21 GHz Wideband Fiber Optic Link*

J. J. Pan

E-TEK DYNAMICS, INC.
Melbourne, Florida 32904

ABSTRACT

1.3 um, 1 Km wideband 21 GHz fiber optic link was demonstrated using the RF enhanced, phase-reverse velocities matched $LiNbO_3$ electro-optic modulator. System signal-to-noise ratio of 102 dB/Hz was achieved with minimum intermodulation products distortion.

INTRODUCTION

Growth of sophisticated satellite communications, electronic warfare, and radar systems, places increasing demands on microwave/millimeter-wave fiber optics for wide instantaneous bandwidth, immunity to EMI/EMP, deployment speed/simplicity, and low cost. The microwave fiber optic communications links using direct modu lated laser diode has limited operation bandwidth due to a wideband impedance matching problem. The frequency response of the laser diode is presently difficult exceeding 14 GHz, except driving at catas trophically high bias conditions.[1] The $LiNbO_3$ electro-optic modulator (EOM) has achieved a frequency response of 24 GHz at switching voltage of V_π of 10 to 11 Volts range[2] using coded electrode. In this paper we report a direct detecting, 1 Km, 21 GHz, 1.3 um fiber optic system using a veloity matched RF enhanced Mach-Zehnder EOM which has low V_π and wide bandwidth.

SYSTEM DESCRIPTION AND ERFORMANCE

The block diagram of the 21 GHz fiber optic link is depicted in Figure 1. The stabilized 1.3 um laser beam of 250 uW is modulated by a traveling-wave intensity EOM with a polarization control. A MESFET amplifier with a 1 dB compression of +20 dBm is employed to drive the EOM. Phase balance of the interferometric EOM branch es is achieved by the DC bias adjustment through a 26 GHz bias tee. 1 Km single- mode optical fiber terminated with a pair of demountable biconical connectors to link the opto-electronic transmitter and receiver. The receiver is fabricated
using a high frequency K-connector mounted InGaAs PIN photodetector with responsivity of approximately 0.4 A/W and a low noise MESFET small signal amplifier with noise figure of 5 dB. The 1 Km fiber optic link was tested from 6 to 22 GHz and had good wideband response. The measured input VSWR varies between 1.1:1 to 2.1:1 and output VSWR is 1.2:1. System signal-to- noise (SNR) measurement is better than 102 dB/Hz. Figure 2 illustrates a SNR mea surement at 21 GHz. Two-tone third-order intermodulation products (IMP) were measured, and no IMP observed. Figure 3 depicts the two-tone output at frequencies of 20.6 and 20.63 GHz without IMP. Extremely careful experimental setup was exercised ensuring no radiation pickup from signal generator.

WIDEBAND MICROWAVE EOM

The wideband EOM was fabricated on Z- cut, Y-propagated $LiNbO_3$ substrate using Titanium indiffusion. The 6 um wide, 500 Å Ti strip diffused into $LiNbO_3$ at temper ature of 1050°C for 6 hours to form Mach- Zehnder optical waveguide. Three layers of 2000 Å SiO_2, 500 Å Cr, and 1000 Å Au were deposited on top of the optical wave guide. Photolithographic technique was employed to generate RF power enhancment with phase-reverse velocities matched traveling-wave electrodes in the configu ration of asymmetrical coplanar waveguide. The impedance of the electrode was smooth ly tapered from 33 Ohms to 50 Ohms K- connector in order to obtain a good input VSWR. The measured insertion loss of the fiber to EOM to fiber without AR coating and matching fluid is 4 dB. The best measured V is approximately 4 Volts.

PRECISION ALIGNMENT AND PACKAGE

Precision interfaces are required to align 10/125 um single-mode fibers to 6 um optical waveguide of EOM and to the photo detector which has an active area of 20 um diameter. Etched on a single crystal Si substrate, the V-groove precisely guides the fibers for EOM interface coupling with the fine adjustments of two miniature micropositioners. V-groove parameters were optimized to minimize fiber to EOM coupling loss. Both the EOM and photo detector with connectorized fiber are firmly mounted on the base plates of the 17-inch rack mounted metallic chasis for minimum vibration effects.

