Radio-on-fiber downlink systems based on InP HEMT oscillators

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***Abstract* — We propose a new antenna base station architecture for millimeter-wave radio-on-fiber downlink system applications. The architecture is made up of an InP-HEMT oscillator, in which the HEMT device simultaneously provides functions of optically injection-locked oscillation and harmonic optoelectronic mixing. With the help of its low phase-noise characteristics, 16QAM radio-on-fiber transmission in 30GHz band is successfully demonstrated.**

I. Introduction

Growing interests in millimeter-wave radio-on-fiber systems have spurred the intensive development of simple antenna base station architectures because these systems essentially require a lot of antenna base stations [1]. Optoelectronic mixers are useful devices for simplifying antenna base stations since they can simultaneously perform functions of photodetection and frequency mixing in a single device. Furthermore, they are fully compatible to monolithic microwave integrated circuits, providing the possibility of one-chip integration on a single substrate [2].

However, millimeter-wave phase-locked oscillators are needed in order to transmit phase-modulated data such as PSK and QAM data. But phase-locked oscillators increase complexities in antenna base stations. In order to overcome this limitation, the scheme of distributing optical LO signals to each antenna base station has been proposed [3]. However, the amount of optical LO power required for frequency mixing and RF radiation at the base station is rather high.

In this paper, we propose a novel antenna base station architecture consisting of a single InP HEMT and passive components. It performs optically injection-locked oscillation and harmonic optoelectronic mixing, simultaneously. Utilizing it, 20Mbps 16QAM radio-on-fiber transmission in 30GHz band is successfully achieved.

II. Proposed scheme

Fig. 1 schematically illustrates the proposed simple antenna base station architecture. A 10GHz free-running oscillator based on an InP HEMT is first realized by simple feedback method using discrete bandpass filter, and injection-locked by the optically delivered 10GHz LO signal from a central office. At the same time, optically transmitted data/IF signals with different wavelength are illuminated to the same InP HEMT and, as a result, harmonic frequency up-conversion to the 30GHz band is achieved. In this scheme, the InP HEMT operates as an optically injection-locked oscillator and a harmonic optoelectronic mixer. The output LO power depends not on the incident optical power but on the free-running oscillator and, thus, it is possible to achieve high LO power independent of optical transmission distance. Although, discrete components are used for our present investigation, an integrated approach based on InP MMIC technology should be equally applicable, providing one chip solution (except antenna) for the antenna base station.

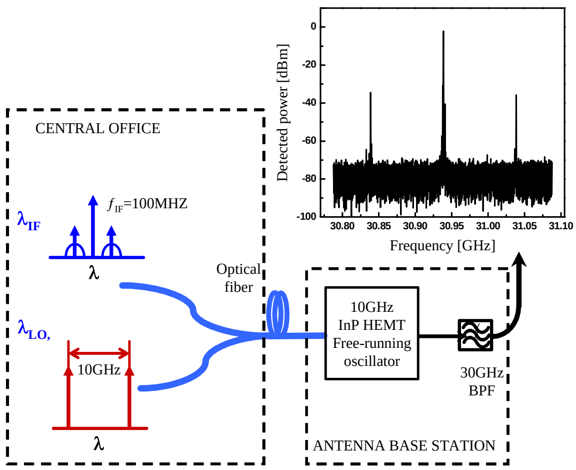

Fig. 1. Proposed antenna base station architecture based on a single InP HEMT.

III. Experimental demonstration

First, direct optical injection-locking characteristics are investigated. We focus on the 3rd harmonic of 10GHz LO for constructing 30GHz radio-on-fiber systems. Optically generated 10GHz LO signals having wavelength of 1552nm are illuminated to a 10GHz band InP HEMT free-running oscillator through backside substrate [2]. Fig. 2-(A), (B) and (C) show the output spectra for free-running, optically injection-locked and unlocked conditions (out of locking range), respectively. While the free-sunning oscillation is unstable and sensitive to environmental conditions, the optically injection-locked oscillator exhibits stabilized oscillation and suppressed phase-noise characteristics as shown in Fig. 3. Under the unlocked condition, many sidebands can be observed due to the frequency mixing of free-running LO signals and optically injection signals.

With the help of low phase-noise characteristics of optically injection-locked oscillator, 20Mbps 16QAM data transmission is successfully demonstrated. Fig. 4 shows the constructed 30GHz radio-on-fiber system adopting our proposed scheme. Under the optically injection-locked condition, the optical 16QAM data at 100MHz IF having 1553.5nm wavelength are simultaneously illuminated to the InP HEMT. It performs the harmonic optoelectronic mixing of these data signals with the 3rd harmonics of LO. The output spectrum including lower sideband 16QAM signals and 3rd harmonics of 10GHz injection-locked LO signals is shown in Fig. 5-(A). In actual RoF applications, these signals would be transmitted to the air through the antenna.

