Suppression of Mixing Spurs

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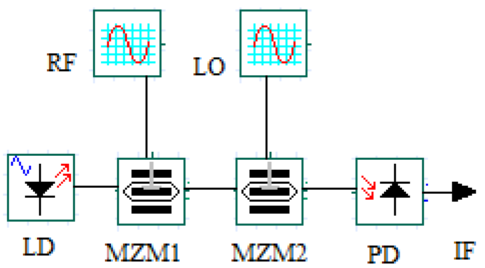
ABSTRACT
Microwave Photonic mixer is proposed and its major critical problem i.e. spurious signals are suppressed using various optical components. These optical components are either added or removed from the system to get the desired outputs. The outputs of both optical and electrical analyzers are also measured.

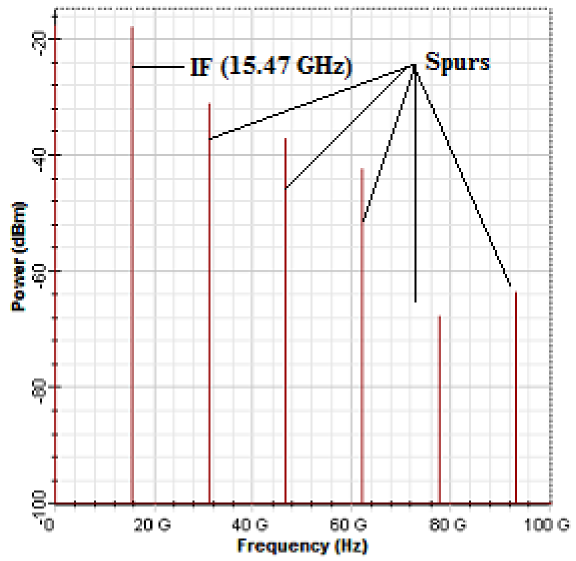
Keywords
Microwave photonic mixer, spurious signals Mach-Zehnder modulator

1. INTRODUCTION
Due to broadband, low loss and high isolation properties of photonics, photonics based microwave mixer is used to down-convert radio frequency (RF) signal to intermediate frequency (IF) signal. Both RF and local oscillator (LO) signals are mixed in the microwave photonic mixer to produce IF signal at the output [1]. Frequency range of the RF signal is 3GHZ to 300GHz. Along with the IF signal some spurious signals are seen at the output of the system. These spurious signals (spurs) arise when LO and RF harmonics are produced at the output. Such signals are not desired at the output of any system. As compared to the conventional mixer the microwave photonic mixer is able to suppress the spurs. These spurs are the unwanted signals which arise because of the complicated components used in the system. Tang et al. [3] developed a frequency down-converter using single dual drive Mach-Zhender modulator (DMZM) to produce an IF signal by biasing the modulator at minimum transmission point. Z. Tang and S. Pan [4] investigated that by using a dual port Mach-Zhender modulator (DPMZM) either LSB or USB RF signal is obtained according to the order of the input signals i.e. IF and LO signal. In this paper, methods and spectra's are measured and discussed to understand the spurious signals (spurs) suppression.

2. MICROWAVE PHOTONIC MIXER
The fig. 1 (a) shows the basic microwave photonic mixer. It consist of a laser-diode which acts as a light source, two Mach Zhender modulators (MZM1 and MZM2), a photo-diode which is used convert the optical signal to an electrical signal. Sinusoidal RF and LO signals are applied to the MZM1 and MZM2 respectively.



(a)



(b)

Fig. 1 (a) Microwave photonic mixer, LD: laser diode; MZM: Mach-Zehnder modulator; PD: photo-detector (b) electrical spectra of IF signal at the output

The frequency of the RF signal is 15.52 GHz and LO signal is 15.56 GHz [2]. An IF signal between frequency 15.4 GHz and 15.7 GHz is obtained. Along with the IF signal some spurious signals (spurs) are also seen at the output.

The graph between power and frequency is shown in fig. 1 (b). The unit of power is dBm and frequency is GHz. The unwanted signals can be referred as spurs. To suppress these spurs some optical components should be added or removed to get the desired output.

