A Digital pulse Generator and RF Front-End Module for 24GHz Automotive Pulse-Doppler Radar

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Abstract - *This paper presents a hybrid digital RF Front-End Module (FEM) that is composed of a digital pulse generator and an I/Q transceiver for automotive pulse Doppler radar. Because the pulse generator of the conventional radar system consists of an analog circuit, it cannot flexibly control pulse width. The transceiver is complex due to its heterodyne architecture. In this paper, we designed and implemented a digital pulse generator and RF Front-End Module (FEM). Our proposed digital pulse generator can control variable pulse width very easily and precisely through software programming. Implemented RF I/Q transceiver can transmit and receive pulse signal. Experimental results show a pulse-Doppler radar with 5 ns and 8 ns of pulse width operating in the 24 GHz frequency band. This digital pulse generator and RF transceiver system promises to be useful for meeting the requirements of the system without changing the hardware.*

Keywords: Digital Pulse Generator, Hybrid Front-End Module, Pulse-Doppler Radar, Digital radar

1 Introduction

Pulse Doppler radar has been studied as a core technology for Intelligent Transport Systems (ITS). Generally, vehicle radar uses a pulse Doppler radar [1]. However, pulse Doppler radar has some problems. First, it is difficult to control arbitrary waveforms such as the pulse width, Pulse Repetition Interval (PRI), and voltage level, because an analog device is used. Second, the front-end module of the pulse Doppler radar is expensive, because the RF transceiver uses a heterodyne architecture in the 24 GHz frequency band.

In this paper, to overcome these limitations, we propose a digital pulse generator and an RF FEM for automotive pulse Doppler radar. The proposed digital pulse generator supports variable pulse width and the RF FEM is composed of an RF I/Q transceiver based on a homodyne architecture.

2 Hybrid Digital RF Front-End Module

2.1 Digital Pulse Generator

Conventional pulse generators of pulse-Doppler radar are not able to control pulse width and PRI without changes to the analog device. In order to digitally control the pulse width of the pulse and PRI, we have designed a digital pulse generator for pulse-Doppler radar using a Field Programmable Gate Array (FPGA). Fig. 1 shows a block diagram of the developed digital pulse generator. It is composed of a Digital Clock Manager (DCM) and a pulse generator [2].

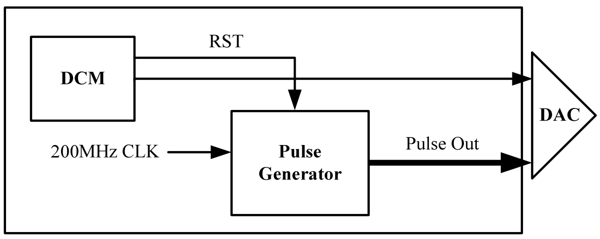


Fig. 1. Block diagram of the developed digital pulse generator.

2.2 RF Front End Module

Fig. 2 shows the homodyne transceiver architecture of the proposed automotive radar RF FEM. In order to achieve cost-effective products in a competitive marketplace and to reduce the size, an RF 24 GHz I/Q transceiver was designed. A pair of transmitting antennas and one receiving antenna were designed in order to increase performance of the received signal.

The transceiver's transmitter section is composed of an in-phase signal input, a quadrature signal input, a mixer, a band pass filter (BPF), and a low-noise amplifier (LNA). The transmission pulse is up-converted to the carrier signal through the mixer.

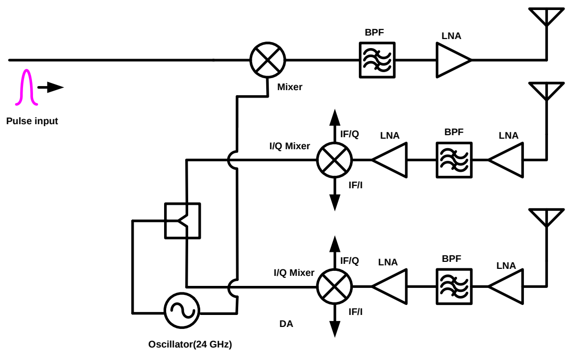


Fig. 2. Block diagram of the developed RF transceiver.

