High gain (1 kOhm) high transimpedance bandwidth (38 GHz) transimpedance amplifier in InP-HBT technology.

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Abstract: A high-gain high-bandwidth transimpedance amplifier in InP-HBT technology is presented. The transimpedance amplifier has differential outputs and has a single-ended transimpedance gain of 1kOhm (2 kOhm differential) at DC. With practical photodiode and interconnect parasitics included the amplifier has a transimpedance bandwidth of 38 GHz with very flat group delay. The amplifier operates from a single +3.3 V supply and dissipates about 280 mW of power.

1. Introduction

Recently, the interest in 40 Gbit/s (OC-768) fiber optic communications has been increasing [1-4]. Various different approaches have been proposed for the fiber-optic receiver: SiGe amplifiers [1], distributed GaAs PHEMT amplifiers [2], and monolithic PIN + InP-HBT amplifiers [3-4]. Here we introduce an InP-HBT amplifier for hybrid combination with a photodetector. The advantage of the hybrid approach over the monolithic approach [3,4] is that it allows for separate optimization of the PIN-photodiode (or other photodetector) fabrication process and the amplifier HBT-fabrication process. The hybrid process also enables the addition of a high-Q inductor in the form of a bond wire between the photodetector and the transimpedance amplifier for bandwidth extension and noise performance optimization[5].

2. Transimpedance amplifier architecture

Figure 1 shows the block diagram of the InP-HBT Transimpedance amplifier with PIN diode and inductance added to the input. The transimpedance amplifier consists of three stages: a common-emitter (CE) input stage with buffered shunt feedback, a buffer stage, and a 50 Ohm driver stage. The feedback resistance at the input stage is 900 Ohm. A small amount of gain in the buffer and 50 Ohm driver increases the total single-ended transimpedance gain to 1 kOhm. The amplifier is designed to operate with input currents ranging from 0 to 1 mA. A DC offset input is provided for output eye optimization.

3. Results

The frequency response of the amplifier was measured in a 50 Ohm environment with an Agilent 8510C network analyzer. To obtain the transimpedance bandwidth the Z-parameters as extracted from the S-parameters are used. The transimpedance $Z_T=Z_{21}*Z_L/(Z_L+Z_{22})$ as obtained from the measured S-parameters in combination with a PIN diode and a 250 pH inductance are shown in Figure 2. The measured single-ended transimpedance is 1 kOhm with a 3 dB bandwidth of about 38 GHz. The group delay of the amplifier remains within ±7ps within the bandwidth of 38 GHz as shown in Figure 3. Figure 4 shows the output return loss which remains greater than 10 dB upto about 38 GHz. Finally, Figure 5 shows an output eye diagram in a 50 Ohm environment at 40 Gbit/s for an estimated input current of 50 µApp and 1 mApp. The RMS added jitter from the transimpedance amplifier is about 1.4 ps and the output eye amplitude is 580 mVpp at 1 mApp input.

4. Conclusions

A high-gain high-bandwidth transimpedance amplifier for OC-768 links is described. The transimpedance amplifier has differential outputs and has a single-ended transimpedance gain of 1kOhm (2 kOhm differential). A transimpedance bandwidth of 38 GHz is achieved. The amplifier operates from a single +3.3 V supply and dissipates about 280 mW of power.

References

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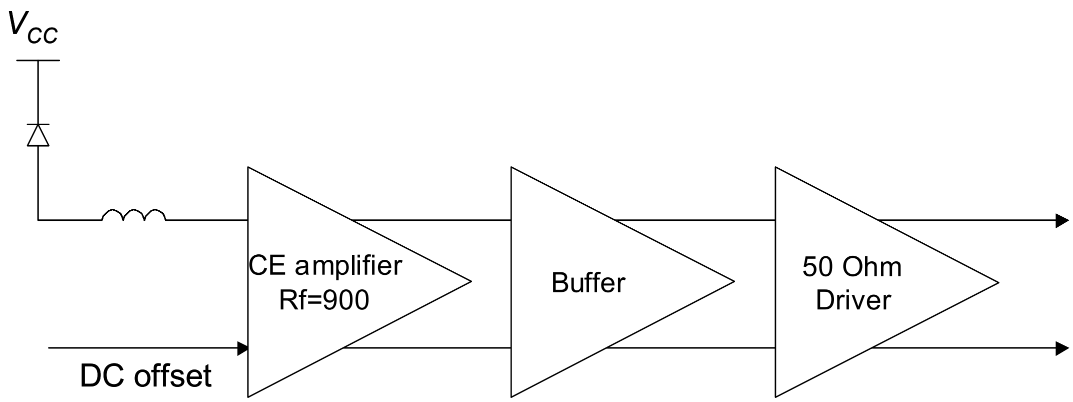

Figure 1. Block diagram of the InP-HBT Transimpedance amplifier with PIN diode and inductance added to the input. The transimpedance amplifier consists of three stages: a common-emitter (CE) input stage with buffered shunt feedback, a buffer stage, and a 50 Ohm driver stage. The feedback resistance at the input stage is 900 Ohm. A small amount of gain in the buffer and 50 Ohm driver increases the total single-ended transimpedance gain to 1 kOhm.

