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Fiber-optic/60GHz broadband data transmission systems using InP HEMT phototransistors

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Abstract — 622Mbps fiber-optic data transmissions in either baseband or wireless 60GHz band are demonstrated using InP HEMT phototransistors. Since the InP HEMT performs not only photodetection with high internal gain but also frequency up-conversion in a single device, merging fiber-optic link with wireless link is possible.

I. INTRODUCTION

The demands for broadband data distribution soar up for not only fixed subscribers but also mobile subscribers. Fiber-to-the-home (FTTH) systems are regarded as an ultimate goal for wired Gbps-data transmission. For the mobile subscribers, radio-on-fiber (RoF) systems are attractive because they provide the flexibility of network installation and alleviate the difficulties in microwave/millimeter-wave signal generation and transmission [1]. Since subscribers may desire accesses to both fixed and mobile networks, it is important to merge these FTTH and RoF systems together.

InP-based HEMT three-terminal phototransistors are expected to play an important role for these applications because they can be used as not only phototransistor but also optoelectronic mixer [2]. In this work, we demonstrate fiber-optic 622Mbps data transmission in baseband and 60GHz band using InP HEMT. Fiber-optic transmission for 622Mbps NRZ data is first presented by utilizing InP HEMT as a phototransistor. Incorporating the photodetection characteristics with device nonlinearity, we perform harmonic optoelectronic mixing which perform the frequency up-conversion from transmitted data to 60GHz band and demonstrate wireless transmission in 60GHz radio-on-fiber systems.

II. INP HEMT PHOTOTRANSISTOR AND HARMONIC OPTOELECTRONIC MIXER

Detailed device descriptions and experimental setup can be found in [3]. Fig. 1 shows the optical modulation response of InP HEMT under turn-on and turn-off mode. By taking difference between them, we define the internal gain provided by phototransistor operation of InP HEMT [4]. In our results, 38dB internal gain is obtained at 100MHz optical modulation frequency. Since InP HEMT should be operated at turn-on condition for the

applications of phototransistor and optoelectronic mixer, the modulation response determine the photodetection bandwidth of optically transmitted intermediate frequency (IF) with data. It can be seen from the figure that IF up to the GHz range can have high internal gain, which is sufficient for our investigation.

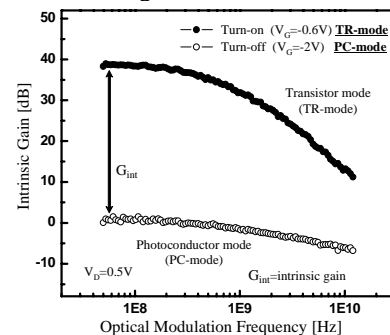


Fig. 1. Optical modulation response of InP HEMT under turn-on condition ($V_G=-0.6V$) and turn-off condition ($V_G=-2V$)

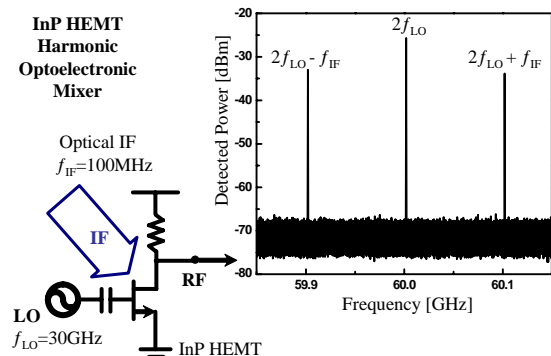


Fig. 2. InP HEMT harmonic optoelectronic mixer and its 60GHz frequency up-conversion spectrum under applying 30GHz LO and optical 100MHz IF

With a single InP HEMT, it is possible to realize the photodetection and harmonic optoelectronic mixing, simultaneously [3]. Fig. 2 shows the schematic diagram for utilizing the InP HEMT as a harmonic optoelectronic mixer and its up-converted output spectrum at 60GHz band. It can be seen that there are harmonic optoelectronic mixing products at $2f_{LO}+f_{IF}$ (60.1GHz) and

