POWER AMPLIFIER POWER MANAGEMENT IN USER EQUIPMENT

BACKGROUND

Field

[0001] Embodiments of the invention relate to electronic systems, and in particular, to radio frequency electronics.

Description of Related Technology

[0002] Radio frequency (RF) communication systems can be used for transmitting and/or receiving signals of a wide range of frequencies. For example, an RF communication system can be used to wirelessly communicate RF signals in a frequency range of about 30 kHz to 300 GHz, such as in the range of about 410 MHz to about 7.125 GHz for fifth generation (5G) communications using Frequency Range 1 (FR1) or in the range of about 24.25 GHz to 52.6 GHz for 5G communications using Frequency Range 2 (FR2).

[0003] Examples of RF communication systems include, but are not limited to, mobile phones, tablets, base stations, network access points, customer-premises equipment (CPE), laptops, and wearable electronics.

SUMMARY

[0004] In certain embodiments, the present disclosure relates to a mobile device. The mobile device includes a transceiver configured to generate a radio frequency signal, a front-end system including a first power amplifier module configured to amplify the radio frequency signal, and a power management system including an envelope tracking power management unit configured to provide an envelope tracking supply voltage to the first power amplifier module, and a first average power tracking power management unit configured to provide an average power tracking supply voltage to the first power amplifier module, the first power amplifier module configured to selectively switch between the envelope tracking supply voltage and the average power tracking supply voltage. In an example, there is provided a phone board assembly for a mobile phone, the phone board assembly comprising: a first power amplifier module configured to amplify a first radio frequency signal; a second power amplifier module configured to amplify a second radio frequency signal; and a first multi-mode power management unit configured to generate a first shared power amplifier supply voltage for the first power amplifier module and the second power amplifier module, the first multi-mode power management unit operable in a plurality of modes including an envelope tracking mode and an average power tracking mode. In an example, there is a provided a method of power

management in a mobile device, the method comprising: amplifying a first radio frequency signal using a first power amplifier module; amplifying a second radio frequency signal using a second power amplifier module; and generating a first shared power amplifier supply voltage for the first power amplifier module and the second power amplifier module using a first multi-mode power management unit that is operable in a plurality of modes including an envelope tracking mode and an average power tracking mode.

[0004a] In an aspect, the present disclosure refers to a mobile device comprising:

a transceiver configured to generate a low band radio frequency signal;

a front-end system including a shared low band and second generation power amplifier module configured to amplify the low band radio frequency signal in a low band mode and a second generation radio frequency signal in a second generation mode; and

a power management system including an envelope tracking power management unit configured to provide an envelope tracking supply voltage to the shared low band and second generation power amplifier module, and a first average power tracking power management unit configured to provide an average power tracking supply voltage to the shared low band and second generation power amplifier module, the shared low band and second generation power amplifier module including a supply voltage switch configured to select the envelope tracking supply voltage in the second generation mode and the average power tracking supply voltage in the low band mode.

[0004b] In an aspect, the present disclosure refers to a phone board assembly for a mobile phone, the phone board assembly comprising:

a shared low band and second generation power amplifier module configured to amplify a low band radio frequency signal in a low band mode and a second generation radio frequency signal in a second generation mode;

an envelope tracking power management unit configured to provide an envelope tracking supply voltage to the shared low band and second generation power amplifier module; and

a first average power tracking power management unit configured to provide an average power tracking supply voltage to the shared low band and second generation power amplifier module, the shared low band and second generation power amplifier module including a supply voltage switch configured to select the envelope tracking supply voltage in the second generation mode and the average power tracking supply voltage in the low band mode.

[0004c] In an aspect, the present disclosure refers to a method of power management in a mobile device, the method comprising:

amplifying a low band radio frequency signal using a shared low band and second generation power amplifier module in a low band mode;

amplifying a second generation radio frequency signal using the shared low band and second generation power amplifier module in a second generation mode;

providing an envelope tracking supply voltage to the shared low band and second generation power amplifier module using an envelope tracking power management unit;

providing an average power tracking supply voltage to the shared low band and second generation power amplifier module using a first average power tracking power management unit;

selecting the envelope tracking supply voltage using a supply voltage switch of the shared low band and second generation power amplifier module in the second generation mode; and

selecting the average power tracking supply voltage using the supply voltage switch of the shared low band and second generation power amplifier module in the low band mode.

[0005] In some embodiments, the first power amplifier module is configured to provide amplification in a low band.

