SUMMARY

[0006] Aspects of this disclosure relate to techniques and electronic systems which can be used to improve power amplifier biasing. For example, in one example, a power amplifier system, includes a bias circuit configured to receive a bias voltage and generate a bias signal; a power amplifier stage configured to receive an input radio frequency signal and generate an output radio frequency signal. The system further includes a bias impedance component operatively coupled between the bias circuit and the power amplifier stage, the bias impedance component configured to receive a control signal and adjust an impedance value of the bias impedance component in response to the control signal.

[0007] A method of adjusting a gain of a power amplifier stage is provided according to the disclosure. The method includes receiving, at a bias circuit, a bias voltage, generating, by the bias circuit, a bias signal based on the bias voltage, and receiving, at a bias impedance component, the bias voltage and a control signal. The method further includes adjusting, at the bias impedance component, an impedance value of the bias impedance component based on the received control signal, receiving, at a power amplifier stage, an input radio frequency signal and the bias voltage from the bias impedance component, and generating an output radio frequency signal based on the input radio frequency signal and the bias voltage.

[0008] A mobile device is provided according to the disclosure. The mobile device includes a power amplifier configured to amplify an input radio frequency signal and generate an output radio frequency signal and a modulator configured to generate a radio frequency transmit signal based on the output radio frequency signal. The power amplifier includes a bias circuit configured to receive a bias voltage and generate a bias signal, a power amplifier stage configured to receive the input radio frequency signal and generate the output radio frequency signal, and a bias impedance component operatively coupled between the bias circuit and the power amplifier stage. The bias impedance component is configured to receive a control signal and adjust an impedance value of the bias impedance component in response to the control signal.According to an aspect of the disclosure, there is provide a power amplifier system comprising:

a bias circuit configured to receive a bias voltage and generate a bias signal;

a power amplifier stage configured to receive an input radio frequency signal and generate an output radio frequency signal; and

a bias impedance component operatively coupled between the bias circuit and the power amplifier stage, the bias impedance component including a transistor configured to receive a control signal and adjust an impedance value of the transistor in response to the control signal, the bias impedance component configured to apply the impedance value of the transistor to bias the power amplifier stage, the control signal being received separately from the bias circuit. According to another aspect, there is provided a method of adjusting a gain of a power amplifier stage, comprising:

receiving, at a bias circuit, a bias voltage;

generating, by the bias circuit, a bias signal based on the bias voltage;

receiving, at a bias impedance component, the bias voltage and a control signal, the bias impedance component including a transistor, the control signal being received separately from the bias circuit;

adjusting, at the bias impedance component, an impedance value of the transistor based on the received control signal;

applying the impedance value of the transistor to the bias voltage:

receiving, at a power amplifier stage, an input radio frequency signal and the bias voltage from the bias impedance component; and

generating an output radio frequency signal based on the input radio frequency signal and the bias voltage.

Claims

1. A power amplifier system, comprising:
a bias circuit configured to receive a bias voltage and generate a bias signal;
a power amplifier stage configured to receive an input radio frequency signal and generate an output radio frequency signal; and
a bias impedance component operatively coupled between the bias circuit and the power amplifier stage, the bias impedance component including a transistor configured to receive a control signal and adjust an impedance value of the transistor in response to the control signal, the bias impedance component configured to apply the impedance value of the transistor to bias the power amplifier stage, the control signal being received separately from the bias circuit.

2. THE POWER AMPLIFIER SYSTEM OF CLAIM 1 WHEREIN THE CONTROL SIGNAL HAS A VOLTAGE CONFIGURED TO OPERATE THE TRANSISTOR IN A TRIODE REGION OF THE TRANSISTOR.

3. THE POWER AMPLIFIER SYSTEM OF CLAIM 2 WHEREIN THE TRANSISTOR INCLUDES A FIELD EFFECT TRANSISTOR AND THE POWER AMPLIFIER INCLUDES A HETEROJUNCTION BIPOLAR TRANSISTOR CONFIGURED TO AMPLIFY THE INPUT RADIO FREQUENCY SIGNAL.

4. THE POWER AMPLIFIER SYSTEM OF CLAIM 3 WHEREIN THE FIELD EFFECT TRANSISTOR AND THE HETEROJUNCTION BIPOLAR TRANSISTOR ARE FABRICATED ON A SINGLE SEMICONDUCTOR DIE.

5. THE POWER AMPLIFIER SYSTEM OF CLAIM 1 WHEREIN THE IMPEDANCE VALUE OF THE TRANSISTOR IS SELECTED SUCH THAT VARIATION IN A GAIN OF THE POWER AMPLIFIER STAGE IS LESS THAN A THRESHOLD VALUE FROM 0 DB/DM.