In order to evaluate signal quality, the resulting signals are filtered and frequency down-converted to IF band whose spectrum is shown in Fig. 5-(B). After additional filtering, error vector magnitude is measured with a vector signal analyzer. Under incident optical power of 9dBm, EVM is about 4.7% which corresponds to 24dB SNR.

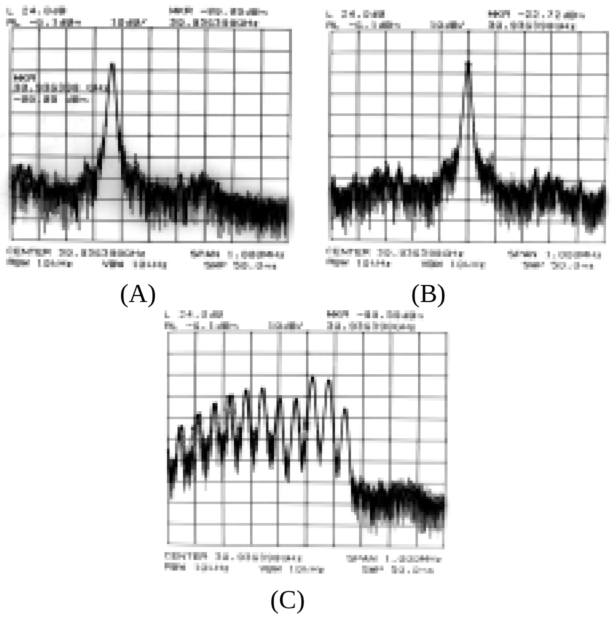

Fig. 2. Output spectrums of (A) free-running, (B) injection-locked and (C) unlocked oscillators

IV. Conclusion

We proposed a new antenna base station scheme based on an InP HEMT oscillator for millimeter-wave radio-on-fiber downlink systems. It is possible to simultaneously achieve the optically injection-locked oscillation and harmonic optoelectronic mixing in the HEMT oscillator. Using this scheme, the antenna base station architecture can be very simple and cost-effective, which can alleviate difficulties in constructing millimeter-wave radio-on-fiber systems.

References

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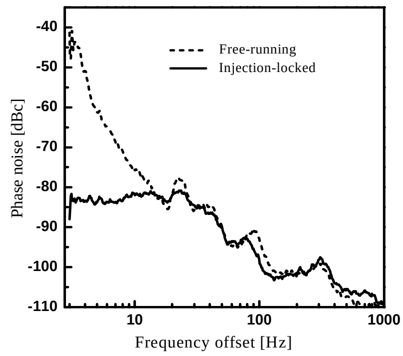

Fig. 3. Phase-noise characteristics of free-running and injection-locked oscillators.

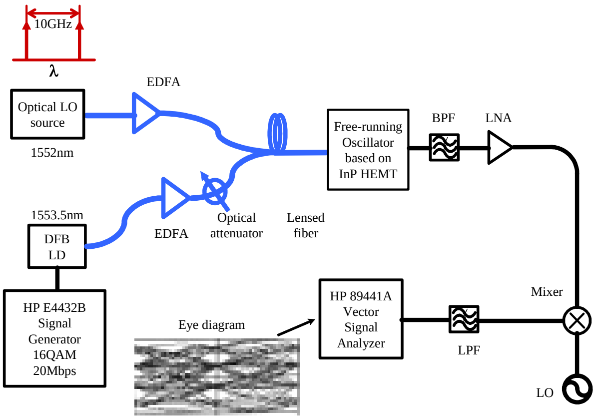

Fig. 4. Experimental setup for proposed 30GHz radio-on-fiber system

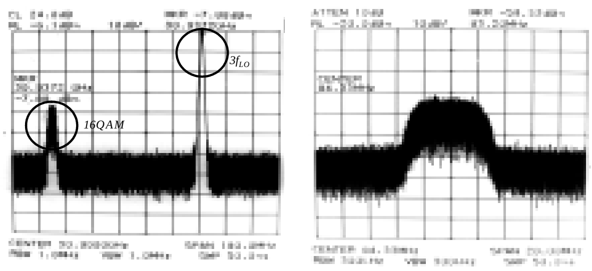

Fig. 5. (A) 30GHz band output spectrum including 3rd harmonic of LO and frequency up-converted 16QAM data signal (B) down-converted 16QAM signal