PERFORMANCE OF A 40 GHZ RF PHOTONIC BALANCED LINK USING A POLARIZATION MODULATOR

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Introduction

Fiber optic links are commonly employed for high bandwidth applications. Analog RF photonic link applications often have critical sensitivity and linearity requirements, as such the noise figure (NF) and spurious free dynamic range (SFDR) are key performance parameters for these links. There has been considerable research dedicated to developing improved components and link designs to yield improvement in NF and SFDR. A single output intensity modulator based on an AlGaAs polarization modulation (PolM) design with half wave voltage $V_\pi \cong 3$ V at 1 GHz, 3 dB roll off at 40 GHz, and optical insertion loss ≅3 dB has been reported and is commercially available.[1,2] If the linear polarizer at the output of this device is replaced with a polarizing beam splitter (PBS), dual complementary outputs similar to a dual output Mach Zehnder modulator (MZM) are provided. This allows for an intensity modulated direct detection balanced link (IMDD-BL) design to be implemented which provides multi-octave operation and common mode suppression (CMS) of laser relative intensity noise (RIN) to improve the link NF.[3] Such a IMDD-BL using a PolM, a single fiber from transmitter to receiver, and the PBS preceded by a polarization controller located at the receiver has been demonstrated at 2 GHz showing common mode suppression of RIN similar to a link using a standard lithium niobate (LN) MZM.[4]

In this paper we report the RF gain and NF measured over 40 GHz bandwidth and SFDR over 24 GHz of an IMDD-BL based on a PolM with the PBS integrated into the modulator package. This design requires two fibers between the transmitter and receiver, but does not require a polarization controller at the receiver as in [4]. NF < 28 dB to 40 GHz is achieved. Initial data on link performance as a function of temperature is discussed.

Link Setup and Measurements

A schematic of the link design is shown in fig.1. The major components in the link are the PolM including the PBS, DFB laser diode (63 mW, RIN = -164 dB/Hz, λ = 1564.7 nm), and balanced photodetector (U^2T Photonics, responsivity = 0.58 A/W, 3 dB roll off at ≅40 GHz). A fixed DC modulator bias (V_b) was used in place of the bias controller (B.C.) shown in the figure for gain, NF, and SFDR measurements. Given the component parameters, optical power ≅10 mW measured at each detector, and 10 dB CMS of RIN, calculation of expected gain, NF, and SFDR are plotted (dotted curves) in fig. 2 and 3.

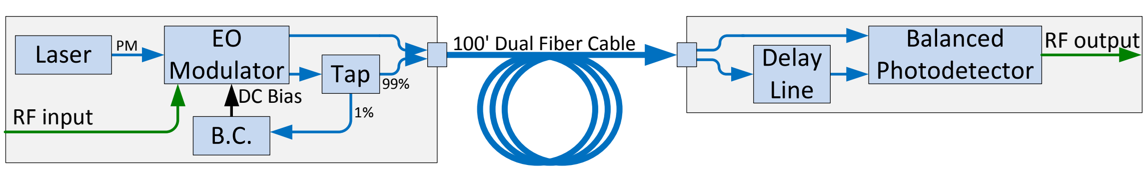

Figure 1. Schematic of the balanced link

RF gain was measured with an HP 8510 network analyzer. NF to 26.5 GHz was measured with an Agilent E4440A with NF personality. NF from 26.5 to 40 GHz was measured via measurement of the noise floor with a HP8565E preceded by a high gain LNA. RF gain (S_{21}) and NF measurements are plotted (solid curves) in fig. 2. Two-tone (spaced by 20 MHz) linearity was measured at several frequencies-- input third-order intercept point (IIP3) and 3rd order SFDR are plotted (solid curves) in fig. 3. The 2nd order SFDR was 96 dB-Hz$^{1/2}$ for the same V_b used for the data in fig. 2 and 3. A 0.4 V increase in V_b improved SFDR2 to >108 dB-Hz$^{1/2}$ while increasing the NF of the link by less than 0.7 dB.

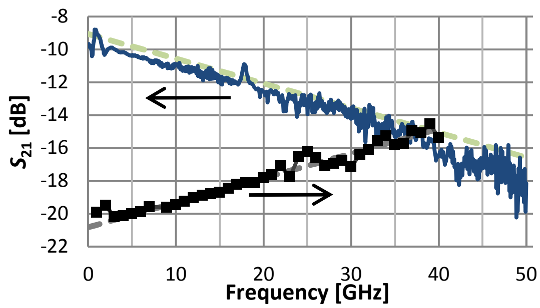

Figure 2. Measured and modeled S_{21} and NF

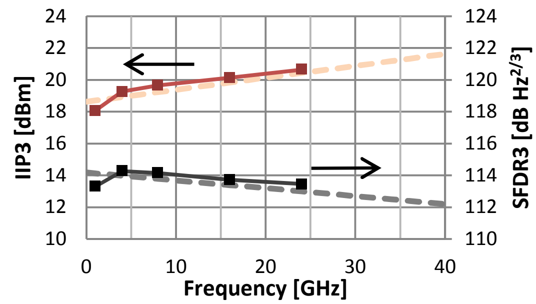

Figure 3. Measured and model linearity.

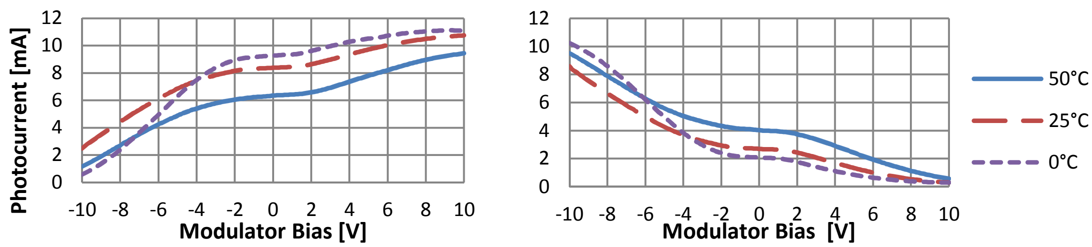

Figure 4. Photocurrent of each photodetector as a function of modulator V_b and temperature.

Operation over extended temperatures is of interest for avionics and other applications. Fig. 4 shows measured photocurrent at each detector as a function of modulator V_b and temperature with the optical power used in the link measurements. As shown in fig. 4, the operating point (i.e. equal power in both channels) varies with temperature. In contrast to a conventional LN MZM, the slope and curvature of the transfer function at the operating point also vary, suggesting the gain and linearity of the link are temperature dependent. Measurements using active dither based bias control as shown in fig. 1 were performed and resulted in 1.7 dB RF gain variation over 10^{o} C to 50^{o} C.

Conclusion

RF gain, NF and SFDR of an IMDD-BL based on a PolM with integrated PBS have been measured. The measured ~6 dB roll off in S_{21} from 0 to 40 GHz matched the expected roll-off based on modulator and detector specifications. NF = 22 dB at low frequency and NF < 28 dB up to 40 GHz were measured, also consistent with modeling. SFDR3 was >113 dB Hz$^{2/3}$ up to 24 GHz. Adjustment of V_b to maximize 2nd order SFDR resulted in a 0.7 dB increase in NF.

To our knowledge NF < 28 dB at 40 GHz for a multi-octave RF photonic link has not been reported previously. This is achieved with moderate optical power providing a low SWAP implementation. Temperature dependence of the modulator transfer function (fig. 4) may complicate the biasing scheme for this RF photonic link. Further results on NF and SFDR as function of V_b and on temperature dependent operation will be reported at the conference.

References

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