3. MPM WITH SUPPRESSION OF RF AND LO SPURS
The RF & LO signals are given to the dual drive Mach Zehnder modulator (DMZM) as shown in fig. 2 and produces IF at the output because of the 180 degree biasing given to DMZM. But by providing 90 degree biasing to the DMZM we get both RF & LO signals at the output. To suppress the RF and LO spurs as compared to the basic MPM here we use DMZM instead of cascaded MZM's [3]. Some new components are also being added like polarization controller (PC), erbium doped fiber amplifier (EDFA). RF & LO signals are given to the DMZM by a 2*2 combiner.

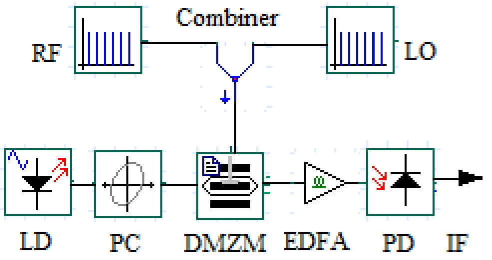
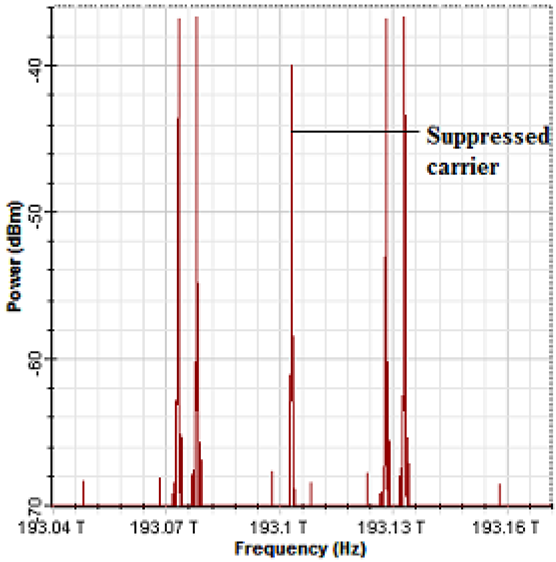
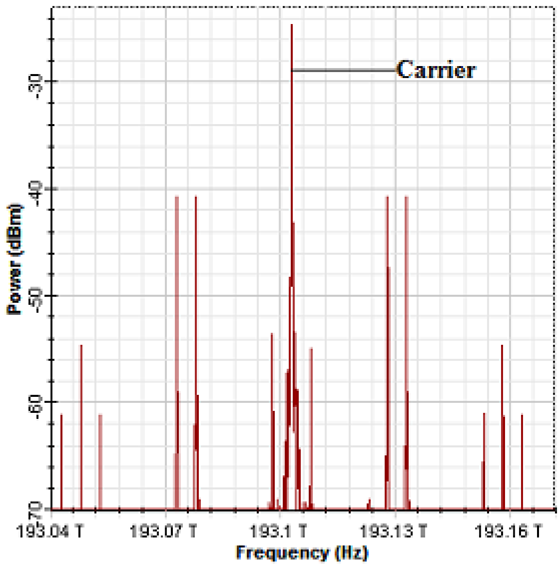


Fig. 2 Diagram of MPM suppressing RF & LO spurs, DMZM: dual Mach-Zehnder modulator; PC: polarization controller; EDFA: erbium doped fiber amplifier

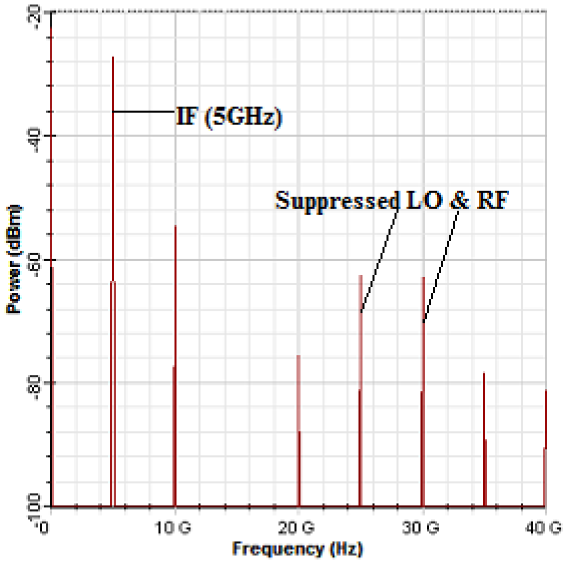


(a)

