POWER AMPLIFIER MODULES INCLUDING RELATED SYSTEMS, DEVICES, AND METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority from U.S. Provisional Application 61/659,848 which was filed Jun. 14, 2012.

BACKGROUND

1. Field of the Invention

This invention relates in general to power amplifiers and, in particular, to power amplifier modules. More specifically, but without restriction to the particular embodiments hereinafter described in accordance with the best mode of practice, this invention relates to power amplifier modules for use in wireless communications and includes related systems, devices, and methods.

2. Description of Related Technology

Power amplifiers can be included in mobile devices to amplify a RF signal for transmission via an antenna. For example, in mobile devices having a time division multiple access (TDMA) architecture, such as those found in Global System for Mobile Communications (GSM), code division multiple access (CDMA), and wideband code division multiple access (W-CDMA) systems, a power amplifier can be used to amplify a RF signal having a relatively low power. It can be important to manage the amplification of a RF signal, as a desired transmit power level can depend on how far the user is away from a base station and/or the mobile environment. Power amplifiers can also be employed to aid in regulating the power level of the RF signal over time, so as to prevent signal interference from transmission during an assigned receive time slot.

The power consumption of a power amplifier and power added efficiency (PAE) associated therewith can be an important consideration. In view of the ever increasing demands associated with providing wireless communication for voice, data, and system control, there is a need for improved power amplifiers, power amplifiers modules, and devices, systems, and methods relating thereto. Furthermore, there is a need for power amplifiers having improved power efficiency.

Certain specific aspects of the present invention relate to the field of integrated circuit packaging, and more particularly to systems and methods of forming wire bond pads for packaging radio frequency (RF) integrated circuits (ICs).

Silicon or other semiconductor wafers are fabricated into integrated circuits as is known to one of ordinary skill in the art of IC fabrication. An IC is bonded and electrically connected to a carrier or substrate, which has layers of dielectric and metal traces, and packaged for use. A surface plating material is plated onto the top layer of copper traces to provide electrical connection points between the IC and the substrate, permitting the IC to interface with the outside world. Traditionally, nickel/gold (Ni/Au) has been a standard surface plating material for RFIC products and in certain situations, the RFIC is wire-bonded to the Ni/Au wire-bond pads plated on the surface of the substrate to form the electrical connections of the RFIC with its package. However, increases in gold prices have increased packaging costs associated with the Ni/Au surface plating.

Other particular aspects of the present invention relate to the field of integrated circuit layout and packaging, and more particularly to systems and methods of layout and packaging of radio frequency (RF) integrated circuits (ICs).

Still other aspects of this invention more particularly to bipolar transistors and products that include bipolar transistors. Bipolar transistors, such as heterojunction bipolar transistors (HBTs), are implemented in a wide variety of applications. Such bipolar transistors can be formed on semiconductor substrates, such as gallium arsenide (GaAs) substrates. One illustrative application for a bipolar transistor is in a power amplifier system. As technology evolves, specifications for power amplifier systems have become more demanding to meet.

As indicated above, one aspect of power amplifier performance is linearity. Measures of linearity performance can include channel power ratios, such as the adjacent channel power ratio (ACPR1) and the alternative channel power ratio (ACPR2), and/or channel leakage power ratios, such as an adjacent channel leakage power ratio (ACLR1) and an alternative channel leakage power ratio (ACLR2). ACPR2 and ACLR2 can be referred to as second channel linearity measures. ACPR2 and ACLR2 values can correspond at measurements at an offset of about 1.98 MHz from a frequency of interest.

Conventionally, most publications in the literature have focused on ACPR1 and ACLR1 linearity measures and little has been published about ACPR2 or ACLR2. Recent ACPR2 and ACLR2 system specifications from industry have been particularly difficult to meet, especially while meeting other system specifications related to RF gain. Accordingly, a need exists for improved linearity in systems that include bipolar transistors, such as power amplifier systems.

Yet still further aspects of the present disclosure relate to a dual mode digital control interface for power amplifiers.

A number of electronic devices, including wireless devices, may have one or more components that are controlled or set by a front-end component. For example, a power amplifier may be set or configured by a power amplifier controller. In some cases, the power amplifier controller may itself be controlled or configured by another interface component based on the state of the device.

Often, various components within a device will be created by different organizations. To facilitate interoperability between components, which may be designed by different organizations, standards are often adopted for different types of devices and components. As technology advances, standards may change or new standards may be adopted. In some cases, the newer standards are not compatible with the older standards.

And still yet other aspects of the present invention relate to heterojunction bipolar transistor (HBT) power amplifier bias circuits. Power amplifiers are typically active elements that can magnify an input signal to yield an output signal that is significantly larger than the input signal. Many types of power amplifiers exist and there are many ways to create power amplifiers. For example, some power amplifiers can be created using heterojunction bipolar transistors (HBT). Many HBT power amplifiers use a diode stack bias configuration. In some such configurations, the diode stack bias configuration exhibits sensitivity to the device beta, which can result in substantial quiescent current variation of the amplifier. Further, the variation of quiescent current may impact performance parameters and may degrade product yield.

Further aspects hereof relate to the understanding that in some semiconductor material systems it is possible to combine different device technologies on a single semiconductor die to form hybrid structures. For example, in certain material systems, it is possible to integrate a heterojunction bipolar