.39 dB for upstream channel.

1. Introduction

The increasing demand for new service applications such as HD video, high-quality internet protocol TV (IPTV) and online gaming alongside the rapid traffic growth has led to a surge in the user bandwidth requirement [1]. It seems that the current deployment of gigabit-class passive optical network (PON) that solves the bandwidth limitation of previous wired technology such as copper and coaxial cable will face a bandwidth bottleneck. This leads to the call to upgrade the existing TDM-PON where among the earliest proposals is the first stage next generation-PON (NG-PON1) that has been standardized by the ITU-T and IEEE [2].

Later, proposals for the second stage Next generation PON (NG-PON2) were brought out as extension of NG-PON1 to support higher bandwidth and data rate, mainly due to the explosive growth of internet based services. NG-PON2 based on (ITU-T G.989.1) requires at least 40 Gb/s that supports minimum splitting ratio of 64 and longer passive reach of 60 km to support business and mobile front-haul/back-haul service applications [3,4]. Its goal is to improve the first stage of NG-PON by providing higher data rate and longer distance at competitive cost.

The NG-PON2 candidates are well known in the literature such as 40 Gb/s TDM-PON, wavelength division multiplex-PON (WDM-PON), time wavelength division multiplexing-PON (TWDM-PON), and orthogonal frequency division multiplexing-PON (OFDM-PON) [5,6]. However, most of these NG-PON2 players are not suitable for practical deployment as some do not adhere to the NG-PON2 requirements i.e. backward compatibility, minimum 40 Gb/s data transmission, low cost, and stacked architecture. For example, WDM-PON does not support backward compatibility because it requires wavelength selective optical distribution networks (ODNs) while components of OFDM-PON are still immature which leads to higher cost. Among them, TWDM-PON is the candidate that adheres to all the requirements of NG-PON2 and has been selected as the best enabling technology for NG-PON2 by the full service access network (FSAN) [7].

As for TWDM-PON itself, several variants have been proposed that differ in terms of power budget. A TWDM-PON prototype with non-symmetric 40/10 Gb/s downstream and upstream transmission has been demonstrated using four pairs of stacked wavelengths [8]. Meanwhile, a symmetric 40 Gb/s TWDM-PON was presented in [9] to improve the capacity of the upstream colorless source by changing the position of tunable filter. In addition, a

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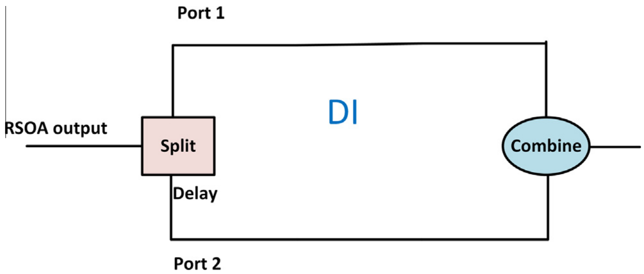

Fig. 1. Schematic of an optical delay interferometer (DI).

reflective semiconductor optical amplifier (RSOA) is used at the ONU to improve the downstream signal's sensitivity. The use of RSOA has also been reported for the application in directly modulated fiber ring laser as the upstream laser source alongside a tunable optical filter (TOF), demonstrated in the upstream multi-wavelength shared (UMWS) TDM-PON environment. The baseline configuration was demonstrated in a bidirectional transmission at data rates of 10 and 1.25 Gbs for downstream and upstream directions, respectively over 25 km transmission distances without any change to the ODN deployed [10]. However, the modulation bandwidth of RSOA is limited by the carrier lifetime in the active layer and typically ranges between 2 and 3.5 GHz. Therefore, it is challenging to accommodate 10 Gb/s signals with this severely limited band device.

