4

SWITCHING POWER CONTROL AND TUNABLE MATCHING METHOD FOR MULTIMODE MULTIBAND POWER AMPLIFIER

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1. Introduction

With increasing demand for high data rate services such as: social networking, web browsing, video streaming, music downloads, gaming, and many other popular applications, wireless communication devices are facing the challenge of supporting multiple air interface technologies such as High Speed Packet Access (HSPA), HSPA+, Wideband Code Division Multiple Access (WCDMA) and Long Term Evolution (LTE). Also, with growing number of frequency bands used in different geographies around the world and to facilitate international roaming, these devices are required to operate on number of frequency bands (multiband). Thus, the market for RF front-end components is growing rapidly driven by adoption of multimode, multiband handsets and modems [1].

Table 4.1 shows the list of 2G/3G/4G frequency bands [2] with the power requirement for different applications. For the sake of clarity, we define the frequencies below 1GHz as 'low-band' and those above 1GHz as 'high-band'. Smartphone nowadays need to support up to five 3G frequency bands and up to three 4G frequency bands [1][3]. The trend toward supporting multiple air interfaces standards (multimode) and the trend towards supporting multiple number of frequency bands (multiband) per mode are driving up in the mobile device RF front-ends.

Table 4.1 Commonly used frequency bands and mobile station transmit power specifications

Band	Mobile Station Transmit Frequency (Uplink)	Power Requirements (dBm)	
1	1920 MHz - 1980 MHz		
2	1850 MHz - 1910 MHz	2.5G GSM (class 4)	33+2/-2
3	1710 MHz - 1785 MHz	3G WCDMA (class 3)	24+1/-3
5	824 MHz - 849 MHz	4G LTE (class 3)	23+2/-2
8	880 MHz - 915 MHz		

The conventional smartphone Power Amplifier (PA) architecture, which utilizes one PA for each band in the 3G/4G bands. Thus, if an application requires 3G/HSPA, 4G/LTE, 850/900/1700/1800/1900 bands, it will require 5 PAs in the mobile devices to support global roaming facilities. In the conventional design, a duplexer switch [1] is used to connect one of the PA outputs to the antenna. Multimode multiband (MMMB) PA based on a converged architecture consists of 2 PAs assigned for low-band (850/900 MHz) and high-band (1700/1800/1900 MHz) respectively. A duplexer switch is used to select the PA output to be connected to the antenna which selects either low-band or high-band at a time.

The SKY77603[4] from Skyworks and TQM7M9023[5] from TriQuint utilized the converged PA architecture. There are a few MMMB PA designs reported in the non-CMOS process. For example, the PA presented in [6] is implemented as MMIC in the 2-μm InGaP/GaAs HBT process. It operates in 820 MHz-920 MHz (low-band). The MMMB PA in [7] is implemented with the GAN HEMT process in the 1.3 GHz- 2.7 GHz (high-band). The dual-mode PA presented in [8] using the InGaP/GaAs HBT operates in the 1.7 GHz-2.0 GHz high-band. A GaN HEMT based MMMB PA [9] is presented in the 1.8 GHz -2.3 GHz band.