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Adaptive Biasing Of Radio-Frequency Power Amplifiers

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ABSTRACT

Radio-frequency (RF) power amplifiers (PA) have a nearly linear response only at small input amplitudes, with their outputs gradually saturating as input amplitudes increase. This slightly sub-linear transfer characteristic gives rise to out-of-band emissions, which can potentially interfere with other users of the RF spectrum. Regulatory requirements place limits on the maximum out-of-band emissions by a device. In turn, these translate to operating the PA at a highly linear region, e.g., at low input amplitudes compared to the dynamic range of the PA. However, low input amplitudes are associated with low PA efficiencies. This disclosure describes techniques to adapt the operating point of the PA to suit the targeted output power and/or bandwidth. By doing so, the emissions mask is met even as the PA operates at its worst conditions, and energy efficiencies are achieved when the device is operating at its most efficient conditions. The techniques reduce current drain and heat dissipation, and improve battery life.

KEYWORDS

- Power amplifier
- Radio-frequency PA
- Amplifier efficiency
- Amplifier bias
- Energy efficiency
- Quiescent current
- Adaptive biasing
- Long-term evolution (LTE)

BACKGROUND

Radio-frequency (RF) power amplifiers (PA) have a nearly linear response only at small input amplitudes, with their outputs gradually saturating as input amplitudes increase. This slightly sub-linear transfer characteristic gives rise to out-of-band emissions, which can potentially interfere with other users of the RF spectrum. Regulatory requirements place limits on the maximum out-of-band emissions by a device. In turn, these translate to operating the PA at a highly linear region, e.g., at low input amplitudes compared to the dynamic range of the PA. However, low input amplitudes are associated with low PA efficiencies.

In present practice, the bias current of the PA is set such that the incoming signal faces the most linear region of the PA without regard to the bandwidth or target output power of the incoming signal. For example, the PA is set to a high linearity region even when the output power or bandwidth is low. Doing so ensures compliance with the regulatory mask, but disregarding the incoming signal bandwidth or target output power can result in a worst-case PA setting, e.g., operating the PA at low efficiency, even if the worst-case PA setting is not necessary.

DESCRIPTION

The techniques of this disclosure utilize the fact that a communications device, e.g., a mobile phone, is not always operated under worst-case conditions. Accordingly, knowledge of the incoming signal bandwidth is utilized to set the bias, e.g., operating point, of the power amplifier.

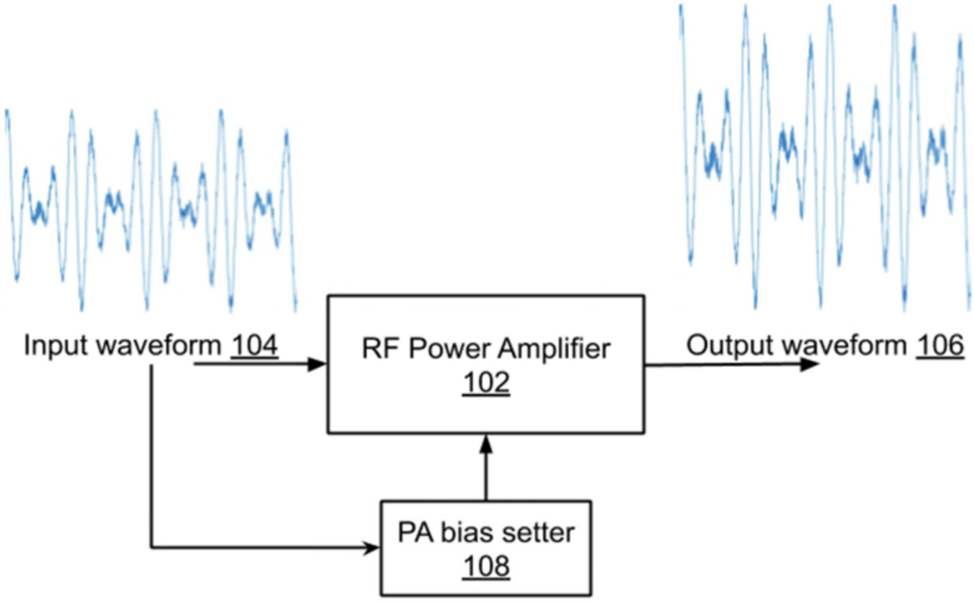

Fig. 1: Adaptive setting of RF PA bias

Fig. 1 illustrates adaptive setting of RF PA bias to optimize efficiency while meeting regulator (e.g., FCC) requirements, per techniques of this disclosure. The power amplifier (102) accepts as input an input waveform (104) and produces as output an output waveform (106), which is an amplified version of the input waveform. Per the techniques, parameters of the input waveform, e.g., input signal bandwidth, target output power, etc. are provided as input to a PA bias setter (108) that sets the biasing (or quiescent) current of the RF power amplifier. The PA bias is adaptively changed to accommodate the linearity.

For example, for an LTE or 5G cellular signal with a signal bandwidth of 5 Megahertz (MHz), 25 Resource Blocks (RB), the quiescent current can be set to a much lower level than the quiescent current for an LTE or 5G cellular signal with an input bandwidth of 10 MHz, 50 RB. For signals with the same input bandwidth, a lower quiescent current setting is used for a lower target output power than the quiescent current setting used for a higher target output power. For signals with the same input bandwidth, a lower quiescent bias current is used for a signal having a lower number of resource blocks than for a signal having a higher number of resource blocks. The PA bias setting can be further optimized and changed on the fly, e.g., using machine learning. For example, the bias setting can be made to depend on one or more parameters such as the number of resource blocks, modulation type, bandwidth, target output power, RF link situation, etc.

CONCLUSION

This disclosure describes techniques to more dynamically set the operating point of the PA. By doing so, the emissions mask is met even as the PA operates more energy-efficiently across a wide variety of conditions. The techniques reduce current drain and heat dissipation and improve battery life.