Full-duplex Wavelength Interleaved DWDM Hybrid Access Radio-over-fiber System

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Abstract

The paper demonstrate a simplified full-duplex wavelength interleaved (WI)-DWDM hybrid access radio-over-fiber (ROF) system for providing 2 GB/s wired and 1 GB/s wireless downlink and 1 GB/s uplink data data simultaneously. Here we use only one arrayed waveguide grating device to realize both the demultiplexing and multiplexing functions. Because of using only the subcarriers of the single channel to carry both the wired and wireless data, we do not need extra optical components such as interleaver to separate them at the base stations. The experimental results demonstrate that this scheme is feasible and has good transmission performance for the future WI-DWDM hybrid access ROF system.

***Keywords**: radio–over-fiber (ROF); arrayed waveguide grating (AWG); wavelength interleaving (WI); full-duplex.*

Introduction

Radio over Fiber (RoF) refers to a technology whereby light is modulated by a radio signal and transmitted over an optical fiber link to facilitate wireless access, such as 3G and WiFi simultaneous from the same antenna.[1] In other words, radio signals are carried over fiber optic cable. Thus, a single antenna can receive any and all radio signals (3G, Wifi, cell, etc..) carried over a single fiber cable to a central location where equipment then converts the signals; this is opposed to the traditional way where each protocol type (3G, WiFi, cell) requires separate equipment at the location of the antenna. In RF-over-Fiber architecture, a data-carrying RF (Radio Frequency) signal with a high frequency (usually greater than 10 GHz) is imposed on a lightwave signal before being transported over the optical link. Therefore, wireless signals are optically distributed to base stations directly at high frequencies and converted from the optical to electrical domain at the base stations before being amplified and radiated by an antenna. As a result, no frequency up/down conversion is required at the various base stations, thereby resulting in simple and rather cost-effective implementation is enabled at the base stations.

The 60GHZ radio–over-fiber (ROF) system, because of its high throughput, high bandwidth and low loss, attracts more and more attentions recently. Since the user's requirements continue to increase, a hybrid access ROF system that is able to provide wired and wireless services simultaneously is desirable. ROF systems adopting wavelength interleaved (WI) DWDM technology makes the utilization of bandwidth resources more efficient and the corresponding system more competitive.

Experimental Setup

At the central office (CO), three light carriers with frequencies of 193.02THz, 193.06THz, and 193.1THz enerated by the CW laser array are combined by an ideal MUX component. Their frequency space is 40GHz. Then they are modulated by 30GHz sinusoidal wave using a MZM biased at the half-wave voltage in order to generate 60GHz OCS optical millimeter-wave. Because of the WI characteristic, the bandwidth efficiency of our scheme is improved effectively. A 20/40 IL1 is followed to separate the two side-bands of every WDM channels. In order to improve the performance of the received wired and wireless signals, IL2 and IL3 are followed at the odd and even output ports of IL1 respectively to filter out the undesired side-bands. The right side-bands (S1R, S2R, S3R) outputting from the even port of IL are then IM by 1Gb/s data using a single-arm MZM for providing wireless service.

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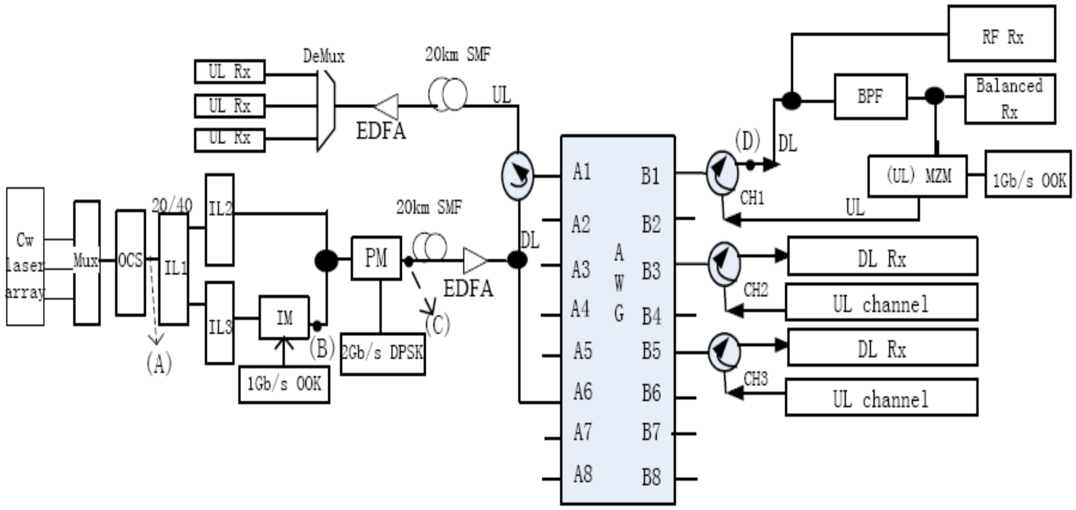

