A Capacitive Peaking of InGaP/GaAs HBT Transimpedance Amplifier

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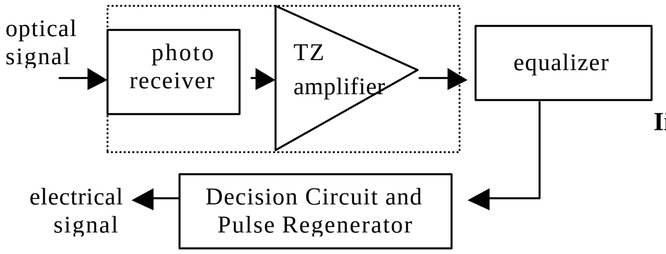
Abstract

High-speed transimpedance (TZ) amplifiers integrated with photodetectors, are widely used as a preamplifier in optical fiber communications to convert the optical signals into electrical signals. However, to boost the speed of preamplifier in optical communication systems still attracts the attention, where new techniques have been constantly proposed. One such method is the so-called peaking technique, where inductors are placed in a strategic location of the amplifier circuit, resulting in a resonance with parasitic capacitances, which broadens the bandwidth of the amplifier. However, the stray capacitances of an inductor may often result in a bandwidth degradation, rather than an improvement. To overcome this problem in this study, we propose a capacitive peaking method in an InGaP/GaAs HBT TZ amplifier design.

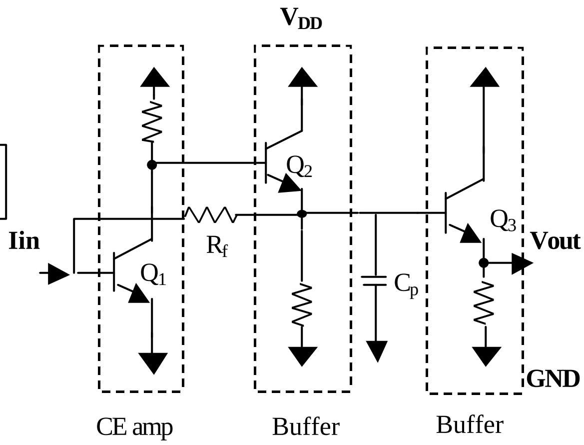
We utilized $In_{0.5}Ga_{0.5}P$/GaAs HBTs realize the TZ amplifier circuits. The InGaP/GaAs HBTs with an emitter size of A_E= 4 x 5 μm^2 exhibited a current gain of 100 at V_{CE}=1.6 V. For the microwave performance, the current gain cut-off frequency (f_T) of 35 GHz and maximum oscillation frequency (f_{max}) of 65 GHz were obtained at I_C=5 mA and V_{CE}=2.6 V.

This TZ amplifier is a shunt-shunt feedback amplifier, consisting of a common-emitter (CE) gain stage (Q1), an active resistive feedback loop (R_F), two output matching buffer stages (Q2 & Q3), and a peaking-capacitor (C_p) at the Q3 base terminal. The transfer function of this amplifier without a peaking-capacitor is given by A(s)/(1+A(s)β(s)), where A(s) and β(s) are open-loop transfer function and feedback factor of transimpedance amplifier, respectively. This function can be expressed by having one dominate pole, which can be derived as TZ(0)/ (1+s/W_{3dB}), where TZ(0) is low-frequency transimpedance gain. The peaking-capacitor designed here is to induce an extra-pole in transfer function, and this equation can be rewritten as $TZ(0)/(1+s/(QW_0^2)+s^2/(W_0^2))$. However, this capacitor peaking design will not sacrifice the low-frequency gain. The linearity of DC gain decreased by the increase of injected current, and the maximum measured DC gain was 371 Ohm. By introducing a peaking capacitor, both simulated and experimental results demonstrated a bandwidth enhancement. The transimpedance gain of 51 dB was obtained in our design, and a pealing response has been observed by using this technique, where the maximum 3dB bandwidth was 10.05 GHz.

