A Single Chip CMOS Transmitter for UWB Impulse Radar Applications

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Introduction

Ultra-wideband (UWB) radar has a vast application in civil engineering and industry, such as family surveillance, medical instrument, detecting live people buried under debris, movement sensors, microwave imaging, collision avoidance etc[1,2]. This work is about a pulse generating transmitter used in radar for the detection of human movement. There are several ways to generate pulses, such as using derivative of Gaussian pulses or digital combination methods, or the "carrier based UWB" [1]-[4]. Adopting ideas reported in [3] and [4], we proposed an impulse radar (IR) transmitter architecture shown in figure1.The proposed transmitter uses the carrier based UWB pulse generation approach. By multiplying the triangular envelope to a continuous sinusoidal wave, the pulses are generated. Triangular shaped envelope, which provides the best side-lobe suppression, is generated by the envelope generator and a special mixer is designed to up-convert the envelope spectrum to the center frequency. Due to single-ended output, the two differential outputs of mixer go through a differential to single-ended converter to get the triangular shaped pulse with the desired spectrum. A two stage drive amplifier is designed to get the -2dBm output power into 50 ohm load.

Circuit Design

Main circuit blocks of the transmitter architecture are shown in figure 2. Each main circuit block is described below.

A. Triangular Envelope Generator

Triangular envelope generator is designed by utilizing the charge pump (CP) to charge and discharge the capacitor. By turning on and off the switches in the CP, the triangular envelope is generated, the same way to generate triangular pulse in [2].

B. Mixer

A single-balanced topology is used for the mixer design. But the tail current source is biased at 450 mV, so there is almost no static current consumption and it has output only when there is triangular envelope signal coming in from the Gm stage. An additional switching transistor pair is added to remove the LO leakage to the output. With the added switching pair the single balanced mixer functions like a double balanced mixer while there is no static currents dissipation, thus LO leakage is suppressed greatly. The proposed mixer topology is novel for the pulse generator application according to the best of authors' knowledge. A simple differential to single-ended converter follows this mixer to convert the output into single-ended (not shown in Figure 2).

C. Ring Oscillator and Drive Amplifier

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LO signal of 4.3 GHz is generated by a three-stage differential ring oscillator. Each stage is using resistor as load. It has a tuning range of 3.8~6.5 GHz and consumes about 5 mA current. A two-stage drive amplifier (DA) is designed for 12 dB gain and -2 dBm output power into a 50 ohm load. Simple cascode topology is used for the DA and low quality factor inductors are used to provide enough bandwidth for the UWB pulse spectrum. The DA consumes about 8 mA current from 1.8-V supply.

Measurement Results

The transmitter has been fabricated in 0.18-μm CMOS technology. The whole circuit is tested with 1.8-V supply. Figure 3 shows the measured output pulse wave form, the pulse has 4.5 ns width and 540 mV amplitude. And figure 4 shows the frequency spectrum of the pulse. We can see that it fits the FCC spectrum mask well. Summary of this transmitter is shown in table I. Die photo is shown in figure 5 and the active area is measured to be 0.45mm×1.2mm which is small for a whole transmitter.

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Reference

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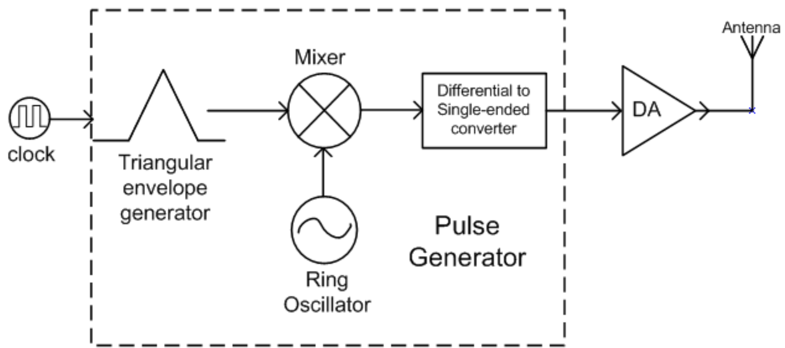
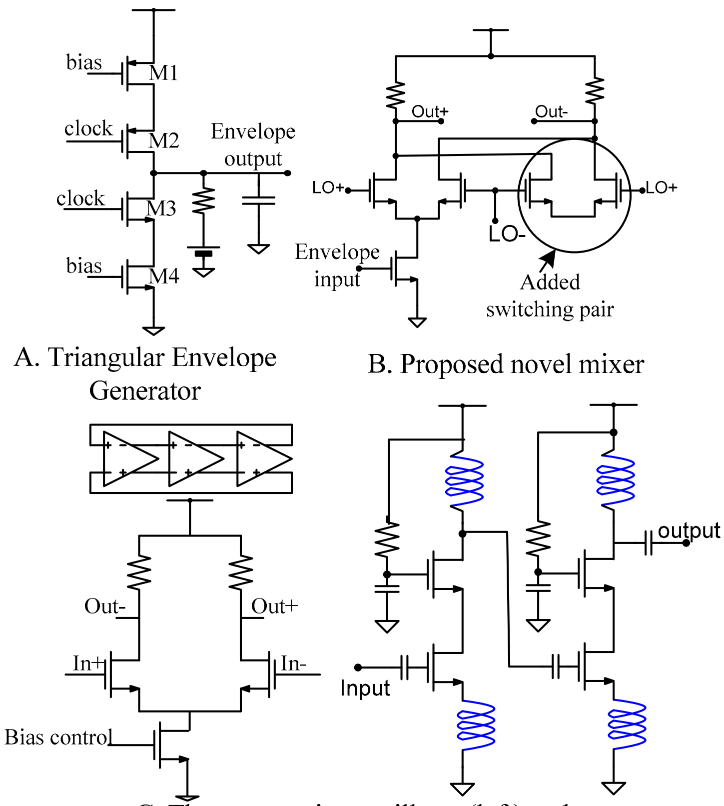


