Multifunctional Microelectronic Wireless Receivers

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Received in final form November 3, 2006

Abstract—Peculiarities and circuitry solutions of the interface section of multifunctional receivers for telecommunications systems have been considered including the issues of building low-noise amplifiers, mixers, heterodynes, channel filters, and analog-to-digital converters. Technical specifications of the devices and the most promising directions of development were presented.

DOI: 10.3103/S0735272707060027

INTRODUCTION

This paper is elaboration of the review [1], which presented the main structural solutions and circuit design of the interface section of radio receivers (RR) for telecommunications systems including RF amplifiers, heterodynes, and mixers, as well as elaboration of papers [2, 3] that dealt with the issues of building microelectronic channel filters and analog-to-digital converters (ADC). This paper considers the most salient (in practical terms) radio systems of mobile communications standards: GSM for voice transmission and WCDMA for data and voice transmission, WLAN on the basis of protocols IEEE 802.11a/b/g for high-speed access to Internet, and Bluetooth for low-speed data transmission at small distances. Table 1, compiled on the basis of materials from publications [4, 5], presents the main characteristics of the above listed systems, namely: modulation frequency band, dynamic range (resolution), and carrier frequency. In order to support the standards with such diverse parameters, RR should possess a high level of universality. In other words, the chip should integrate the multifunctional type units ensuring the signal reception and processing for the maximum possible number of standards. The first publications dealing with the development of multifunctional RR appeared at the end of the 1990s. For example, paper [6] proposed a mobile communications receiver for digital CDMA and analog AMPS standards built in accordance with a parallel circuit, while paper [7] provided an analysis of one of the first two-band low-noise amplifiers (LNA) with variable gain and frequencies 0.9 GHz and 2 GHz having the power gain up to 16 dB that was built on bipolar transistors with boundary frequencies \( f_t = 30 \text{ GHz} \), \( f_{\text{max}} = 60 \text{ GHz} \).

In paper [5] two main approaches were singled out for implementing a multifunctional system: 1. The concurrent reception by several channels (concurrent system). 2. Signal reception of only one standard in a unit of time.

The implementation of competitive systems appears to be the most complex. Moreover, the complexity of devices increases with the growing number of channels received simultaneously. In this case, usually, the fulfillment of the strictest demands is usually required for all the standards. In this connection the main concern of designers is focused on systems of the second type, which will be predominantly considered hereafter.

This paper is organized as follows: after the introduction the first section provides an analysis of the structure solutions of multifunctional receivers, next, the second and subsequent sections consider the circuit design of main units (LNA, mixers, master oscillators, channel filters, and ADC) of multifunctional receivers, and finally the brief inferences are presented.

GENERALIZED STRUCTURES OF MULTIFUNCTIONAL RR

The selection of standards that could be expediently integrated into one RR represents a non-trivial task. One of the conventional options implies the combining of G\( \text{SM} \) standards with different carrier frequencies: EGSM (extended global system for mobile communications), DCS (digital communications system), PCS (personal communications system) [8–11]. However, such circuits shall be expediently called “multiband” rather than “multifunctional”. Indeed, the only difference involves the value of the carrier frequency; hence, after the frequency conversion the structure of the receiver section does not depend on the choice of...