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DISCUSSION AND CONCLUSION

In conclusion, 1.3 um, 1 Km wideband 21 GHz fiber optic link has demonstrated 102 dB/Hz system SNR and low IMPs. The preliminary experimental results indicate that 21 GHz and the future millimeter-wave fiber optic systems are viable and feasible. Link performance can be improved considerably when photodetector impedance matches to post-detector amplifier and laser diode output power increases. Furthermore, a 10 to 20 dB SNR improvement is conceivable when coherent optical detections replace the presently employed direct detection.[3]

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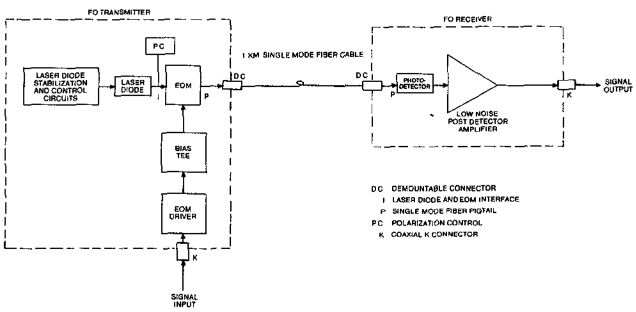

Figure 1 Block Diagram of 21 GHz Fiber Optic Link

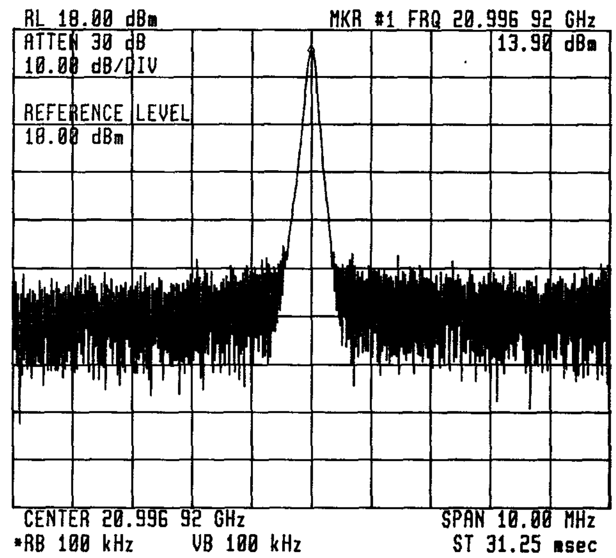

Figure 2 System Signal-to-Noise Measurement of 21 GHz Fiber Optic Link

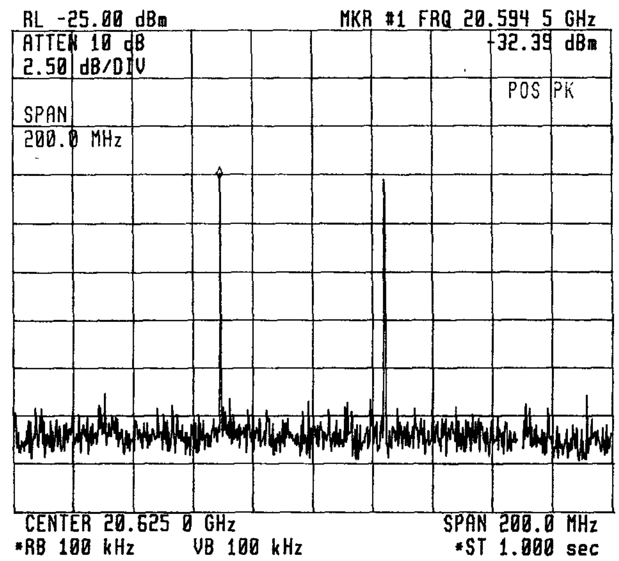

Figure 3 Two-Tone IMP Test of 21 GHz Fiber Optic Link