Millimeter-wave Optoelectronic Mixers based on InP HEMT

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Abstract — We investigate characteristics of InP HEMT optoelectronic mixers in 60GHz band. They provide mixing function with high internal conversion gain over the wide LO frequency range. Utilizing them, 622Mbps transmission is demonstrated in a fiber-supported 60GHz wireless system.

I. Introduction

Fiber-supported wireless systems have been of much interest because they utilize optical fiber as a low loss and flexible transmission medium. Indium phosphide high-electron mobility transistors (InP HEMTs) are useful devices for these applications because they can be utilized as optoelectronic mixers which perform photodetection of optically transmitted data and, simultaneously, frequency up-conversion into desired millimeter-wave band in a single device [1-2]. They are particularly attractive since millimeter-wave monolithic integrated circuits based on them can provide simplification in antenna base station architecture. High conversion gain and perfect isolation are additional benefits. In this paper, we present characteristics of millimeter-wave optoelectronic mixers based on InP HEMTs and demonstrate their applicability to fiber-supported 60GHz wireless systems.

II. InP HEMT Optoelectronic Mixer

Details of InP HEMT device used in our investigation can be found in [2]. We utilize the InP HEMT as a harmonic optoelectronic mixer which allows less stringent high frequency LO. Figure 1 shows the schematic diagram for the InP HEMT harmonic optoelectronic mixer and its spectrum at 60GHz band. When 30GHz LO is applied to the gate port and 100MHz optical IF signal is injected into the device, mixing products at $2f_{LO}+f_{IF}$ (60.1GHz), $2f_{LO}-f_{IF}$ (59.9GHz), and 2nd harmonic of LO at $2f_{LO}$ (60GHz) are clearly observed. In order to obtain the maximum mixing performance, gate-to-source bias conditions (V_{GS}) were optimized considering internal conversion gain, defined as the power ratio of optoelectronic mixing signal to the primary photodetected signal [3]. Figure 2 shows the results. It should be noted that the mixing products at $2f_{LO}+f_{IF}$ can be selectively enhanced at V_{GS} of -0.9V while suppressing other mixing components at $f_{LO}+f_{IF}$. At this condition, 17dB internal conversion gain was obtained.

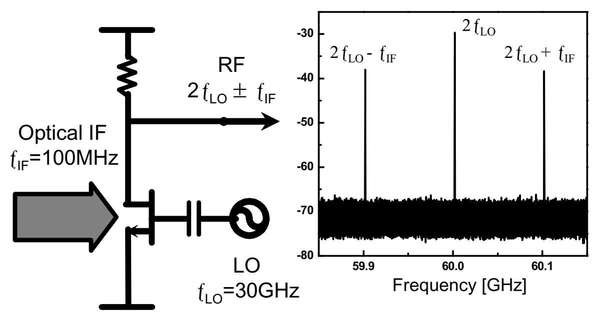

Fig. 1. InP HEMT as a harmonic optoelectronic mixer and its output spectrum at 60GHz band

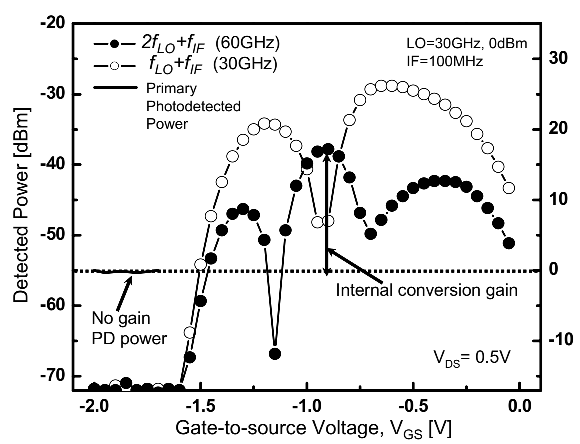

Fig. 2. Mixing products at $f_{LO}+f_{IF}$ and $2f_{LO}+f_{IF}$ as a function of V_{GS}. Solid line indicates primary photodetected power at f_{IF}.

LO pumping power determines the conversion efficiency in a frequency mixer. Figure 3-(A) shows the internal conversion gain at $2f_{LO}+f_{IF}$ as a function of LO pumping power. The LO power needed for positive internal conversion gain is about -7dBm. When LO power is higher than 6dBm, internal conversion gain begins to

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saturate. LO frequency range is also investigated for its uses at V-band. As observed in Fig. 3-(B), the optoelectronic mixer exhibits wide LO frequency ranges while maintaining high internal conversion gain.

