High-Gain (1 kOhm), High-Bandwidth (38 GHz) Transimpedance Amplifier in InP-HBT Technology

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Abstract: A high-gain, high-bandwidth transimpedance amplifier (TIA) in InP-HBT technology is presented. The TIA has differential outputs and a single-ended transimpedance gain of 1 kOhm (2 kOhms 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 approaches have been proposed for the fiber optic receiver, including SiGe amplifiers [1], distributed GaAs PHEMT amplifiers [2], and monolithic PIN + InP-HBT amplifiers [3-4]. Here, we introduce an InP-HBT amplifier for 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 of 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 TIA for bandwidth extension and noise performance optimization[5].

2. Transimpedance amplifier architecture

Figure 1 shows the block diagram of the InP-HBT TIA with PIN diode and inductance added to the input. The TIA 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 Ohms. 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.

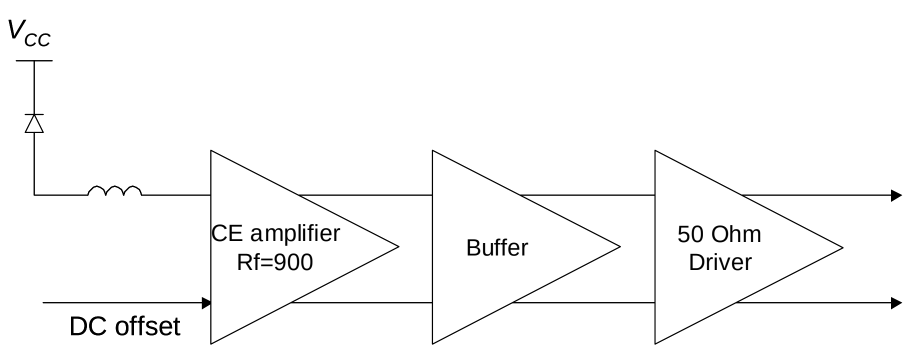


Figure 1. Block diagram of the InP-HBT TIA with PIN diode and inductance added to the input.

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 ±7 ps within the bandwidth of 38 GHz, as shown in Figure 3. Figure 4 shows the output return loss, which remains greater than 10 dB up to 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 TIA is about 1.4 ps, and the output eye amplitude is 580 mVpp at 1 mApp input.

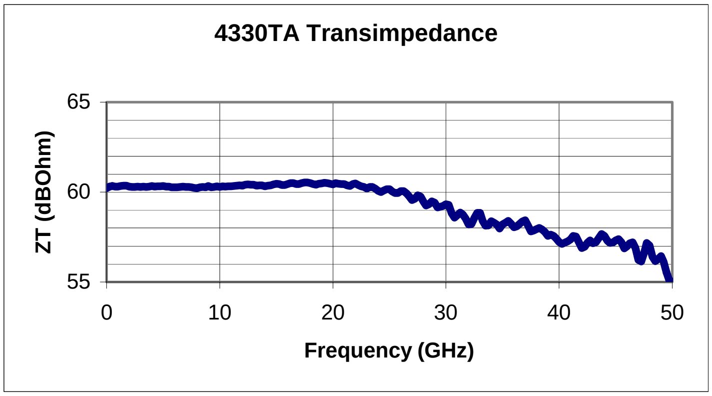


Figure 2. Transimpedance as obtained from the measured amplifier S-parameter data and combined with a PIN-diode connected with a 250 pH inductance. The inductance is added for bandwidth extension and noise performance optimization and is typically achieved with a bond wire.

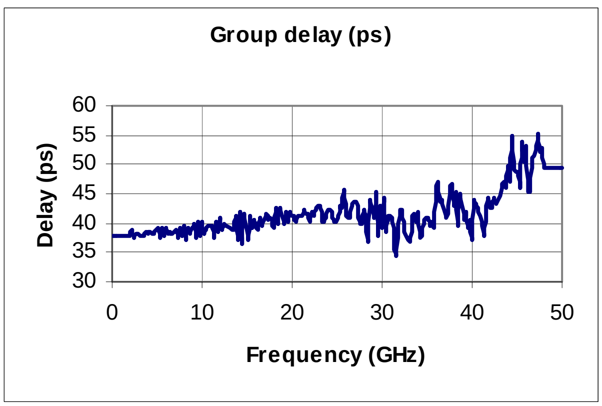


Figure 3. Group delay for the PIN+TIA combination as obtained from measured amplifier S-parameter data and combined with a PIN diode and a 250 pH bond wire inductance.

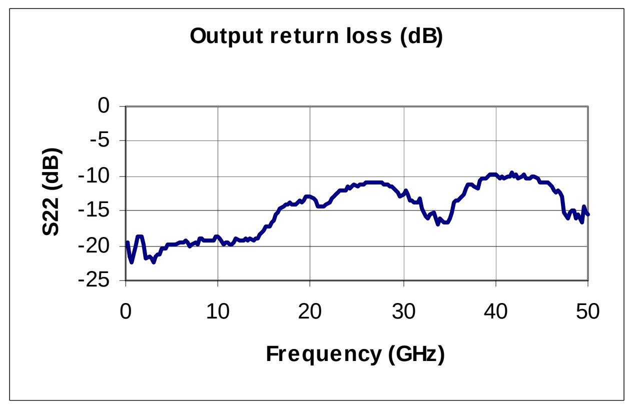
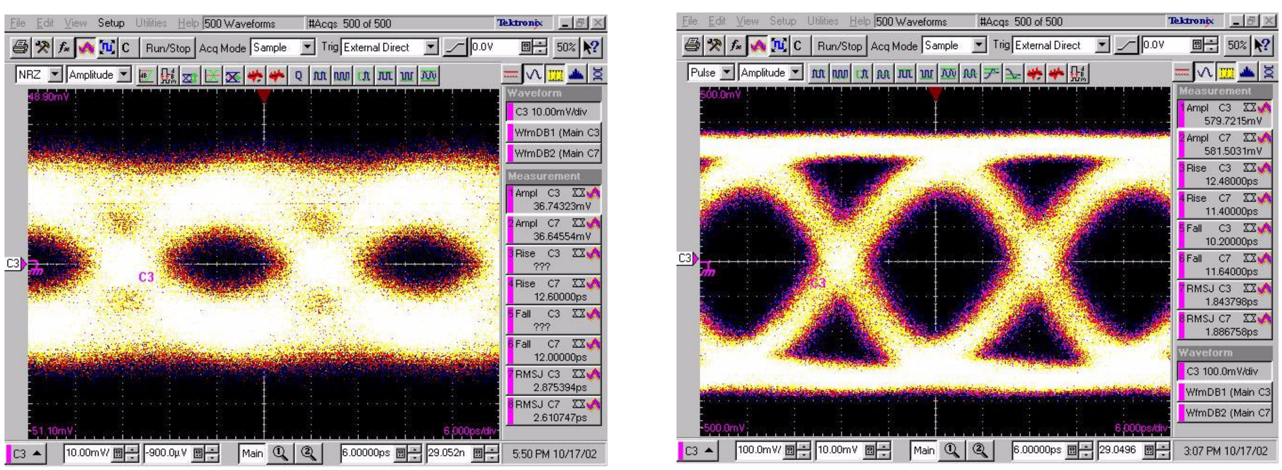


Figure 4. Measured output return loss of the TIA. The output return loss is greater than 10 dB up to 38 GHz.



(a) **(b)**

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.

4. Conclusions

A high-gain, high-bandwidth TIA for OC-768 links is described. The TIA has differential outputs and a single-ended transimpedance gain of 1 kOhm (2 kOhms 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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