Design of a High-Speed and Compact Electro-Optic Modulator using SiGe HBT

by

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ABSTRACT

Optical interconnects between electronics systems have attracted significant attention and development for a number of years because optical links have demonstrated potential advantages for high-speed, low-power, and interference immunity. With increasing system speed and greater bandwidth requirements, the distance over which optical communication is useful has continually decreased to chip-to-chip and on-chip levels. Monolithic integration of photonics and electronics will significantly reduce the cost of optical components and further combine the functionalities of chips on the same or different boards or systems. Modulators are one of the fundamental building blocks for optical interconnects. High-speed modulation and low driving voltage are the keys for the device's practical use. In this study two separate designs show that using a graded base SiGe HBT we can modulate light at high speeds with moderate length and dynamic power consumption.

The first design analyzes the terminal characteristics of the HBT and a close match is obtained in comparison with npn HBTs using IBM's 8HP technology. This suggests that the modulator can be manufactured using the IBM 8HP fabrication process. At a sub-collector depth of 0.4 µm and at a base-emitter swing of 0 V to 1.1 V, this model predicts a bit rate of 80 Gbit/s. Optical simulations predict a π phase shift length (L_π) of 240.8 µm with an extinction ratio of 7.5 dB at a wavelength of 1.55 µm. Additionally, the trade-off between the switching speed, L_π and propagation loss with a thinner sub-collector is analyzed and reported. The dynamic power consumption is- reported to be 3.6 pJ /bit.

The second design examine a theoretical aggressively-scaled SiGe HBT that may approximate a device that is two device generations more advanced than available today. At a base-emitter swing of 0 V to 1.0 V, this model predicts a bit rate of 250 Gbit/s. Optical simulations predict a π phase shift length (L_π) of 204 µm, with an extinction ratio of 13.2 dB at a wavelength of 1.55 µm. The dynamic power consumption is reported to be 2.01 pJ /bit.

This study also discusses the design of driver circuitry at 80 Gbit/s with voltage swing levels of 1.03V. Finally the use of slow wave structures and use of SiGe HBT as a linear analog modulator is introduced.