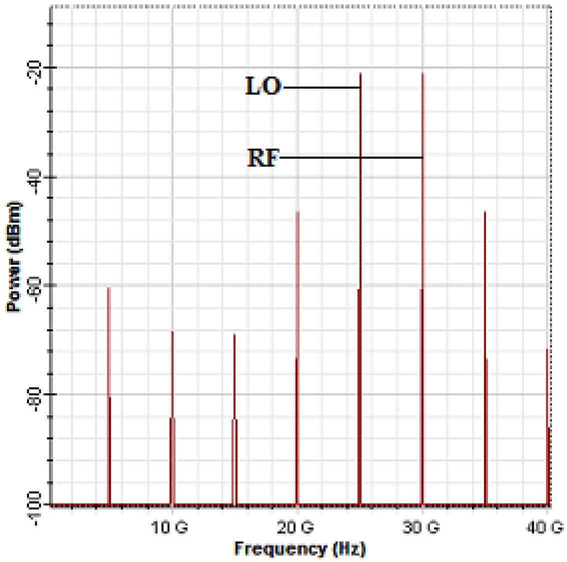


(b)

The RF spectrum analyzer is used to show the output after the photo-detector. It shows that the biasing has a very important role in modulators. As can be seen from the fig. 3 (a), (b), (c) and (d) if biasing is of 180 degree then IF signal is obtained and if it is of 90 degree then RF & LO signals are there at the output. IF signal at the output photo-detector is obtained at frequency 5GHz when 180° biasing is there and RF and LO signals at frequencies 30 and 25 GHz are obtained when there is 90° biasing. The power of signal is less at 180° biasing and more at 90° biasing.



(c)

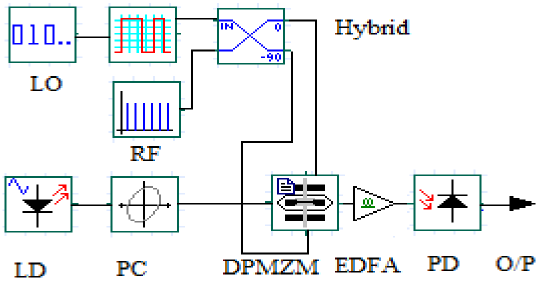


(d)

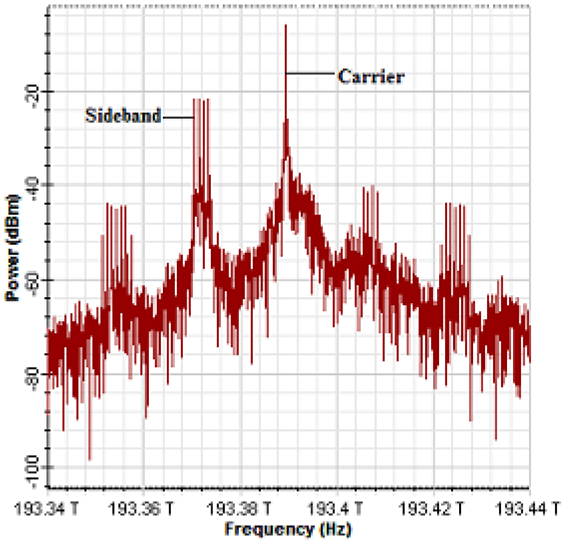
Fig. 3 Optical spectra and electrical spectra of output signal with (a), (c) 180° biasing and (b), (d) 90° biasing

4. MPM WITH SUPPRESSION OF SIDEBAND SPURS

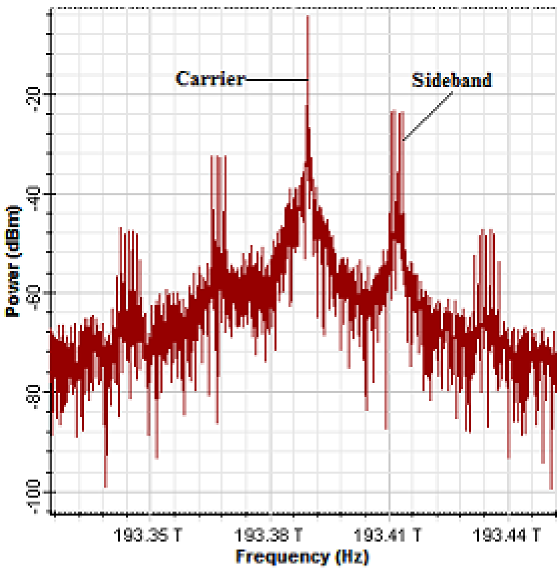
Sidebands are the unused bands which are not needed with the required output. To suppress these sidebands RF & LO signals are given to the dual port Mach-Zehnder modulator via 90 degree hybrid coupler as shown in fig. 4 (a). This coupler will give lower sidebands (LSB) or upper sidebands (USB) according to the required output.