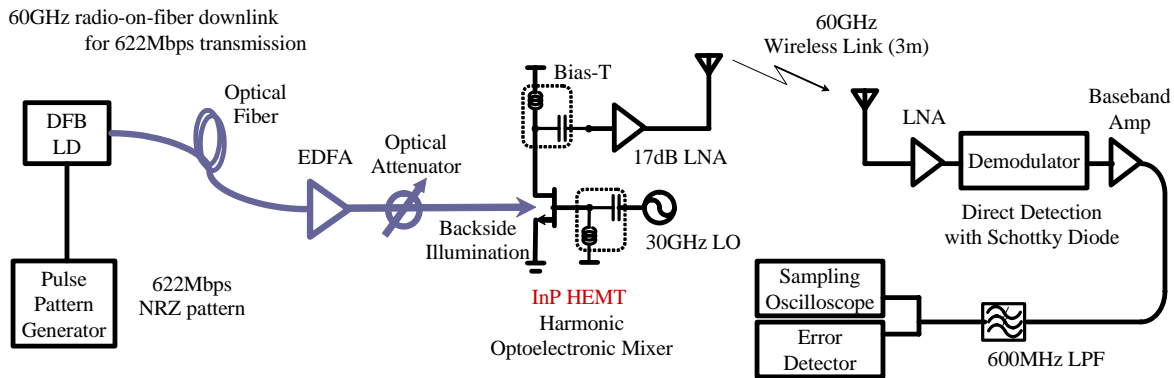


Fig. 4. 60GHz radio-on-fiber systems utilizing InP HEMT as a harmonic optoelectronic mixer

$2f_{LO}-f_{IF}$ (59.9GHz) and 2^{nd} harmonic of LO at $2f_{LO}$ (60GHz) with 30GHz LO and optical 100MHz IF. With this harmonic up-conversion, lower frequency LO can be used for millimeter-wave frequency up-conversion.

IV. 60GHz RADIO-ON-FIBER SYSTEM

In order to investigate the feasibility of using InP HEMT as a phototransistor, 20Km fiber-optic transmission is demonstrated. Optical data channel produced by a DFB laser directly modulated with 622Mbps NRZ pseudo-random bit sequence ($2^{15}-1$) was transmitted. The eye-diagram of photodetected signal measured at drain port and its bit-error rate (BER) characteristics are shown in Fig. 3. From these results, we conclude that a InP HEMT phototransistor can be used for 622Mbps optical receiver.

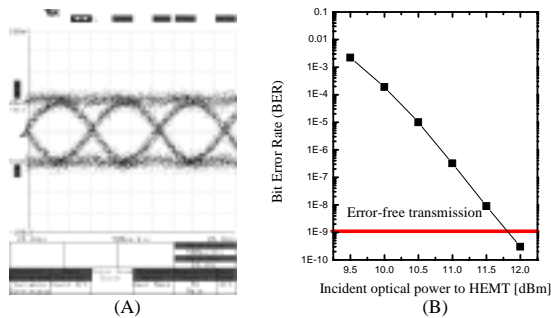


Fig. 3. (A) Eye diagram for photodetected 622Mbps data from fiber-optic link (B) Bit-error rate as a function of incident optical power to HEMT

Fig. 4 shows the constructed 60GHz radio-on-fiber transmission system utilizing InP HEMT as a harmonic optoelectronic mixer. The optically transmitted data were then frequency up-converted to 60GHz band using the InP HEMT harmonic optoelectronic mixer with the optimal bias conditions and 30GHz, 1dBm LO [2]. The output signal at drain port was amplified by 17dB LNA and radiated from the horn antenna with the 20dB gain. After

3m wireless transmission, the received signals were demodulated using the direct detection technique with a Schottky diode. Clear eye-opening was observed for the recovered data as shown in Fig. 5-(A). In addition, the link performance was evaluated by measuring the BER as a function of incident optical power to the InP HEMT. It should be noted that actually absorbed power is less than 10% of incident optical power. Fig. 5-(B) shows the experimental results for BER performance of 60GHz radio-on-fiber links.

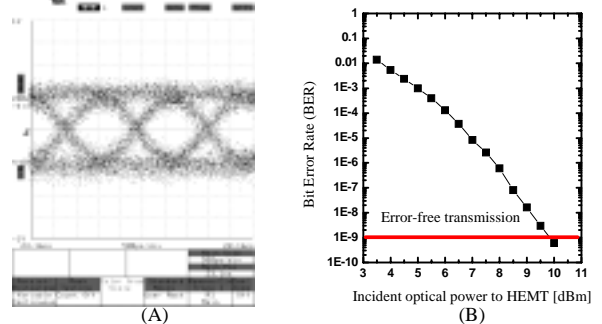


Fig. 5. (A) Eye diagram for recovered 622Mbps data from 60GHz radio-on-fiber system (B) Bit-error rate as a function of incident optical power to HEMT

IV. CONCLUSION

We demonstrate 622Mbps data transmission in baseband and 60GHz radio-on-fiber systems. Since InP HEMT can be used as phototransistor and harmonic optoelectronic mixer, it is expected to be useful in merging fiber-optic links with millimeter-wave wireless communication systems.

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