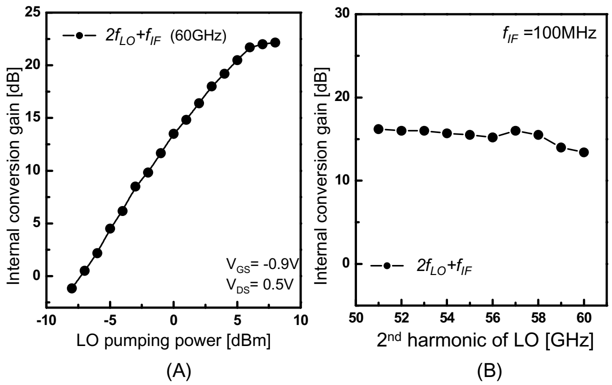

Fig. 3. Dependence of internal conversion gain on LO pumping power (A) and LO frequencies (B).

In order to investigate the feasibility of using the InP HEMT optoelectronic mixer in a fiber-supported wireless system, 622Mbps downlink transmission is demonstrated in a 60GHz wireless link shown in Fig. 4. The resulting eye diagram and bit-error rate (BER) characteristics are shown in Fig. 5-(a) and (b), respectively.

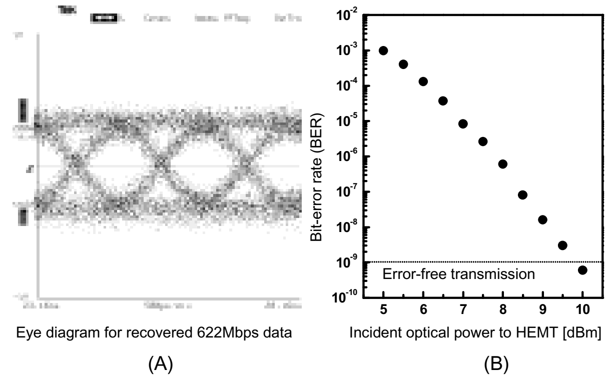

Fig. 5. (A) Eye diagram for recovered 622Mbps data signals and (B) BER characteristics as a function of incident optical power to HEMT.

IV. Conclusion

We investigated InP HEMT optoelectronic mixer characteristics and its applications to fiber-supported 60GHz wireless downlink transmission systems. Since InP HEMTs give many functionalities and the possibility of integration with other RF components, they are expected to be useful for realizing simple base stations.

References

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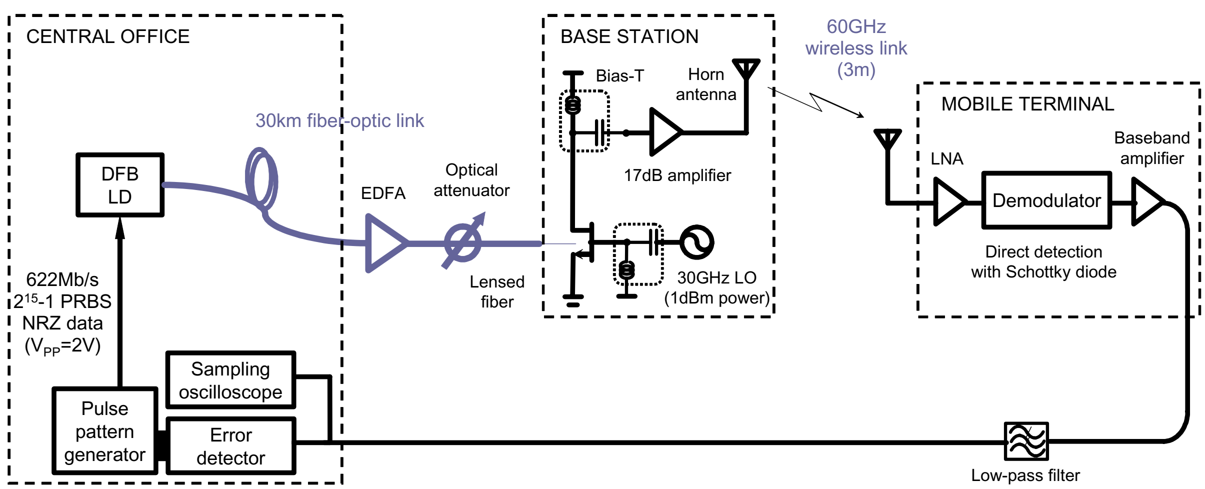

Fig. 4. Fiber-supported 60GHz wireless transmission system using InP HEMT harmonic optoelectronic mixer