Above figure shows the experimental setup

Then the modulated right side-bands are combined with the un-modulated left side-bands (S1L, S2L, S3L) outputting from the odd port by a 3-dB optical coupler. In order to provide wired service, the recombined carriers are fed into an optical phase modulators to carry the 2Gb/s DPSK data signal. Then the obtained WI-DWDM signals which carries the wireless and wired hybrid data are traveled down along 20km single mode fiber (SMF) link. At the RN, the dispersion impairment is compensated for by ~4km dispersion compensating fiber (DCF) and the loss impairment is compensated for by an Erbium-doped fiber amplifier (EDFA) with the gain ~20dB.

A bidirectional AWG model with 8 ports, 20-GHz channel space, 3dB insertion loss, is followed as the MUX/DEMUX component at the RN. The downlink signals are equally split by a 3-dB coupler and then injected into AWG via port A1 and A6. According to the I/O characteristic of 8 port AWG, thethree left side-band (S1L, S2L, S3L) signals input to port A1 are output to the odd number output ports B1, B3, B5, and the right side-band (S1R, S2R, S3R) signals input to port A6 are also distributed to the output ports B1, B3, B5, respectively. Then all of three channels (Ch1, Ch2, and Ch3) are demultiplexed. The Ch1 (S1L, S1R) signal output from the port B1 is routed to the BS and equally split into two parts for the wired and wireless services without using narrowband filtering or IL. For wireless access, the OOK signals are directly detected by a photodiode and down-converted to baseband data by mixing process and low-pass filtering in the RF receiver. For wired access, the DPSK signals are recovered by passing through a BPF, with the same center frequency as that of the wired subcarriers. Then it is sent to balanced receiver to demodulate the wired signals. The Ch2 (S2L, S2R) and Ch3 (S3L, S3R) signals are also demodulated at the corresponding BS. Both the recovered wired and wireless data are sent to the bit error rate (BER) analyzer to evaluate the system performance. For the uplink data transmission, we adopt the wavelength reuse technique to reduce the complexity and cost of BSs. In our scheme, the DL left side-bands (S1L S2L S3L) are remodulated by 1Gb/s OOK UL data at one MZM device. After passing through an optical delay line, the three modulated UL channels are routed to the AWG via input port B1, B3, B5, respectively. According to the I/O characteristic of AWG, they are output at the same port A1, and then transmitted over a 20km SMF to CO. At the CO, the three UL channels carried OOK data are demultiplexed, and then sent to the PD for O/E conversion and BER analyzer for evaluating their performance.

Experimental Results

The optical spectrum at the point A is shown in the fig .1.The obtained carrier to signal ratio is 26 dB.The optical spectrum of signals modulated by 1G/s wireless OOK data at the B point and that modulated by 2G/s wired DPSK data at the C point are shown in Fig. 2and Fig. 3. Fig. 4 shows the optical spectrum of DL demultiplexed Ch1 signals at the D.

