High Speed InP HBT Driver IC For Laser Modulation

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Abstract: High-speed IC for time-division multiplexing (TDM) optical transmission systems have been designed and fabricated by using InP heterojunction-bipolar-transistor (HBT) technology. The driver IC was developed for driving external modulators, featuring differential outputs and the operation speed up to 10 Gbps with an output voltage swing of 1.3 V_{PP} at each output which was the limit of the measurement. Because -3 dB frequency was 20GHz, this circuit will be operated up to 20Gbps. 1.3Vpp differential output was achieved by switching 50 mA into a 50 Ω load. The power dissipation of the driver IC was 1W using a single supply voltage of -3.5V. Input and output return loss of the IC were better than 10 dB and 15 dB, respectively, from DC to 20GHz. The chip size of fabricated IC was 1.7□1.2 mm^2.

1. INTRODUCTION

The demands for large capacity optical transmission systems have rapidly increased in resent years. To integrate the systems by using time-division multiplexing (TDM) technology, high speed optical devices [1], broadband analog ICs, and high-speed digital ICs are indispensable. In such systems, the modulator drivers for electro absorption (EA) modulators or Mach-Zehnder modulators must normally operate at both high-speed and large drive voltage which are required to ensure a sufficient extinction ratio at 10Gbps. So modulator drivers are the most critical components.

In recent years, many driver ICs based on different devices have been reported on 10 Gbps in T-gate AlGaAs/InGaAs PHEMT [2] and Si BJT driver IC [3], 20 Gbps in SiGe driver IC [4], and 30 Gbps AlGaAs/GaAs high electron mobility transistor (HEMT) driver IC [5].

In this paper, we describe the design and characteristics of an InP HBT laser modulator driver IC for 10 Gbps applications.

2. CIRCUIT DESIGN

The HBT devices, in general, are naturally suited for high speed application because of their wide bandwidths and large current densities, the latter property is important to minimize the number of necessary stage for building the required output current level.

Fig. 1 shows circuit diagram of modulator driver. It consisted of two emitter follower pairs, broad-band amplifier with emitter followers in feedback loop, two additional emitter follower pairs, and an output differential stage that drives an external 50Ω load.

First two emitter follower pairs were used for level shifting, impedance transformation and increasing the drain-gate voltage of the current-switch transistor to lower drain-gate capacitances. Broad-band amplifier was based on the Cherry-Hooper structure [6]. This amplifier was implemented with localized series feedback, followed by localized shunt feedback, and then an emitter follower buffer. The shunt feedback

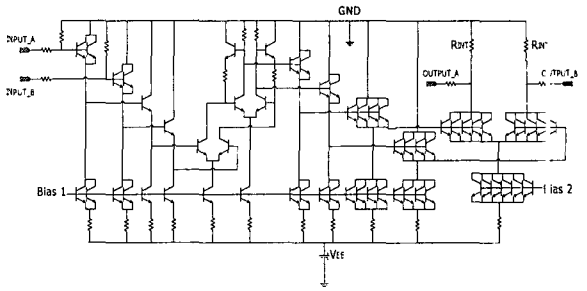

Fig. 1 Circuit diagram of driver IC

consisted of an emitter follower and a resistor. This feedback substantially increased the circuit bandwidth in comparison to a simple resistive feedback.

Final stage for modulation schemes converts the amplified and limited data voltage to a usable current. For good impedance matching of the output, the 50Ω (R_{INT}) load inside the chip was connected to the 50Ω load outside the chip. Parallel transistors were used to swing more high amplitude for the 50Ω load outside the chip. Single-ended or differential output signals are available, depending on the configuration of EA modulators or Mach-Zehnder modulators. Matching

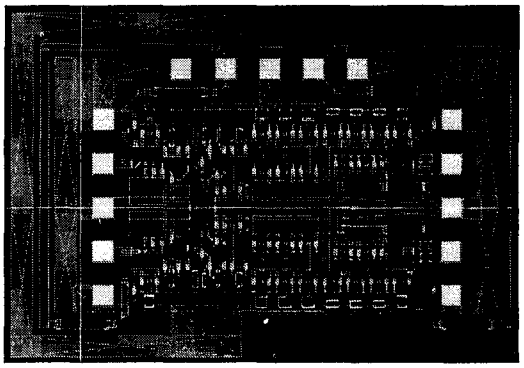

Fig. 2 Layout photograph of high speed InP HBT driver IC

propagation delay for the differential signals was achieved using symmetric layout as shown in Fig 2.