(a)



(b)



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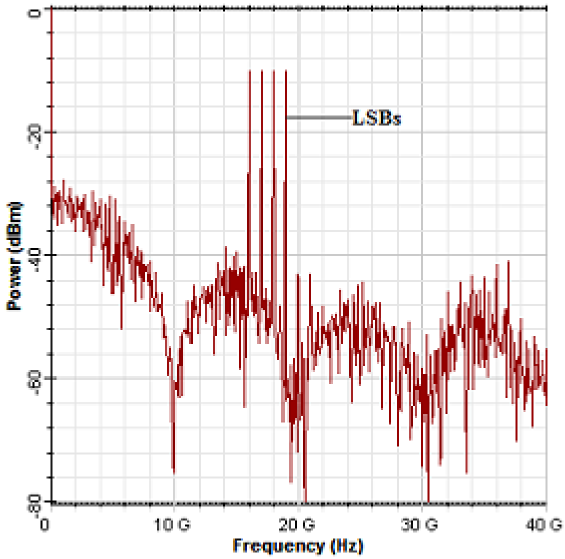

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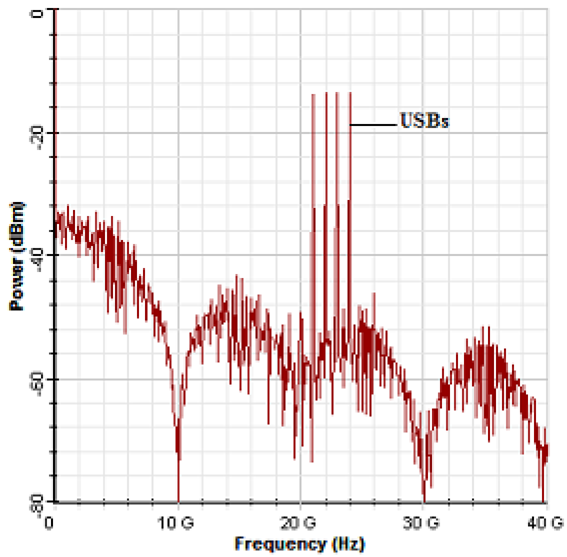


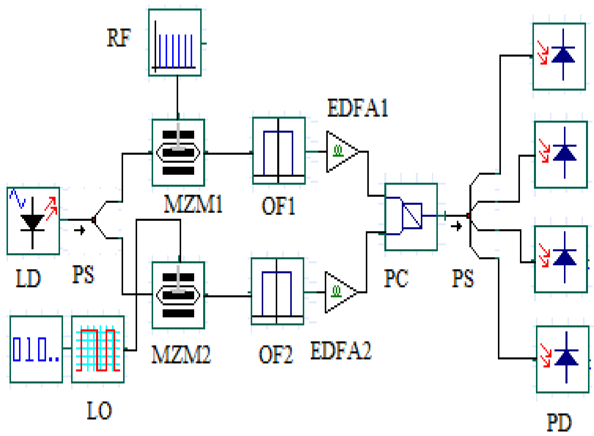
(e)

Fig. 4 (a) Diagram of MPM suppressing sideband spurs, DPMZM: dual port Mach-Zehnder modulator with optical spectra at (b) LSB and (c) USB modes and electrical spectra of output signal at (d) LSB and (e) USB modes

