Bandwidth Enhancement Technique with Low Group Delay Variation CMOS Power Amplifier for UWB System

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***Abstract*—This paper introduced a bandwidth enhancement technique for ultra-wideband (UWB) transmitter design with low group delay variation for CMOS power amplifier (PA). Three stages of cascade common source topology are implemented to provide high gain with good gain flatness. Shunt peaking inductor is introduced at every stage of the introduced PA to improve the bandwidth and to achieve low group delay variation simultaneously. A resistive shunt feedback method is implemented at the first stage to acquire good input matching. The first and second stages attain gain at lower corner and upper-end frequency respectively, whilst the third stage smoothed the gain flatness curve. In addition, the theoretical analysis of group delay is investigated to determine the important design factor for low group delay variation in 3.1 to 10.6 GHz CMOS PA for UWB transmitters. The outcome of the research shows that a gain about 11.48 ± 0.6 dB at average, S11 less than -10 dB, and S22 less than -14 dB is achieved. Moreover, excellent group delay variation is acquired throughout the entire band, measuring about ±85.8 ps.**

***Index Terms*—Bandwidth Enhancement; Cascade Topology; CMOS PA; Group Delay Variation; UWB.**

I. INTRODUCTION

Ultra-wideband (UWB) system has become more popular compared to narrowband system due to its capability to provide short-range wireless personal area networks [1] that can offer low microwave power radiation. Besides, the transmission data rate is notably higher compared to hundreds of megabits per second. One of the challenges in UWB module design is to improve the overall group delay performance characteristic in complex RF module. A minor variation in group delay is required to retain the original identity of the output whilst the time domain does not distort, particularly for UWB system employing impulse signal [2]. Several different approaches have been proposed to enhance bandwidth with low group delay for UWB application. Even though the fabricated UWB power amplifier (PA) in [3] can cover frequency from 3.1 - 10.6 GHz but it deteriorates the group delay of the PA design. Another fabricated PA forming different reported work has shown that low group delay is achieved but the frequency only covers from 5 - 10.6 GHz [4, 5]. Hence, bandwidth enhancement techniques frequently sacrifice the group delay variation and it shows that this is a trade-off characteristic that needs to be compromised. By revisiting previous authors' publication [6], only low group delay variation is being focused. Thus, here a design method is proposed to enhance the bandwidth and at the same time able to achieve low group delay variation simultaneously. The bandwidth extension using shunt peaking technique, a few results that have yet been discussed are explained while centering on the low group delay variation.

II. TOPOLOGY REVIEW

There are many power amplifier topologies that have been reported for wideband communication application with CMOS technology. Ever since multiband orthogonal frequency division multiplexing (MB-OFDM), as well as direct-sequence code division multiple access (DS-CDMA), become two main solutions for UWB transceiver, various UWB for such frequency bands of 3.0 - 5.0 GHz [7], 3.0 - 6.0 GHz [8, 9], 3.0 - 7.0 GHz [10], 6.0 - 10.6 GHz [4, 11], and 3.1 - 10.6 GHz [3, 6] have been implemented with numerous topologies.

The distributed amplifier is one of the well-known topologies for a broadband circuit that provides high-speed communication and good linearity. However, this topology requires a large area and high-power consumption due to several stages active transistor connected in tailored transmission lines to obtain the desired frequency behavior [12]. Improved distributed amplifier by means the combination of both low and high pass filters has been professed to produce artificial transmission line that achieves high output power and spectrum pre-shaping for UWB signal [3]. Nevertheless, it does not solve the problems of the large area resulted from the consumption of many inductors to perform signal delay. Moreover, high group delay is attained in the devised UWB PA.

The shunt feedback topology is typically used to achieve a stable circuit with flat gain, as well as 50 Ω input matching. However, the resulted process variation causes the load resistor to suffer, whereas the power consumption is high. Besides, it is difficult to compromise between gain and bandwidth in this topology [12]. An RLC matching topology was proposed to solve the issue of the wideband matching and power consumption. Unfortunately, several reactive elements like the inductor employed in this topology to form the wideband pass filter cause it to consume a considerable area of the chip [13].

To realize low power consumption, the current-reused