6. THE POWER AMPLIFIER SYSTEM OF CLAIM 1, FURTHER COMPRISING:
AN ADDITIONAL BIAS CIRCUIT CONFIGURED TO RECEIVE THE BIAS VOLTAGE AND GENERATE AN ADDITIONAL BIAS SIGNAL;
AN ADDITIONAL POWER AMPLIFIER STAGE CONFIGURED TO RECEIVE THE OUTPUT RADIO FREQUENCY SIGNAL FROM THE POWER AMPLIFIER STAGE AND GENERATE AN ADDITIONAL RADIO FREQUENCY OUTPUT SIGNAL; AND

AN ADDITIONAL BIAS IMPEDANCE COMPONENT OPERATIVELY COUPLED BETWEEN THE ADDITIONAL BIAS CIRCUIT AND THE ADDITIONAL POWER AMPLIFIER STAGE, THE ADDITIONAL BIAS IMPEDANCE COMPONENT CONFIGURED TO RECEIVE AN ADDITIONAL CONTROL SIGNAL AND ADJUST AN IMPEDANCE VALUE OF THE ADDITIONAL BIAS IMPEDANCE COMPONENT IN RESPONSE TO THE ADDITIONAL CONTROL SIGNAL.

7. THE POWER AMPLIFIER SYSTEM OF CLAIM 6, WHEREIN THE IMPEDANCE VALUE OF THE TRANSISTOR AND THE IMPEDANCE VALUE OF THE ADDITIONAL BIAS IMPEDANCE COMPONENT ARE SELECTED SUCH THAT VARIATION IN AN OVERALL GAIN OF THE POWER AMPLIFIER STAGE AND THE ADDITIONAL POWER AMPLIFIER STAGE IS LESS THAN A THRESHOLD VALUE FROM 0 DB/DM.

8. THE POWER AMPLIFIER SYSTEM OF CLAIM 1 FURTHER COMPRISING AN ADDITIONAL BIAS IMPEDANCE COMPONENT OPERATIVELY COUPLED BETWEEN THE BIAS IMPEDANCE COMPONENT AND THE POWER AMPLIFIER STAGE, THE ADDITIONAL BIAS IMPEDANCE COMPONENT CONFIGURED TO RECEIVE THE CONTROL SIGNAL AND ADJUST AN IMPEDANCE VALUE OF THE ADDITIONAL BIAS IMPEDANCE COMPONENT IN RESPONSE TO THE CONTROL SIGNAL.

9. THE POWER AMPLIFIER SYSTEM OF CLAIM 1 WHEREIN THE POWER AMPLIFIER STAGE IS CONFIGURED TO GENERATE THE OUTPUT RADIO FREQUENCY SIGNAL HAVING A FIRST CURRENT, THE BIAS CIRCUIT CONFIGURED TO GENERATE THE BIAS SIGNAL HAVING A SECOND CURRENT THAT MIRRORS THE FIRST CURRENT.

10. A METHOD OF ADJUSTING A GAIN OF A POWER AMPLIFIER STAGE, COMPRISING:
RECEIVING, AT A BIAS CIRCUIT, A BIAS VOLTAGE;
GENERATING, BY THE BIAS CIRCUIT, A BIAS SIGNAL BASED ON THE BIAS VOLTAGE;
RECEIVING, AT A BIAS IMPEDANCE COMPONENT, THE BIAS VOLTAGE AND A CONTROL SIGNAL, THE BIAS IMPEDANCE COMPONENT INCLUDING A TRANSISTOR, THE CONTROL SIGNAL BEING RECEIVED SEPARATELY FROM THE BIAS CIRCUIT;
ADJUSTING, AT THE BIAS IMPEDANCE COMPONENT, AN IMPEDANCE VALUE OF

THE TRANSISTOR BASED ON THE RECEIVED CONTROL SIGNAL;
APPLYING THE IMPEDANCE VALUE OF THE TRANSISTOR TO THE BIAS VOLTAGE:
RECEIVING, AT A POWER AMPLIFIER STAGE, AN INPUT RADIO FREQUENCY SIGNAL AND THE BIAS VOLTAGE FROM THE BIAS IMPEDANCE COMPONENT; AND
GENERATING AN OUTPUT RADIO FREQUENCY SIGNAL BASED ON THE INPUT RADIO FREQUENCY SIGNAL AND THE BIAS VOLTAGE.

11. THE METHOD OF CLAIM 10 WHEREIN THE CONTROL SIGNAL HAS A VOLTAGE CONFIGURED TO OPERATE THE TRANSISTOR IN A TRIODE REGION OF THE TRANSISTOR.

12. THE METHOD OF CLAIM 11 WHEREIN THE TRANSISTOR INCLUDES A FIELD EFFECT TRANSISTOR AND THE POWER AMPLIFIER INCLUDES A HETEROJUNCTION BIPOLAR TRANSISTOR, THE METHOD FURTHER COMPRISING AMPLIFYING, AT THE HETEROJUNCTION BIPOLAR TRANSISTOR, THE INPUT RADIO FREQUENCY SIGNAL.

