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Thesis Title: Effects of Non-ideal Characteristics of BJT on Band Gap Reference Circuits

Abstract:

In advanced integrated circuit design, it requires an accurate on-chip band gap reference for optimal system performance. Precision band gap voltage references are an essential building block in analog integrated circuits design. Band gap reference circuit produces a stable reference voltage, which is insensitive to variation in voltage supplies and temperature. Band gap reference circuits are commonly used in many applications such as analog to digital data converters, digital to analog data converters and power management ICs. The increasing demand of higher accuracy and complexities in IC applications put more and more stringent design requirements of band gap reference circuits over process and temperature.

In a typical band gap reference circuit the non-ideal characteristics of PNP BJT can cause inaccuracies in the reference voltage. In a typical bipolar transistor fabrication process, diffusion is used to create the base region. The characteristics of BJT are strongly affected by the diffused base region. The base region is very thick which contains a large parasitic resistance called base spreading resistance. The BSR will cause a base-emitter voltage drop in BJT and the collector current will vary due to this voltage change. A mathematical analysis of kuijk band-gap reference circuit is presented in chapter II. However, the non-ideal characteristics of BJT have not been addressed in the analysis. The following sections will discuss those non-ideal characteristics of BJT. Besides the non-ideal characteristics of the BJT, the temperature dependence of resistors will also affect the reference voltage significantly. The effects illustrated in chapter III, which shows that by including the temperature dependence of the three resistors, the inflection point of voltage reference will shift to a lower temperature and the sensitivity of the reference voltage will be increased from 22.7  to 47.32. Chapter IV shows the temperature dependence of beta, which causes the inflection point to shift to a much higher temperature and the sensitivity of the reference voltage will be increased from 22.7  to 45.5. At the same time a large area BJT will have an apparent base-emitter voltage variation due to the base spreading resistance. As shown in chapter V, the BSR will cause the reference voltage increasing by about 10mV at a temperature range of -40 to 100. Finally, calibration and different layout of BJT will be discusses in chapter VI and chapter VII.