Composite Transistors for Compensation of HBT Self-heating Effect and Enhancement of HBT Linearity

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BACKGROUND

Heterojunction bipolar transistors (HBT's) are the key components in the high output power densities circuits at microwave frequencies and are increasingly being utilized for large signal applications such as power amplifiers, oscillators, and mixers. These high power densities in HBT can easily lead to significant operating temperatures when the transistors are working under the large signal operation. Although the temperature sensitivity of transistor parameters is significant for all types of power transistors, it is particularly important for the HBT based on GaAs with its high associated power densities, relatively poor thermal conductivity, and strong dependence of junction behavior on temperature. When the HBT's are working under high current densities, generally more than 10kA/cm2, a phenomenon commonly observed is self-heating effect or a decreasing current gain with increasing collector-emitter voltage. The responsible mechanisms are generally attributed to a variation in current gain with junction temperature and are the same as those giving rise to the variation of gain with ambient temperature. Thus, with increasing the biasing voltage between collector and emitter of NPN HBT, the current gain will decrease because of self-heating effect. This will cause the instability of DC quiescent point on the load line for large signal design, which is very important for circuit design. Furthermore, HBTs have high efficiency in class AB saturated power operation at microwave frequencies. However the transmitter power amplifier (PA) of a communication system needs to have both high efficiency and good linearity. Nonlinearity creates intermodulation distortion and raises the bit error rate (BER), and is one of the key issues in microwave communication systems. As a consequence, the linearity of the circuit is a big concern for large signal design.

Many efforts have been made to alleviate the self-heating effect in the defined current operation range for HBTs. Bas

TECHNOLOGY DESCRIPTION

University researchers have designed a composite transistor that solves this problem with a conventional processing technology, without sacrificing too much power gain or chip area. The compensation mechanism of self-heating effect in active HBT is based on the concept of negative feedback in control theory. After the compensation, the DC performance of forward output is much better than before.

Thus, it makes the design of DC biasing for RF and microwave circuit easier and the DC biasing point is much more stable than before. The linearity of composite transistors is greatly improved by the cancellation of the sources of non-linearity of HBTs.

According to the simulation results, the input power 1-dB gain compression point is increased by 2 dB with negligible insertion power loss and almost no decrease in power gain. Furthermore, the S-parameters of the composite transistors are independent of the DC biasing, thereby easing the design of the input and output matching circuits. This self-heating compensation theory can be used in a power cell, and any circuit, to increase the linearity by reducing the collector current dependence on the VCE.

APPLICATIONS

Can be used in power amplifiers, and other power circuits, especially for broadband power applications.

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OTHER INFORMATION

CATEGORIZED AS

» **Energy**
» Other

RELATED CASES

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PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	7,425,871	09/16/2008	2004-408

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