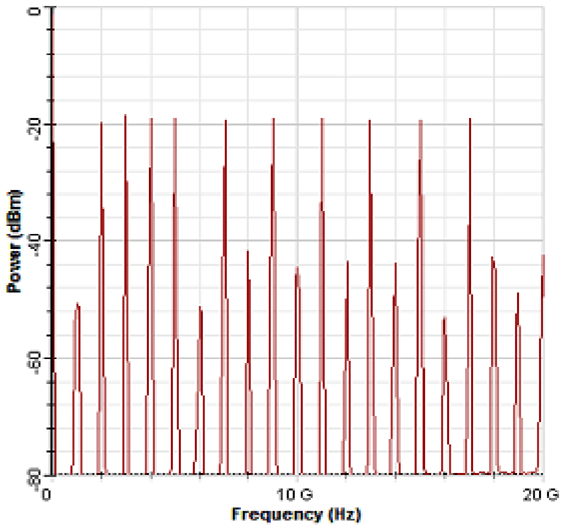
The fig. 4 (b), (c), (d) and (e) shows the outputs of spectrum analyzer when DPMZM is working in USB or LSB mode. Four LSB's and Four USB's are obtained at the output. The LSB's are at frequencies between 16 GHz to 20 GHz and USB's are at frequencies between 21 GHz to 24 GHz. The optical spectrum of LSB is in decreasing order and that of USB is in increasing order [4].

5. MPM WITH SUPPRESSION OF HARMONIC SPURS

To suppress harmonic spurs optical filters and hybrid are used after the MZM's. These spurs occurs when there are LO & RF harmonics in the system. The optical splitter split light into two cascaded MZM's. The RF signal is given to MZM1 and LO is given to MZM2 which are further connected to rectangular optical filters which filter outs the undesired harmonics in the system. The electrical analyzer's spectrum is shown in fig. 5 (b) when input is in wide range of frequency.



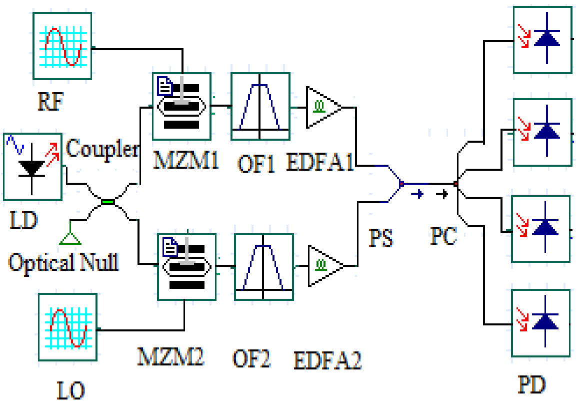
(a)



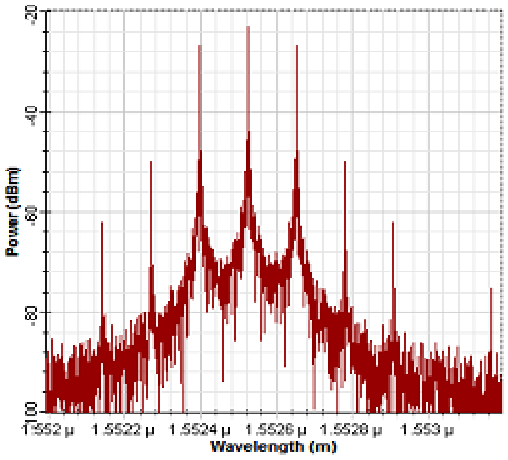
(b)

Fig. 5 (a) Diagram of MPM suppressing harmonic spurs with wide range of frequency, PS: power splitter; OF: optical filter; PC: polarization combiner (b) electrical spectra at the output

When sinusoidal input is given to the two MZM's as shown in fig. 6 (a), an IF signal at frequency nearly 2 GHz is obtained. This means as compared to the previous system no wide range of frequencies are at the outputs. Here trapezoidal filter is used instead of rectangular filter and light source is given to both MZM1 and MZM2 through coupler. RF signal is at 18 GHz and LO signal is at 15.93 GHz frequency. The light source is at 1552.5 nm and responsivity of photo-detector is 0.85.