Figure 1. Architecture of proposed IR-UWB transmitter



C. Three-stage ring oscillator (left) and
Two-stage drive amplifier (right)

Figure 2. Circuit Blocks of the Transmitter

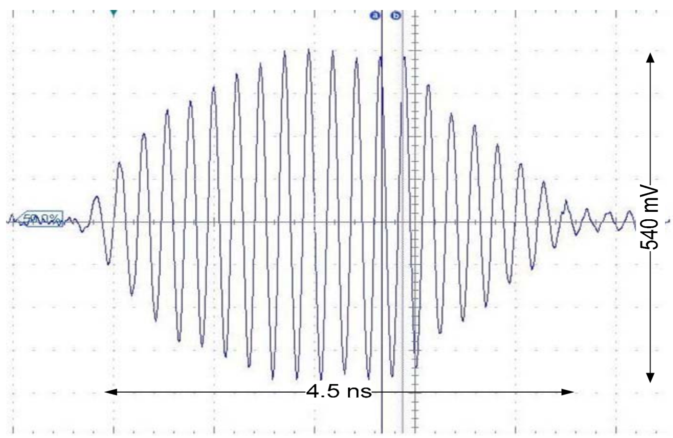


Figure 3. Measured Output Pulse Shape

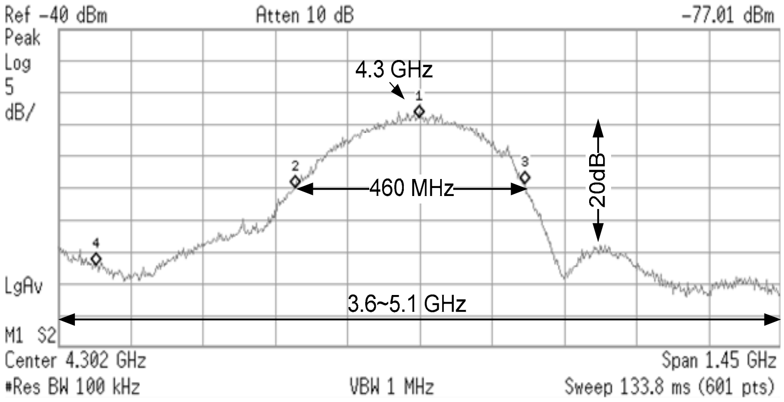


Figure 4. Power Spectrum of Output Pulse

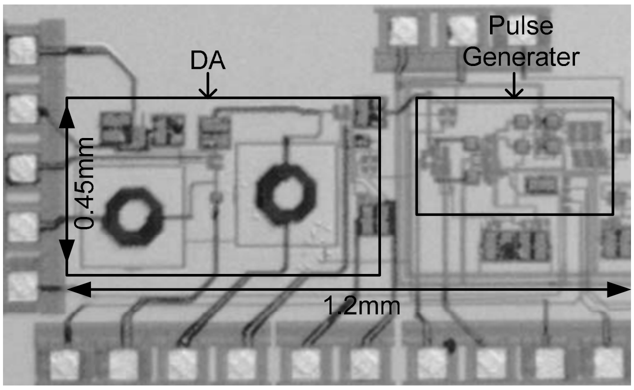


Figure 5. Die Photo of the Transmitter

Table I
Measurement Result of the Transmitter

Parameter	Measurement result
Center frequency	4.3 GHz
Side-lobe Suppression	>20 dB
Bandwidth	460 MHz
Pulse Width	4.5 ns
Pulse Amplitude	540 mV (-2 dBm)
PRF	1 MHz
Power Consumption	30.6 mW
Supply voltage	1.8 V
Chip Size(without pad)	0.54 mm^2
Technology	0.18-µm CMOS