3 Experimental Results

We evaluate the performance of the proposed digital pulse and the 24 GHz transceiver. The performance of the digital pulse and the RF FEM is measured using the test setup shown in Fig. 3. The 24 GHz hybrid digital FEM was fabricated by combining a digital pulse generator and a 24 GHz RF I- and Q-channel transceiver via a coaxial cable connection.

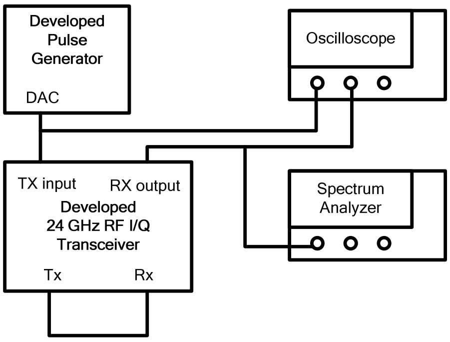
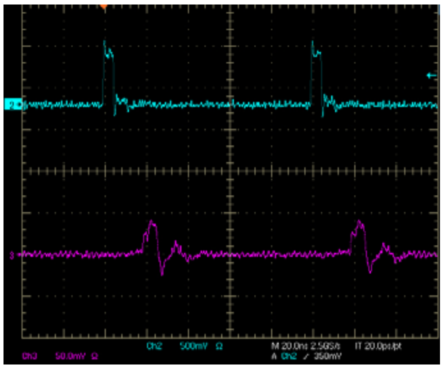


Fig. 3. Measurement setup of the proposed a digital pulse generator and RF FEM.

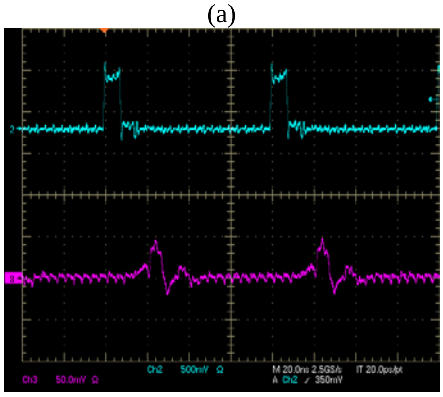
Fig. 4 shows the measurement results of the transmitted and received signal of the developed hybrid digital FEM using an oscilloscope. To prove the proposed system concept, pulses were designed. Pulse widths of the designed pulses were 5 ns and 8 ns. Generated pulses were sent to the 24 GHz band through the implemented I/Q transceiver. The transmit pulse was the output signal of the pulse generator. The receive pulse of the 24 GHz transceiver, through a low loss cable, was the loopback signal of the transmit pulse. Fig. 4 (a) and (b) shows the transmitted and received signals of the 5 ns pulse width and 8 ns pulse width, respectively.

4 Conclusions

For this study, we designed and implemented a hybrid digital and RF Front-End Module for 24 GHz automotive pulse-Doppler radar. The Module is composed of a digital pulse generator and an I/Q transceiver based on the homodyne principle. To overcome the disadvantages of conventional pulse generators, which cannot control pulse width or PRI, we have developed the digital pulse generator. And, to transmit and receive signals with wide bandwidth, we have implemented an I/Q transceiver. Experimental results show that developed hybrid digital RF FEM is able to control pulse width and transmit the signal generated by the developed digital pulse generator through the RF I/Q transceiver in the 24 GHz frequency band. We expect that the proposed digital pulse generator of pulse Doppler radar will be used for various applications.



(a)



(b)

Fig. 4. The transmitted and received pulse of hybrid digital RF FEM (a) pulse width = 5ns (b) pulse width = 8ns.

5 Acknowledgments

This work was supported by the DGIST R&D Program of the Ministry of Education, Science and Technology of Korea (12-RS-02).

6 References

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