Design and Implementation of a High-Performance 79 GHz Up-Conversion Mixer in 90 nm CMOS

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Abstract—A 79 GHz mixer for direct up-conversion using standard 90 nm CMOS technology is reported. The mixer comprises an enhanced double-balanced Gilbert cell with current injection for power consumption reduction, and dual negative resistance compensation for conversion gain (CG) enhancement, a Marchand balun for converting the single LO input signal to differential signal, and another Marchand balun for converting the differential RF output signal to single signal. The mixer consumes 13.6 mW and achieves IF-port input reflection coefficient ($S_{11}$) of $-11.4$ dB at 0.1 GHz, LO-port input reflection coefficient ($S_{12}$) of $-12.2$ to $-28.7$ dB for frequencies $75$–$90$ GHz. At IF of 0.1 GHz and RF of 78.1 GHz, the mixer achieves CG of 2.1 dB and LO-RF isolation of 35.9 dB, the best CG and isolation results ever reported for a W-band CMOS/ BiCMOS mixer with power consumption lower than 15 mW.

Index Terms—CMOS, up-conversion mixer, conversion gain, Marchand balun, LO-RF isolation

I. INTRODUCTION

Recently, thanks to the rapid development of CMOS and SiGe processes, it has become possible to use them to implement 60 GHz wireless personal area network (WPAN) system and even 77 GHz radar system [1]–[5]. In transmitter design, the up-conversion mixer (or modulator) is a critical block which receives intermediate frequency (IF) signals, and then up-converts (or modulates) them by local oscillator (LO) signals to the whole RF band of interest. The basic requirements of a up-conversion mixer include good input impedance matching and LO-RF isolation, good output power and linearity, high conversion gain (CG) over the whole band of interest, and low power consumption.

To date, several excellent 60 GHz CMOS up-conversion mixers have been reported [6]–[7]. However, to our knowledge, there is no W-band (75–90 GHz) CMOS up-conversion mixer published in the literature (with power consumption lower than 15 mW), and there are only two reported W-band SiGe BiCMOS up-conversion mixers [8]–[9]. In [8], an 80 GHz SiGe BiCMOS Gilbert-cell based double-balanced up-conversion mixer with on-chip baluns at both RF and LO ports was demonstrated. Though high CG of 3.2 dB is achieved, its 104 mW power consumption and 21.4 dB LO-RF isolation is not good enough. In [9], an 80-GHz SiGe BiCMOS Gilbert-cell based double-balanced up-conversion mixer with multi-tanh triplet (N=3) transconductance stage was reported. Though excellent CG of 3.8 dB is achieved, its 107 mW power consumption and 21.1 dB LO-RF isolation is not satisfactory. To demonstrate that low-power, high CG, and excellent LO-RF isolation can be achieved simultaneously for a W-band CMOS up-conversion mixer using negative resistance compensation technique, in this work, we report a low-power 77–81 GHz up-conversion mixer with excellent CG and LO-RF isolation properties for short range automotive radars using 90 nm CMOS technology. The up-conversion mixer comprises an enhanced double-balanced Gilbert cell with current injection for power consumption reduction, and dual (NMOS and PMOS) negative resistance compensation for CG enhancement, and two Marchand baluns for converting the single LO input signal to differential signal, and the differential RF output signal to single signal.