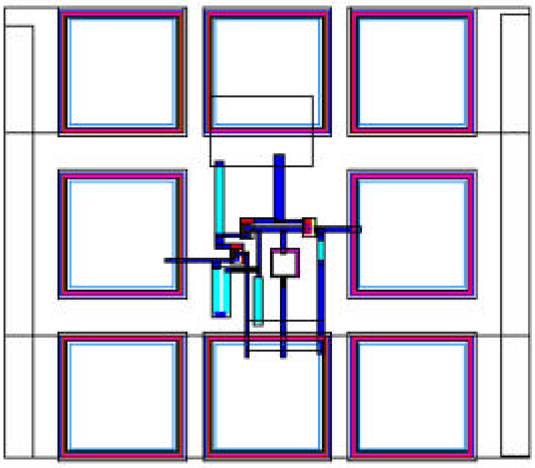
Peaking effect of InGaP/GaAs HBT transimpedance amplifier with a capacitor has been investigated and fabricated. By adding a peaking-capacitor in this amplifier, the bandwidth can be enhanced without sacrificing the low-frequency transimpedance gain.



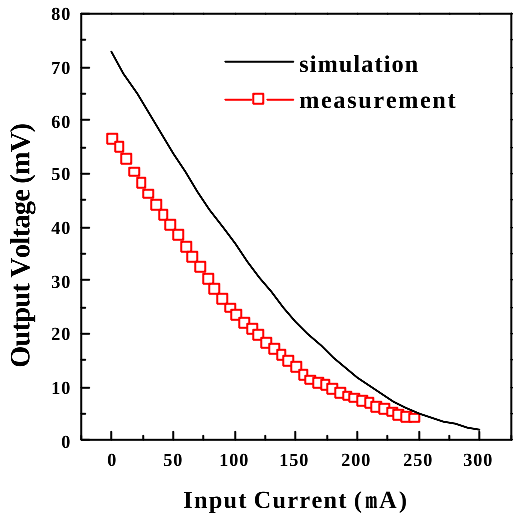
Optical fiber communication system block



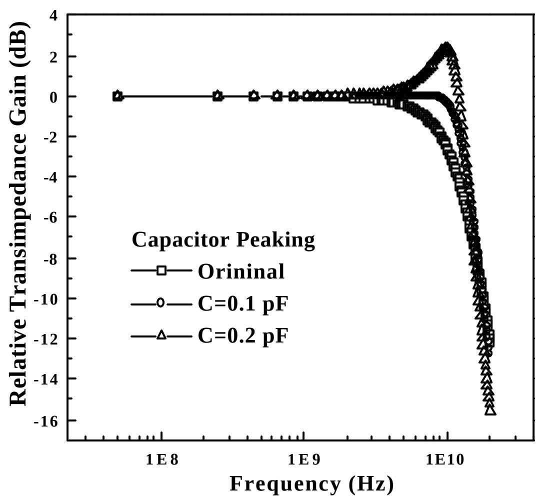
Schematic of trasnimpedance amplifier with a C-peaking design



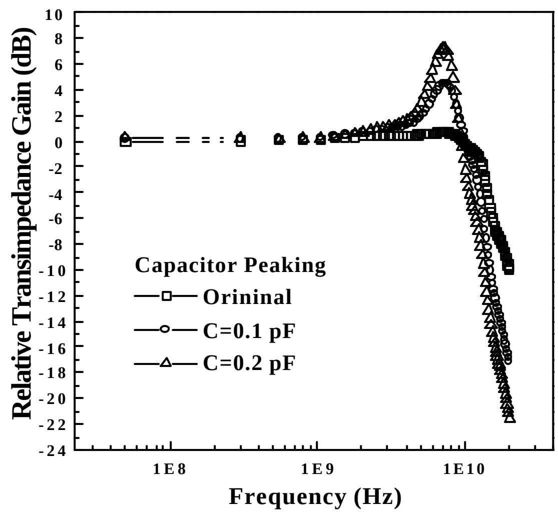
Layout of transimpedance amplifier with a C-peaking design (400x470 μm^2)



Characteristics of output voltage against injected current of transimpedance



Simulated transimpedance response with and without a peaking capacitor



Measured transimpedance response with and without a peaking capacitor