Detection of Multiple Target Distance using a PN Radar System

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1. Introduction

Radar is an object detection system that uses electromagnetic waves to identify the range, altitude, direction, or speed of both moving and fixed objects such as aircraft, ships, motor vehicles, weather formations, and terrain. A radar system has used a short pulse of radio signal or continuous-wave signals for the detection. Pulse radar can detect the distance of multiples targets. It needs high power source to detect a object. In contrast, FMCW radar can detect the distance of multiple targets and the speed of a moving object with lower power. It can be easily implemented due to the simple structure. However, leakage signal problems should be considered [1].

A pseudo random binary sequence (PRBS) has widely been used in direct spread (DS) communication system in order to spread a signal into a wideband bandwidth. A pseudo-noise (PN) sequence is very stronger than a surrounding noise because it has high autocorrelation properties. It is very challenge task that we utilize a PN sequence in radar applications [2]. It can detect not only the distance of multiple targets and the speed of a moving object with lower power because the processing gain can be increased according to the length of PN sequence. In this paper, we show the measured results of multiple target distance.

2. System Architecture

The configuration of a TX PN radar system is shown in Fig. 1, and that of a RX PN radar system is shown in Fig. 2. It consists of an RF part, a baseband part, and a control computer. Especially, this system communicates with control computers via a gigabit network so that high-speed data acquisition can be possible. Originally, this system can be expanded up to 4 channels radar using a TDD method. Therefore, it has a possibility to be utilized in emerging MIMO radar applications [3].

The baseband signal which has 20 MHz bandwidth is up-converted to 80 MHz IF frequency by using high-speed DAC. Then, the IF signal is up-converted again to 2580 MHz RF signal, and is transmitted. The received 2580 MHz RF signal is down-converted to 20 MHz IF frequency. Then, the IF signal is down-converted to the baseband stage by using high-speed ADC. Finally, the channel impulse response can be obtained by taking the autocorrelation of the transmitted PN sequence and the received PN sequence.

The digital part and RF part of PN radar systems use the common 10 MHz reference clock. The precision Rubidium oscillators are used for the clock synchronization of TX and RX systems. Before, the measurement, synchronization process should be performed enough for an accurate manipulation of the autocorrelation.

3. Measurement Campaigns

To estimate the performance of a PN radar system, we chose this area shown in Fig. 3. Here is Munji-dong near KAIST-ICC. Four targets which are outstanding in this area were selected for the distance detection. The resolution of a PN radar system is 20 ns and 15 m because the bandwidth of the system is 20 MHz. To discriminate targets in the measured channel impulse response (CIR) exactly, the distance from the system to a target should be larger than 15 m.

The double-ridged broadband horn antennas have been used in the measurement. The direct coupling affects the dynamic range of a PN radar system. To increase the dynamic range of a PN radar system, the enough separation distance is required between the TX and RX antennas.

4. Results and Discussions

Four kinds of measurement configurations are considered in the map according to the angles of the TX and RX antennas. Figure 4 shows the TX and RX antenna configurations and the measured channel impulse response. Three peaks can be observed in the measured results after the first arrived signal. The first arrived signal is the direct coupling component between the TX and RX antennas. The system delay of 750 ns was considered in the manipulation process. A PN radar system can detect three targets which are 232.5 m, 610.5 m, and 967.5 m away from the system. It is very similar with the actual distances on the map.

Figure 5 shows the TX and RX antenna configurations with a tilted TX antenna angle and the measured channel impulse response. In similar with Fig. 4, three targets can be observed in the measured channel impulse response. In contrast to the previous measurement, the amplitude of the reflected signal from Target 1 decreases due to the tilted angle.

Figure 6 shows the TX and RX antenna configurations with tilted TX and RX angles and the measured channel impulse response. It is hard to discriminate three peaks which are easily detected in Fig. 4 and Fig. 5 because many reflection components except the predefined targets are existed. Nevertheless, three targets can be detected due to the previous measured results.