This paper proposes a low cost and simple architecture for a symmetric 40 Gb/s TWDM-PON system employing RSOAs for both downstream and upstream links that are equipped with DI techniques. DI is used to overcome the limitation of low RSOA bandwidth signal when the initial phase of DI is adjusted to be 180° so that this can result in an optimum offset between the laser

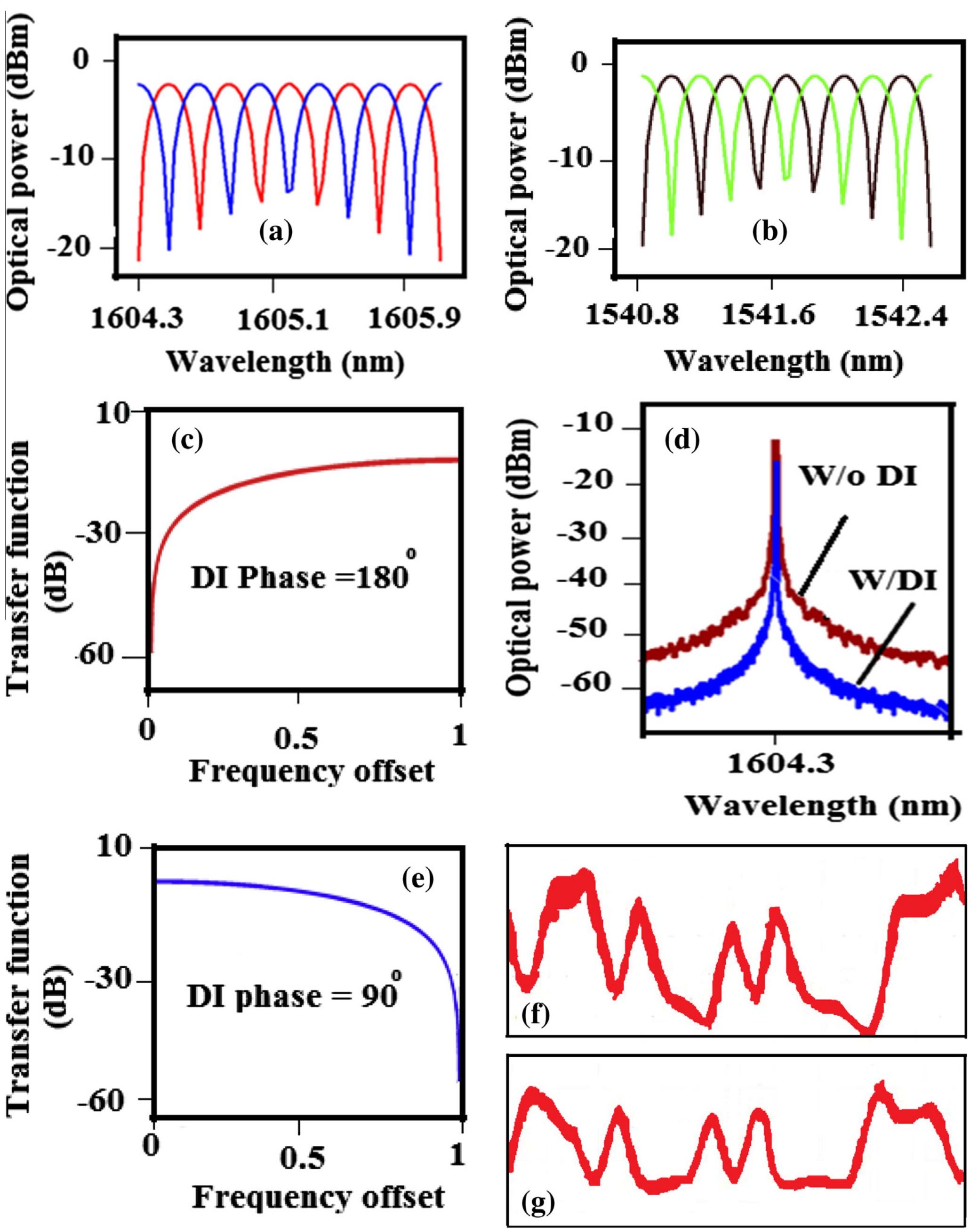

Fig. 2. (a) Downstream transmission DI curves, (b) upstream transmission DI curves, (c) DI phase at 180° as HPF, (d) frequency offset for input DI signal and output DI signal, (e) DI phase at 90° as LPF, (f) and (g) are the captured waveforms after 40 km SMF transmission without and with DI.