POWER AMPLIFICATION WITH REDUCED GAIN VARIATION

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority to U.S. Provisional Application No. 63/168,870 filed March 31, 2021, entitled POWER AMPLIFICATION WITH REDUCED GAIN VARIATION, the disclosure of which is hereby expressly incorporated by reference herein in its respective entirety.

BACKGROUND

Field

[0002] The present disclosure relates to power amplification of signals such as radio-frequency (RF) signals.

Description of the Related Art

[0003] In many radio-frequency (RF) applications, it is desirable to amplify a signal. In an example context of a transmit operation, such amplification of signal can provide power amplification of the signal, and the power-amplified signal can be transmitted from an RF device such as a wireless device.

SUMMARY

[0004] In accordance with an aspect, the present disclosure relates to a power amplifier that includes an input stage that includes an amplifying transistor having an input node and an output node, such that a signal at the input node has a first power level and an amplified signal at the output node has a second power level. The power amplifier further includes a bias circuit configured to provide a bias signal to the amplifying transistor, and a feedback circuit that couples the output node of the amplifying transistor to the input node of the amplifying transistor. The feedback circuit includes a resistance and a capacitance arranged in series. The power amplifier further includes a gain compensation circuit implemented relative to the input stage such that the second power level is compensated for a variation in temperature associated with the power amplifier.

[0010] In some embodiments, the gain compensation circuit can include a variable capacitance circuit configured to provide a variable capacitance value based on the variation in temperature. The variable capacitance value can provide some or all of the capacitance of the feedback circuit. The variable capacitance circuit can be configured to provide a plurality of discrete values based on the variation in temperature. The variable capacitance circuit can include a plurality of capacitances arranged to be electrically parallel, with at least one of the plurality of capacitances being configured to be switchable.

[0011] In some embodiments, the variable capacitance circuit can be configured to provide analog values based on the variation in temperature. The variable capacitance circuit can include a diode capacitance circuit controlled by a control signal that depends on the variation in temperature. The variable capacitance circuit can include a plurality of diodes and controlled by a control voltage to provide the variable capacitance value based on the variation in temperature. The control voltage being provided to the variable capacitance circuit can depend on the variation in temperature. The plurality of diodes can include a first diode and a second diode arranged such that an anode of the first diode is on an input side of the variable capacitance circuit, and anode of the second diode is on an output side of the variable capacitance circuit, and cathodes of the first and second diodes are coupled to each other, with the control voltage being provided to a node between the cathodes of the first and second diodes.

[0012] In some embodiments, the power amplifier can further include a second stage configured to further amplify the amplified signal from the input stage. In some embodiments, the second stage can include first and second amplifying transistors arranged in a cascode configuration.

[0013] In some embodiments, the bias circuit can be configured such that the bias signal provided to the amplifying transistor depends on the variation in temperature. The bias circuit can be configured to utilize a reference current to generate the bias signal, with the reference current depending on the variation in temperature.

[0014] In an aspect, the present disclosure relates to a semiconductor die that includes a substrate and a power amplifier implemented on the substrate. The power amplifier includes an input stage that includes an

amplifying transistor having an input node and an output node, such that a signal at the input node has a first power level and an amplified signal at the output node has a second power level. The power amplifier further includes a feedback circuit that couples the output node of the amplifying transistor to the input node of the amplifying transistor. The feedback circuit includes a resistance and a capacitance arranged in series. The power amplifier further includes a gain compensation circuit implemented relative to the input stage such that the second power level is compensated for a variation in temperature associated with the power amplifier.

[0015] In some embodiments, the power amplifier can further include a bias circuit configured to provide a bias signal to the amplifying transistor.

[0016] In an aspect, the present disclosure relates to a packaged module that includes a packaging substrate and a semiconductor die mounted on the packaging substrate and including a power amplifier. The power amplifier includes an input stage that includes an amplifying transistor having an input node and an output node, such that a signal at the input node has a first power level and an amplified signal at the output node has a second power level. The power amplifier further includes a feedback circuit that couples the output node of the amplifying transistor to the input node of the amplifying transistor. The feedback circuit includes a resistance and a capacitance arranged in series. The power amplifier further includes a gain compensation circuit implemented relative to the input stage such that the second power level is compensated for a variation in temperature associated with the power amplifier.

[0017] In some embodiments, the packaged module can further include a bias circuit configured to provide a bias signal to the amplifying transistor. In some embodiments, the bias circuit can be implemented on the semiconductor die.

[0018] In some embodiments, the packaged module can further include one or more passive devices with each generating at least some heat during operation of the power amplifier. The variation in temperature can result from either or both of operation of the power amplifier and use of the one or more passive devices.

In an aspect, the present disclosure relates to a wireless device that includes a transceiver configured to generate a signal, and a