Figure 7 shows the TX and RX antenna configurations with a tilted RX angle and the measured channel impulse response. Fourth peak can be found in the measured channel impulse response. Target 4 is 1140 m away from the system. However, in this measurement, the distances of three targets cannot be extracted.

5. Conclusions

The distance measurement results using a PN radar system have been demonstrated. Multiple targets on the map can be discriminated due to the strong reflections with the specific TX and RX antenna configurations. With low transmitting power, a target which is far away from the system can be detected because of the processing gain which is caused by the autocorrelation property of a PN sequence.

Acknowledgments

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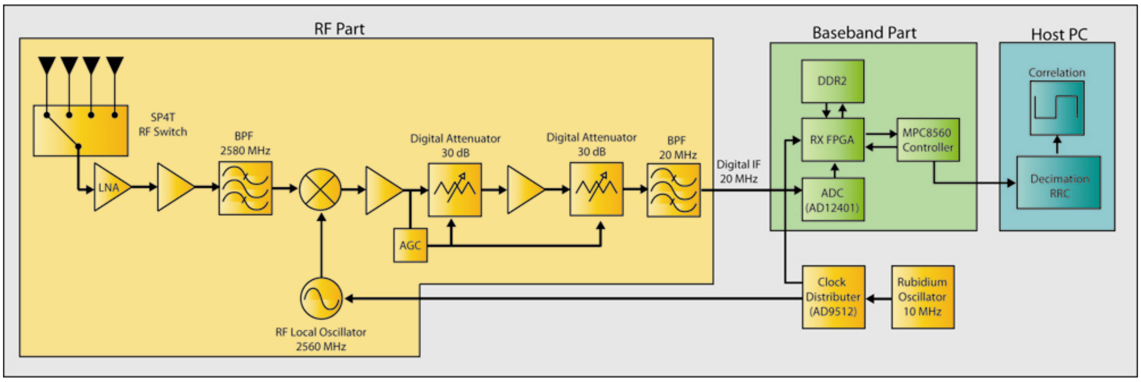