WHAT IS CLAIMED IS:

1. A mobile device comprising:
a transceiver configured to generate a low band radio frequency signal;
a front-end system including a shared low band and second generation power amplifier module configured to amplify the low band radio frequency signal in a low band mode and a second generation radio frequency signal in a second generation mode; and
a power management system including an envelope tracking power management unit configured to provide an envelope tracking supply voltage to the shared low band and second generation power amplifier module, and a first average power tracking power management unit configured to provide an average power tracking supply voltage to the shared low band and second generation power amplifier module, the shared low band and second generation power amplifier module including a supply voltage switch configured to select the envelope tracking supply voltage in the second generation mode and the average power tracking supply voltage in the low band mode.

2. The mobile phone of claim 1 wherein the front-end system further includes a first mid band and high band power amplifier module configured to receive power from the envelope tracking supply voltage and a second mid band and high band power amplifier module configured to receive power from the average power tracking supply voltage.

3. The mobile phone of claim 2 wherein the front-end system further includes an ultrahigh band power amplifier module configured to receive power from the average power tracking supply voltage.

4. The mobile phone of claim 2 wherein the power management system further includes an ultrahigh band power amplifier module and a second average power tracking power management unit configured to provide power to the ultrahigh band power amplifier module.

5. The mobile phone of claim 1 wherein the first average power tracking power management unit and the shared low band and second generation power amplifier module are on a first side of the mobile phone and the envelope tracking power management unit is on a second side of the mobile phone, the envelope tracking supply voltage crossing from the second side to the first side in the second generation mode.

6. The mobile phone of claim 1 wherein the low band radio frequency signal is a fourth generation signal or a fifth generation signal.

7. A phone board assembly for a mobile phone, the phone board assembly comprising:
a shared low band and second generation power amplifier module configured to amplify a low band radio frequency signal in a low band mode and a second generation radio frequency signal in a second generation mode;
an envelope tracking power management unit configured to provide an envelope tracking supply voltage to the shared low band and second generation power amplifier module; and
a first average power tracking power management unit configured to provide an average power tracking supply voltage to the shared low band and second generation power amplifier module, the shared low band and second generation power amplifier module including a supply voltage switch configured to select the envelope tracking supply voltage in the second generation mode and the average power tracking supply voltage in the low band mode.

8. The phone board assembly of claim 7 further comprising a first mid band and high band power amplifier module configured to receive power from the envelope tracking supply voltage and a second mid band and high band power amplifier module configured to receive power from the average power tracking supply voltage.

9. The phone board assembly of claim 7 further comprising an ultrahigh band power amplifier module, the first average power tracking power management unit further configured to power the ultrahigh band power amplifier module.

10. The phone board assembly of claim 7 further comprising an ultrahigh band power amplifier module and a second average power tracking power management unit configured to power the ultrahigh band power amplifier module.

11. The phone board assembly of claim 7, wherein the first average power tracking power management unit and the shared low band and second generation power amplifier module are on a first side of the phone board assembly and the envelope tracking power management unit is on a second side of the phone board assembly, the envelope tracking supply voltage crossing from the second side to the first side in the second generation mode.

12. The phone board assembly of claim 7 wherein the low band radio frequency signal has a frequency content of 1 gigahertz or less.

13. The phone board assembly of claim 7 wherein the low band radio frequency signal is a fourth generation signal or a fifth generation signal.

14. A method of power management in a mobile device, the method comprising:
amplifying a low band radio frequency signal using a shared low band and second generation power amplifier module in a low band mode;
amplifying a second generation radio frequency signal using the shared low band and second generation power amplifier module in a second generation mode;
providing an envelope tracking supply voltage to the shared low band and second generation power amplifier module using an envelope tracking power management unit;
providing an average power tracking supply voltage to the shared low band and second generation power amplifier module using a first average power tracking power management unit;
selecting the envelope tracking supply voltage using a supply voltage switch of the shared low band and second generation power amplifier module in the second generation mode; and
selecting the average power tracking supply voltage using the supply voltage switch of the shared low band and second generation power amplifier module in the low band mode.

15. The method of claim 14 further comprising powering a first mid band and high band power amplifier module using the envelope tracking supply voltage and powering a second mid band and high band power amplifier module using the average power tracking supply voltage.

16. The method of claim 14 further comprising powering an ultrahigh band power amplifier module using the first average power tracking power management unit.

17. The method of claim 14 further comprising powering an ultrahigh band power amplifier module using a second average power tracking power management unit.

18. The method of claim 14 wherein the first average power tracking power management unit and the shared low band and second generation power amplifier module are on a first side of a

mobile phone and the envelope tracking power management unit is on a second side of the mobile phone, the method further comprising providing the envelope tracking supply voltage from the second side to the first side in the second generation mode.

19. The method of claim 14 wherein the low band radio frequency signal has a frequency content of 1 gigahertz or less.

20. The method of claim 14 wherein the low band radio frequency signal is a fourth generation signal or a fifth generation signal.