13. THE METHOD OF CLAIM 12 WHEREIN THE FIELD EFFECT TRANSISTOR AND THE HETEROJUNCTION BIPOLAR TRANSISTOR ARE FABRICATED ON A SINGLE SEMICONDUCTOR DIE.

14. THE METHOD OF CLAIM 10 FURTHER COMPRISING SELECTING A VOLTAGE OF THE CONTROL SIGNAL TO PRODUCE THE IMPEDANCE VALUE OF THE TRANSISTOR SUCH THAT VARIATION IN A GAIN OF THE POWER AMPLIFIER STAGE IS LESS THAN A THRESHOLD VALUE FROM 0 DB/DM.

15. THE METHOD OF CLAIM 10 FURTHER COMPRISING:
RECEIVING, AT AN ADDITIONAL BIAS IMPEDANCE COMPONENT, THE BIAS VOLTAGE FROM THE BIAS IMPEDANCE COMPONENT AND THE CONTROL SIGNAL; AND
ADJUSTING, AT THE ADDITIONAL BIAS IMPEDANCE COMPONENT, AN IMPEDANCE VALUE OF THE ADDITIONAL BIAS IMPEDANCE COMPONENT BASED ON THE RECEIVED CONTROL SIGNAL, THE ADDITIONAL BIAS IMPEDANCE COMPONENT OPERATIVELY COUPLED BETWEEN THE BIAS IMPEDANCE COMPONENT AND THE AMPLIFIER STAGE.

16. A MOBILE DEVICE, COMPRISING:
A POWER AMPLIFIER CONFIGURED TO AMPLIFY AN INPUT RADIO FREQUENCY SIGNAL AND GENERATE AN OUTPUT RADIO FREQUENCY SIGNAL; AND
A MODULATOR CONFIGURED TO GENERATE A RADIO FREQUENCY TRANSMIT SIGNAL BASED ON THE OUTPUT RADIO FREQUENCY SIGNAL,
THE POWER AMPLIFIER INCLUDING A BIAS CIRCUIT CONFIGURED TO RECEIVE A BIAS VOLTAGE AND GENERATE A BIAS SIGNAL, A POWER AMPLIFIER STAGE CONFIGURED TO RECEIVE THE INPUT RADIO FREQUENCY SIGNAL AND GENERATE THE OUTPUT RADIO FREQUENCY SIGNAL, AND A BIAS IMPEDANCE COMPONENT OPERATIVELY COUPLED BETWEEN THE BIAS CIRCUIT AND THE POWER AMPLIFIER STAGE, THE BIAS IMPEDANCE COMPONENT INCLUDING A TRANSISTOR CONFIGURED TO RECEIVE A CONTROL SIGNAL AND ADJUST AN IMPEDANCE VALUE OF THE TRANSISTOR IN RESPONSE TO THE CONTROL SIGNAL, THE BIAS IMPEDANCE COMPONENT CONFIGURED TO APPLY THE IMPEDANCE VALUE OF THE TRANSISTOR TO BIAS THE POWER AMPLIFIER STAGE, THE POWER AMPLIFIER FURTHER INCLUDES AN ADDITIONAL BIAS IMPEDANCE COMPONENT OPERATIVELY COUPLED BETWEEN THE BIAS IMPEDANCE COMPONENT AND THE POWER AMPLIFIER STAGE, THE ADDITIONAL BIAS IMPEDANCE COMPONENT CONFIGURED TO RECEIVE THE CONTROL SIGNAL AND ADJUST AN IMPEDANCE VALUE OF THE ADDITIONAL BIAS IMPEDANCE COMPONENT IN RESPONSE TO THE CONTROL SIGNAL.

17. THE MOBILE DEVICE OF CLAIM 16 WHEREIN THE CONTROL SIGNAL HAS A VOLTAGE CONFIGURED TO OPERATE THE TRANSISTOR IN A TRIODE REGION OF THE TRANSISTOR.

18. THE MOBILE DEVICE OF CLAIM 17 WHEREIN THE TRANSISTOR INCLUDES A FIELD EFFECT TRANSISTOR AND THE POWER AMPLIFIER INCLUDES A HETEROJUNCTION BIPOLAR TRANSISTOR CONFIGURED TO AMPLIFY THE INPUT RADIO FREQUENCY SIGNAL.

19. THE MOBILE DEVICE OF CLAIM 18 WHEREIN THE FIELD EFFECT TRANSISTOR AND THE HETEROJUNCTION BIPOLAR TRANSISTOR ARE FABRICATED ON A SINGLE

SEMICONDUCTOR DIE.

20. THE MOBILE DEVICE OF CLAIM 16 WHEREIN THE IMPEDANCE VALUE OF THE TRANSISTOR IS SELECTED SUCH THAT VARIATION IN A GAIN OF THE POWER AMPLIFIER STAGE IS LESS THAN A THRESHOLD VALUE FROM 0 DB/DM.