Figure 1: The transmitter architecture of a PN radar system for 2.58 GHz band

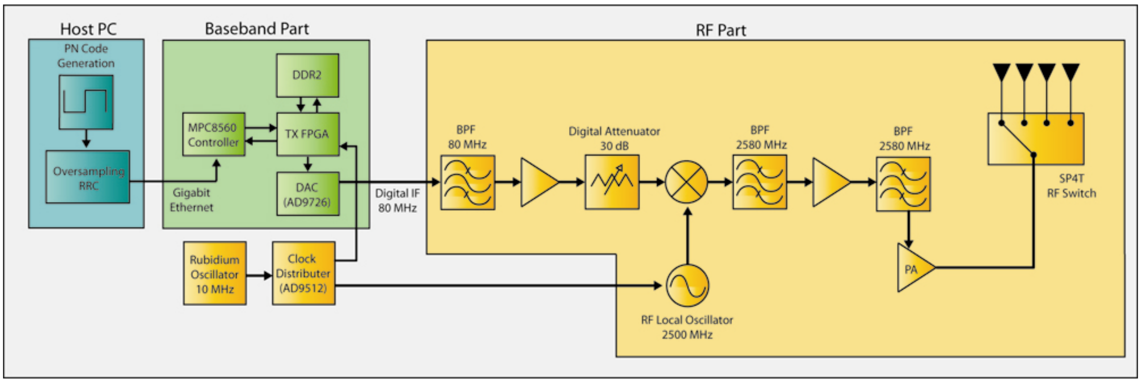

Figure 2: The receiver architecture of a PN radar system for 2.58 GHz band

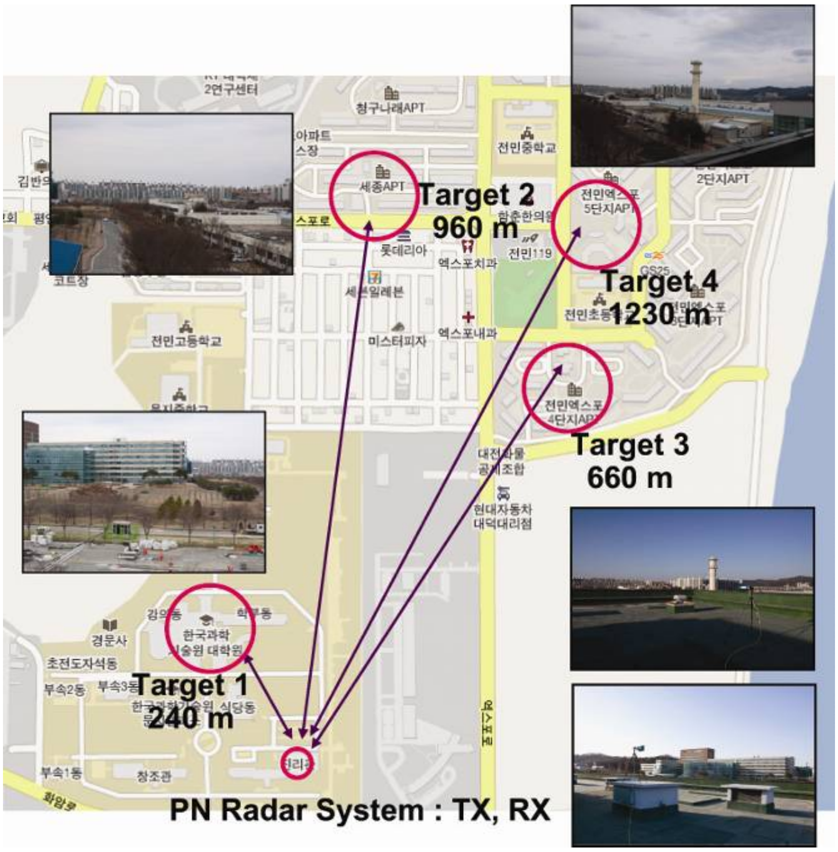

Figure 3: Measurement Site Planning

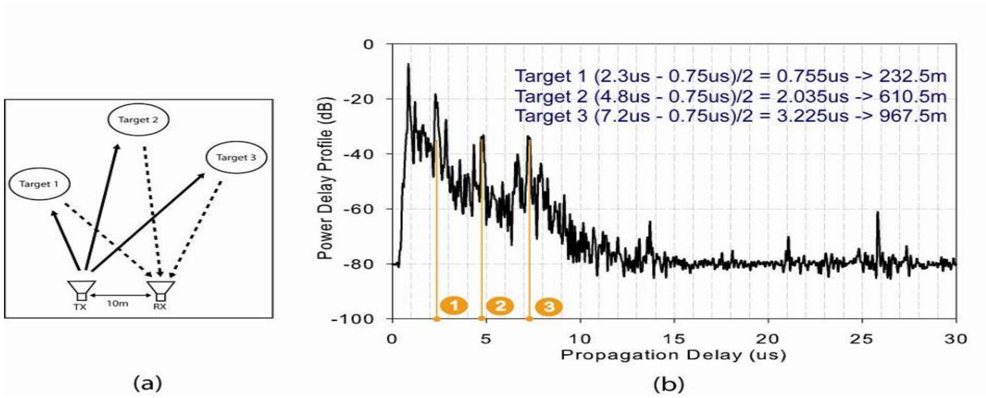

Figure 4: Measurement campaign planning 1, (a) the TX and RX antenna configuration, (b) the measured power delay profile

