Chapter 10

Design Issues for Multi-Mode Multi-Standard Transceivers

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ABSTRACT

Multi-mode and multi-band transceivers, i.e., transceivers with the capability to operate in different frequency bands and to support different waveforms and signaling schemes, are objects of intense study. In fact, hardware reuse among different standards would help to reduce production costs, power consumption, and to increase the integration level of a given implementation. The design of such transceivers is indeed very complex, because it not only implies the choice of the architecture more suitable for the target application, but also the choice and the design of reconfigurable building blocks to perform tuning among the different standards and signaling schemes. In addition, different standards may have considerably different requirements in terms of receiver sensitivity, linearity, input dynamic range, error vector magnitude (EVM), signal bandwidth, and data rate, which in turn make the design of a multi-mode reconfigurable transceiver a very challenging task. In this chapter, the authors present the most common techniques and architecture schemes used in modern wireless communication systems supporting standards for cellular, wireless local area networks (WLAN), and wireless personal area networks (WPAN), i.e., GSM, WCDMA, IEEE 802.11 (Wi-Fi), IEEE 802.15.1 (Bluetooth), IEEE 802.15.4 (Zigbee), and IEEE 802.15.3 (UWB). State-of-the-art techniques for multi-standard cellular, WLAN, and WPAN transceivers are thoroughly analyzed and reviewed with special emphasis on those relying on bandpass sampling and multi-rate signal processing schemes.

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1. INTRODUCTION

The widespread use of wireless communications has prompted an ever increasing demand for radio frequency transceivers. Until now, a rich variety of wireless technologies have been standardized and commercialized; however, no single solution is considered the best to satisfy all the communication needs and target applications due to different coverage, power consumption, and bandwidth limitations. Therefore, internetworking between heterogeneous wireless networks is extremely important for achieving ubiquitous and high performance wireless communications. Many studies dedicated to the internetworking of 3G cellular networks and WLAN are available in the literature (Ala-Laurila, et al., 2001; Pahlavan et al., 2000; Salkintzis et al., 2002; Buddhikot et al., 2003), and the support for heterogeneous network interconnection has been finally standardized by the Third Generation Partnership Project (2004). Nonetheless, a wireless device operating under multiple network protocols must mandatorily rely on a multi-standard transceiver (Agnelli et al., 2006).

In modern communication systems, the co-existence of numerous cellular systems requires multi-mode, multiband, and multi-standard mobile terminals that have the capability to process heterogeneous information, i.e., text, voice, audio, and video using different standards, and support seamless handover among different networks with different data rates. This requires a careful design in which the number of the handset components shared by the different standards must be maximized, and the power consumption must be minimized in order to slow down battery depletion and prolong talk time without degrading the performance compared to that of a conventional single-standard transceiver. The simplest way to implement a multi-standard design is by duplicating more than one transceiver; however, this solution is economically unfeasible as well as highly inefficient under the power consumption point of view (Ryynänen et al., 2000).

When different standards do not operate simultaneously, circuit blocks of a multi-standard handset can be shared. This consideration is marking the trend in the design of state-of-the-art reconfigurable and adaptive modules for RF IC. Several multi-mode, multi-band integrated implementations of low-noise amplifiers (Hashemi & Hajimiri, 2001), oscillators (Tasić, Serdijn, & Long, 2005), power amplifiers (Imanishi et al., 2010) and transceivers (Hueber & Staszewski, 2011) are reported in the literature.

Adaptivity and reconfigurability should be implemented at baseband frequencies as well. After a signal is down-converted to the baseband, it must be filtered, amplified and digitized before further processing. To accommodate on a single monolithic transceiver multiple radio standards with different bandwidths and modulation schemes, such receivers should require channel and image reject filters with tunable bandwidths, as well as analogue-to-digital converters with programmable resolutions and dynamic ranges.

The mainstream techniques for implementing multi-mode multi-standard reconfigurable transceivers rely on the Software-defined Radio approach (Burns, 2002; Reed, 2002; Dillinger, Madani, & Alonistioti, 2003). A Software-Defined Radio system (SDR), is a radio communication system where modulation and demodulation operations typically performed by analog components (e.g. mixers, filters, amplifiers, etc.) are instead implemented by means of digital reconfigurable and programmable hardware. Although, a fully digital implementation is actually not possible due to the accuracy and conversion rate limitations of the Analog-to-Digital (ADC) and Digital-to-Analog (DAC) Converters, SDR techniques can be used to replace most of the expensive analog blocks with low-cost reconfigurable digital blocks. However this task is not easy and requires a deep understanding of the basic transceiver architectures and of the standard requirements; in addition,