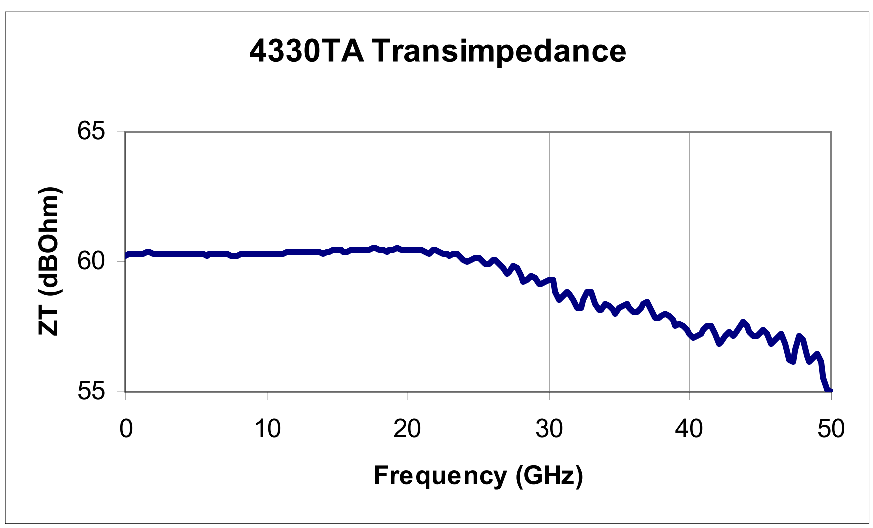

Figure 2. Transimpedance as obtained from the measured amplifier S-parameter data and combined with a PIN-diode connected with a 250 pH inductance. The inductance is added for bandwidth extension and noise performance optimization and is typically achieved with a bond-wire.

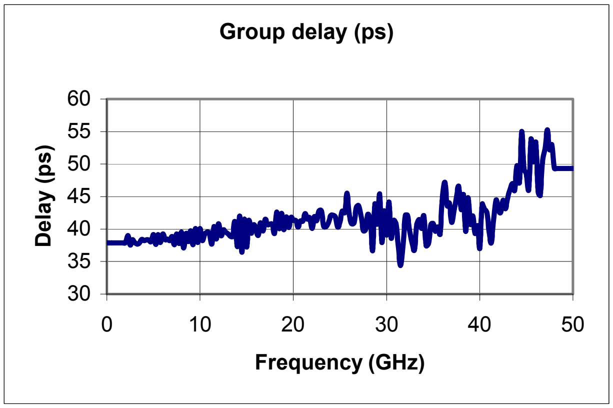

Figure 3. Group delay for the PIN+TIA combination as obtained from measured amplifier S-parameter data and combined with a PIN diode and a 250 pH bondwire inductance.

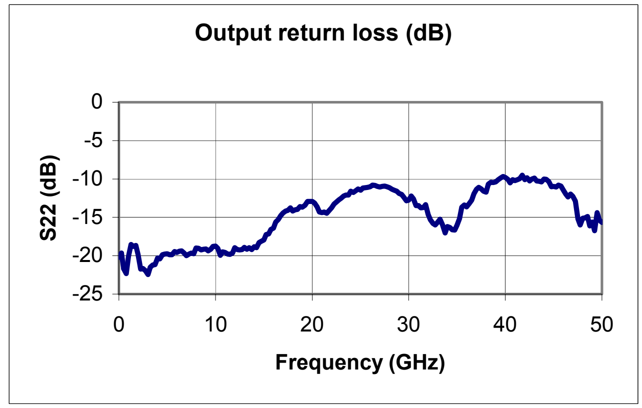

Figure 4. Measured output return loss of the transimpedance amplifier. The output return loss is greater than 10 dB up to 38 GHz.

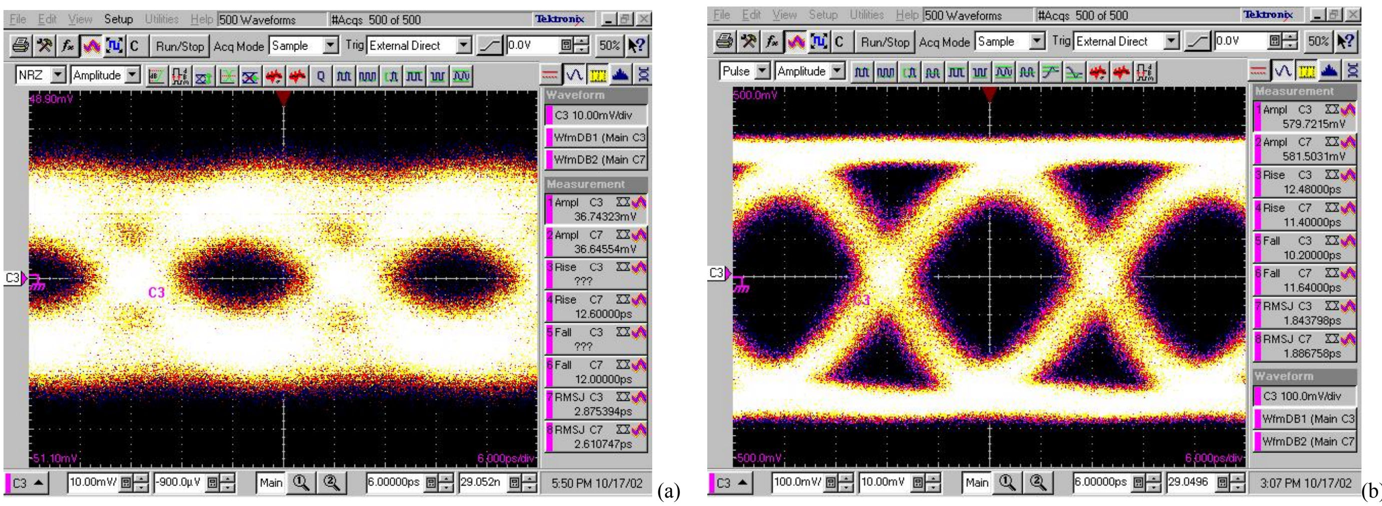

Figure 5. Output eye diagram at 40 Gbit/s in a 50 Ohm environment. Shown for two different input currents (a) at a small signal input of 50 µApp and (b) at a large signal input of 1 mApp input.