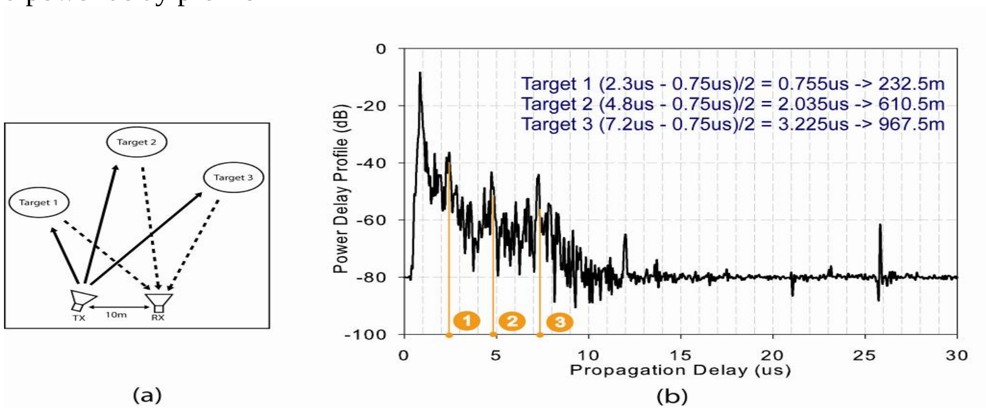

Figure 5: Measurement campaign planning 2, (a) the TX and RX antenna configuration, (b) the measured power delay profile

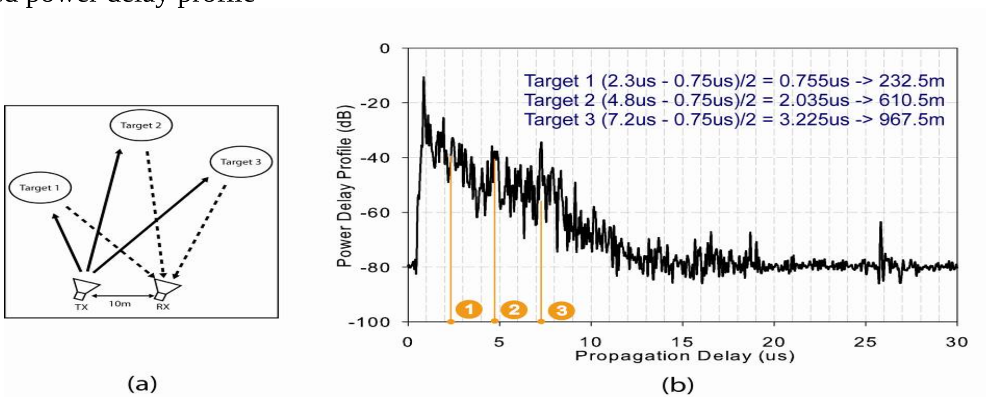

Figure 6: Measurement campaign planning 3, (a) the TX and RX antenna configuration, (b) the measured power delay profile

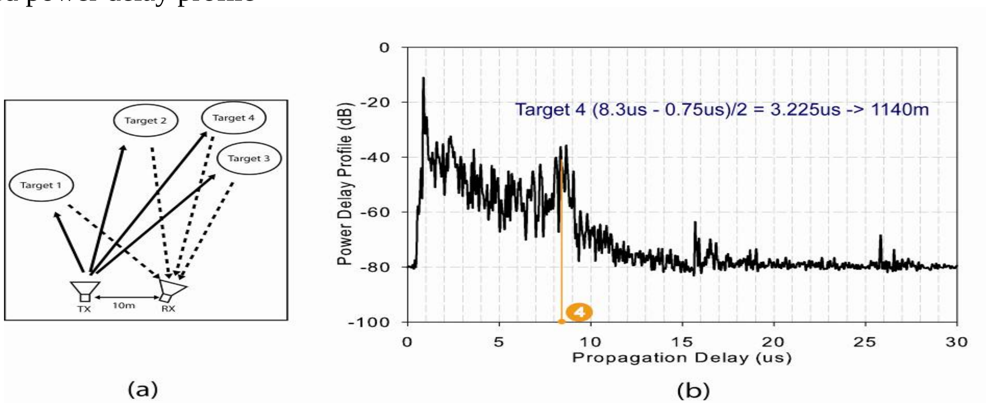

Figure 7: Measurement campaign planning 4, (a) the TX and RX antenna configuration, (b) the measured power delay profile