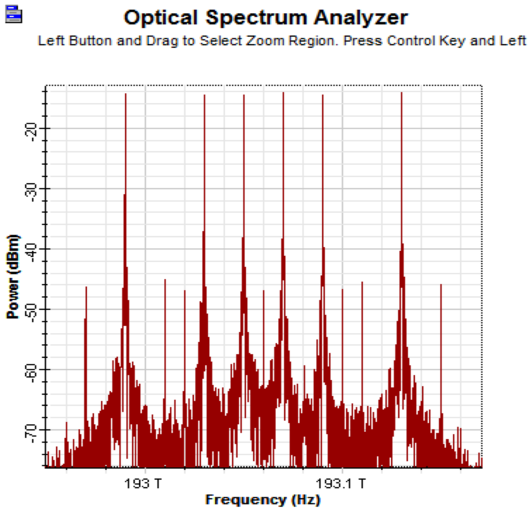

Fig. 1 Optical spectrum of the WI-DWDM OCS signals

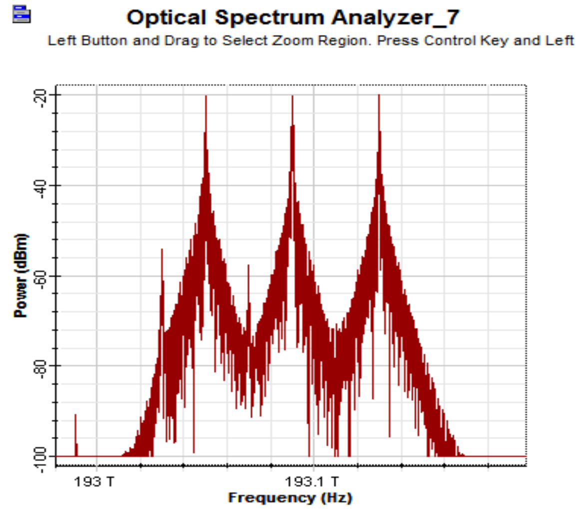

Fig.2 Optical spectrum of signals carried the DL wireless OOK data.

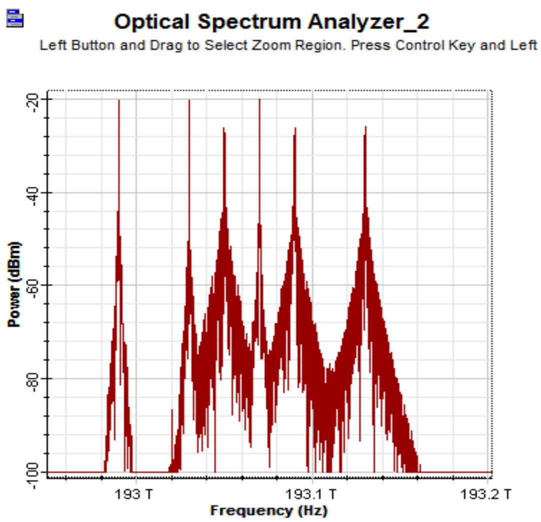

Fig.3 Optical spectrum of signals carried the DL wired DPSK data

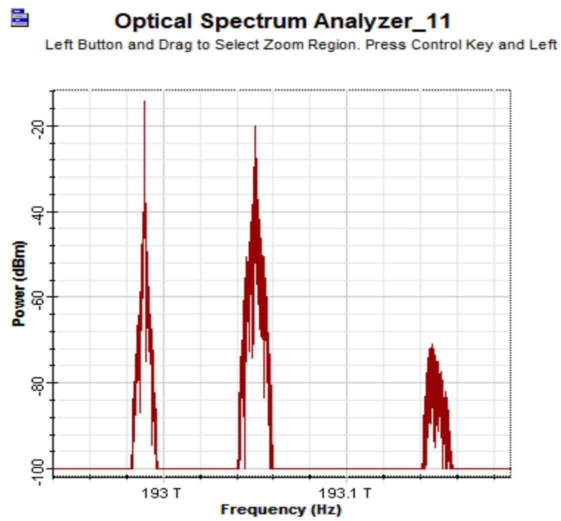

Fig.4 Optical spectrum of the DL demultiplexed Ch1 signals

CONCLUSION

The system demonstrate a full-duplex wavelength interleaved hybrid access radio-over-fiber (ROF) system for providing 2 GB/s wired and 1 GB/s wireless downlink and 1 GB/s uplink data data simultaneously. It uses only one AWG for transmission. The experimental results demonstrate that this scheme is feasible and has good transmission performance WI-DWDM hybrid access Radio-Over-Fiber system.

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