3. EXPERIMENTAL RESULTS

High speed measurement of driver IC was made on-wafer. A 10 Gb/s pattern generator with 2^{31}-1 bit word length was used. The output signal of the IC was measured with a 40 GHz sampling scope. The differential input voltage swing of the circuit was chosen to be 500 mV.

At 10 Gb/s, the measured internal current switched by the driver IC was as high as 50 mA. The corresponding maximum single-ended output voltage swing at 50Ω load was 1.3 VPP. Fig. 3 shows the measured clear output eye diagrams. The rise and fall time were 60 ps and 75 ps (20% ~ 80%) under the above condition. With ground and -3.5V applied to V_{CC} and V_{EE}, respectively. The power dissipation including modulation current was 1W.

Measured S-parameter characteristics of the driver IC are shown in Fig. 4. A flat gain (S_{21}) characteristic of 15 dB over 1 – 10 GHz was obtained. -3dB frequency was 20 GHz. Therefore this circuit will be operated up to 20Gbps. Here, the input reflection coefficient (S_{11}) was less than -10 dB over 0.05 – 50 GHz, and the output reflection coefficient (S_{22}) was less than -15 dB over 0.05 – 30 GHz.

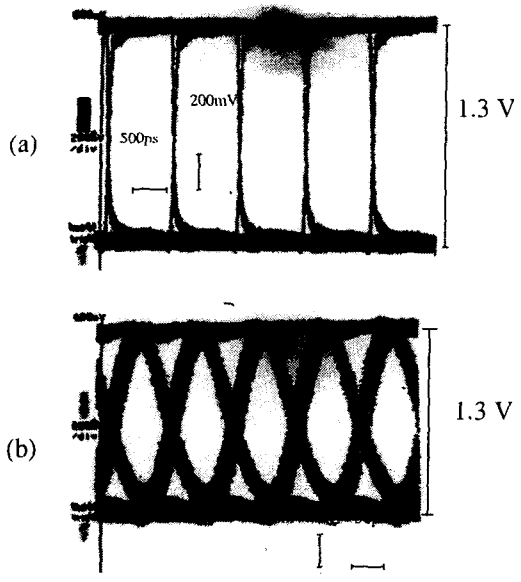

Fig. 3 On-wafer measured output eye-diagram of the driver IC at (a) 1Gbps (b) 10Gbps.

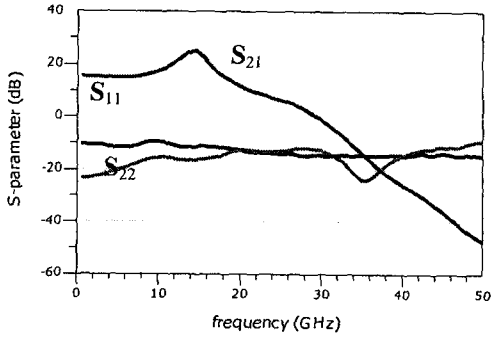

Fig. 4 Measured S-parameters of high speed InP HBT driver IC

4. SUMMARY

In this paper we have demonstrated the performance features of external laser modulator driver IC. The driver IC was designed, fabricated and tested using InP HBT technology which is promising due to the combination of good electrical performance. The modulator driver IC operated up to 10 Gbps with an output voltage swing of 1.3 V_{PP} at each output (corresponding to an internal current swing of 60 mA). This driver IC consumed 1W power using a single supply voltage -3.5 V. This implementation provides an easy 10 Gbps laser modulator driver IC using HBT and enhance the performance of transmitting circuits in optical communication system.

5. REFERENCES

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