(a)



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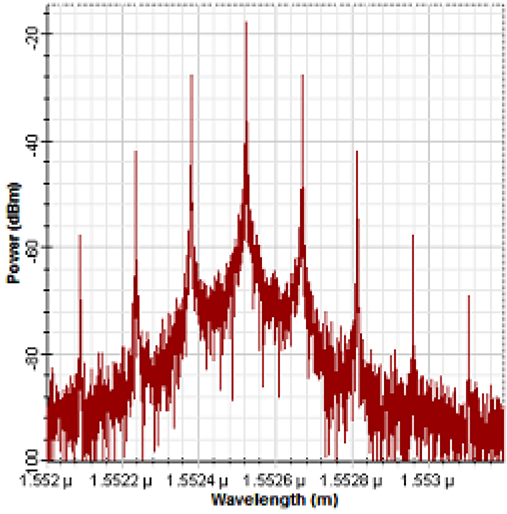

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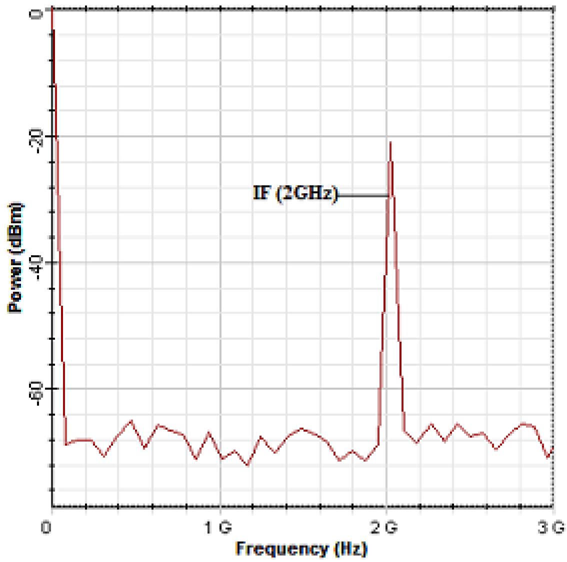

(d)

Fig. 6 (a) MPM with sinusoidal input, PC: power combiner (b) optical spectra of MZM2 and (c) MZM1 (d) electrical spectra of output signal

In fig. 6 (d) IF signal of frequency 2 GHz is obtained at the output [5].

6. CONCLUSION

Microwave photonic mixer with suppressed mixing spurs is demonstrated using different techniques. The useless sidebands are removed and desired bands are produced at the outputs using those techniques.

7. REFERENCES

[1] Z. Tang and S. Pan, "Microwave photonic mixer with suppression of mixing spurs" in Proc. 14th Int. Conf. Optical Commun. Netw. (ICOCN), 2015, pp. 1-3.

[2] G. K. Gopalakrishnan, W. K. Burns, and C. H. Bulmer, "Microwave optical mixing in $LiNbO_3$ modulators " IEEE Trans. Microwave Theory Tech. , vol. 41, no. 12, pp. 2383-2391, Dec. 1993.

[3] Z. Z. Tang, F.Z. Zhang, D. Zhu, X. H. Zou, and S. L. Pan, "A photonic frequency down-converter based on single dual drive Mach-Zehnder modulator" in the MWP 2013, paper W4-8, 2013.

[4] Z. Tang and S. Pan, "A filter free photonic microwave single sideband mixer" IEEE Microwave Theory and Technique Society, vol. 26, pp. 67-69, Dec. 2015.

[5] Z. Z. Tang and S. L. Pan, "A reconfigurable photonic microwave mixer" in the MWP 2014, pp. 343-345, 2014.

[6] A. J. Seeds, "Microwave photonics," IEEE Transactions on Microwave Theory and Techniques, vol. 50, no. 3, pp. 877-887, 2002.

[7] Jianping Yao, "A tutorial on microwave photonics," IEEE Photonics Society Newsletter, pp. 4-12, 2012.

[8] B. Hraimel, X. Zhang, Y. Pei, K. Wu, T. Liu, T. Xu and Q. Nie, "Optical single sideband modulation with tunable optical carrier to sideband ratio in radio over fiber systems," Journal of Lightwave Technology, vol. 29, no. 5, pp.775-781, 2011.

[9] Qi Zhou and Mable P. Fok, "Microwave photonic mixer based on polarization rotation and polarization dependent modulation," IEEE Photonics Technology Letters, vol. 27, no. 23, 2015.

[10] Sai Naing Min Htet, "Generation of optical carrier suppressed signal for radio-over-fiber system using dual-drive Mach-Zehnder modulator," International Journal of Scientific and Research Publications, vol. 4, Issue. 9, 2014.

[11] E.H.W. Chan and R. A. Minasian, "Microwave photonic down-converter with high conversion efficiency," IEEE Journal of Lightwave Technology, vol. 30, no. 23, pp. 3580-3585, 2012.