Chapter 8
IIP2 Improvement Techniques
for Multi-standard Mobile Radio

Mohammad B. Vahidfar and Omid Shoaei

8.1 Introduction

An effort toward realization of universal radios, i.e. radios able to tune a carrier
frequency over a wide RF range and supporting high data rate modulations is under-
way [1–4]. This is a trend toward the integration of multiple functions (phone, 
video-game console, personal digital assistant, digital camera, web-browser, e-mail, etc.) into a wireless device that can be used anywhere in the world. Enabling factor
of this evolution is the increasing availability of multi-standard terminals, integrated
in low-cost silicon technologies that can communicate efficiently, using many dif-
ferent standards, for voice and data, depending on the availability and convenience.
The ultimate solution for the radio of such a multi-functional terminal would be a
multi-standard radio, built in a very low-cost CMOS technology, capable of being
programmed to operate according to all major communications standards [1–5].

While progress has been made in DSP and base-band functions of such a termi-
nal, the low voltage low power radio front-end has remained intangible. Hardware
sharing between different applications and programmability are key to save silicon
costs. Direct conversion architecture lends itself to a compact solution, with mini-
um number of external components and a simpler reconfigurable base-band [5–7].
However, several challenging issues including second order intermodulation (IM2)
appears in this kind of receivers. Moreover, the dynamic range requirements set by
cell-phones in particular make the RF radio front-end extremely challenging [8–10].

In this manuscript, we focus the attention on the down-conversion mixer, the ma-
jor responsible one for the limited dynamic range in the RF front-end, investigating
a high second order input intercept-point (IIP2) reconfigurable Gilbert type solution.
In a perfectly balanced down converter, the even-order distortion caused by device nonlinearity would not appear in the signal path. However, in a practical situation where mismatch in the load and switching transistors exist, the even-order intermodulation appears in the signal path. The even-order nonlinearity can be reduced by using differential topology and symmetric layout, but the required performance especially for cellular phone applications can not be met.

An effective solution for improving IIP2 is using an external SAW filter between LNA and mixer in order to make the mixer linearity requirement relaxed by attenuating the out of bands blockers [11–13]. This solution is expensive and also for multi-standard application realizing a multi-standard (MS) tunable SAW is necessary. There are already MS SAWs for the main GSM bands, with low insertion loss, while electronically tunable MS SAWs are in their research phase [14].

Therefore, to meet the required IIP2 performance, especially for cellular phone applications in sub scaled CMOS technologies with low voltage supplies, using some IIP2 improvement techniques including on-chip calibration circuits [15–18] or analog techniques [10, 19, 20] is necessary. The core competency of analog techniques is being simple and consuming lower power, while generally using several techniques is needed to be considered in order to cancel the IM2 components generated by different sources. However the calibration techniques, which are usually complex, are less sensitive in PVT variation and are capable of cancelling IM2 components generated by different sources and mechanisms. In this manuscript, both analog techniques and calibration circuits are considered for enhancing mixer IIP2 performance in multi-standard applications. Considering multi-standard, the main standards for personal communications currently deployed: GSM and UMTS, for cellular telephony and IEEE802.11b-g-a for wireless local area network access are assumed. These standard are in 1–6 GHz frequency range which is today crowded of a variety of standards for wireless communications (Fig. 8.1).

The manuscript is organized as follows. The IIP2 performance required by MS-radio is discussed in Section 8.2. The IM2 sources in an active mixer are introduced in Section 8.3. The proposed IIP2 improvement techniques are presented in Sections 8.4–8.6 while Section 8.7 draws conclusions.

![Multi-standard frequency spectrum](image-url)