AN EXPERIMENTAL 24 GHZ RADAR USING PHASE MODULATION SPREAD SPECTRUM TECHNIQUES

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ABSTRACT

In this contribution, an experimental bistatic radar sensor at 24 GHz is described, based on phase coded spread spectrum modulation. The sensor uses a code clock rate of 200 MHz and a code length of 1023, resulting in a range resolution (for two targets) of 1.5 m and an unambiguous range of about 750 m. The digital signal modulates a 1.6 GHz signal which then is upconverted to 24 GHz. The received signal is downconverted to an IF frequency of 1.6 GHz and then demodulated with the reference frequency of 1.6 GHz, modulated with a delayed phase code. The setup of the digital part as well as the microwave part of the sensor will be described together with first test results.

INTRODUCTION

For advanced sensor technology in industrial and traffic application, a high precision distance as well as a range sensitive speed measurement in adverse weather and dirt environment are of great importance [1]-[4]. FMCW radars typically provide a simple setup but show some problems with the separation of distance and speed information. Although more complicated with respect to the digital as well as the microwave circuitry, phase coded spread spectrum systems [5] exhibit some advantages like interference and multi-path resistance or low spectral density. Furthermore, multiple frequency band reuse with minimum interference is possible. To evaluate these features, an experimental radar in the 24 GHz frequency range was built, applying a direct sequence method for signal modulation.

DESCRIPTION OF THE SENSOR

Digital part of the radar

For the modulation of the radar, a pseudo noise (PN) code is used with a clock rate of 200 MHz and a code length of 1023 bits generated by a shift register with feedback (Fig. 1). The same but delayed PN code is taken for demodulation in a heterodyne correlator. The delay of the code for the planned close range applications is achieved in a dual way. Firstly, the shift register generating the code is extended from a length of 10 to 24 bits; at the additional outputs the code can be extracted with three to fourteen bit lengths delay. Secondly, for a fine adjustment, three delay chips based on cascaded gates provide additional delays in steps of 1 ns.

IF part of the radar

A block diagram of the IF circuitry of the presented radar is shown in Fig. 2. A frequency of 1.6 GHz is used as clock (divided by 4), as intermediate carrier for the transmitter signal and for the IF frequency. The demodulation is performed in a heterodyne correlator using again the 1.6 GHz signal modulated with the delayed PN code. Most of the employed components are commercial products; only the IF band pass filter was realized specifically for this application using a dual metallisation suspended stripline technique [6]. The IF output spectrum is displayed in Fig. 3 both wideband and with high resolution near the center frequency. The theoretical auto-correlation function as well as the measured one is plotted in Fig. 4. Both digital and IF part are mounted in a 19" rack separated from the RF part.

RF part of the radar

The basic concept of the RF part of the radar is displayed in Fig. 5. It consists of an oscillator at 22.5 GHz acting as LO for both up and down converter, band pass filters in the transmitter output and in the transmitter LO path to prevent interferences of unwanted mixing products with the receiver and in the transmitter output, an IF amplifier, and two horn antennas. For the planned tests, the use of two antennas helps improving the transmitter-receiver isolation. The overall output power of the radar sensor amounts to about 0 dBm. Except for the filters which again were designed on the basis of suspended stripline, commercial available components were used. This concept easily can be applied to other microwave or millimeter-wave frequencies by just replacing the RF part. The RF circuitry is mounted on a separate rack which easily can be mounted outside a test vehicle.

FIRST RESULTS

First tests in a stationary setup have been conducted and show a satisfactory performance of the radar. Fig. 6 shows the response of a triple reflector as a function of the adjusted delay time of the PN code in the receiver. In this plot, the distance is plotted at the horizontal axis instead of the delay time. The auto-correlation function as displayed already in Fig. 4 clearly can be recognized. In a second test, a fan was placed at a distance of 1.6 m in front of the radar, Fig. 7 showing a typical Doppler spectrum of the fan. The dependency of the maximal amplitude of the spectrum is plotted in Fig. 8 as a function of the distance of the fan to the radar sensor, showing a very good range discrimination of the Doppler response.

CONCLUSION

An experimental phase coded radar has been built showing good results in first tests. This radar now will be mounted to a vehicle and undergo further investigations with respect to traffic and industrial application.

REFERENCES

[1] Daembkes, H., Luy, J. F.: Millimetrewave components and systems for automotive applications. Microwave Engineering Europe, Dec./Jan. 1996, pp. 43 – 48.
[2] Zimmermann, B., Wiesbeck, W., J. Kehrbeck: 24 GHz Microwave close-range sensors for industrial measurement applications. Microwave Journal, May 1996, pp. 228 – 238.
[3] Millitech Corp.: Crash avoidance sensors. Microwave Journal, July 1994, pp. 122 – 126.
[4] Edvardson, O.: Radar for precision tank gauging. Military Microw. Conf. 1992, pp. 91 – 95.
[5] Dixon, R. C.: Spread spectrum systems.2nd Edition, Wiley, New York, 1984.
[6] Menzel, W.: Broadband Filter Circuits Using an Extended Suspended Substrate Transmission Line Configuration. 22nd Europ. Microw. Conf., 1992, Helsinki, Finland, 459-463.

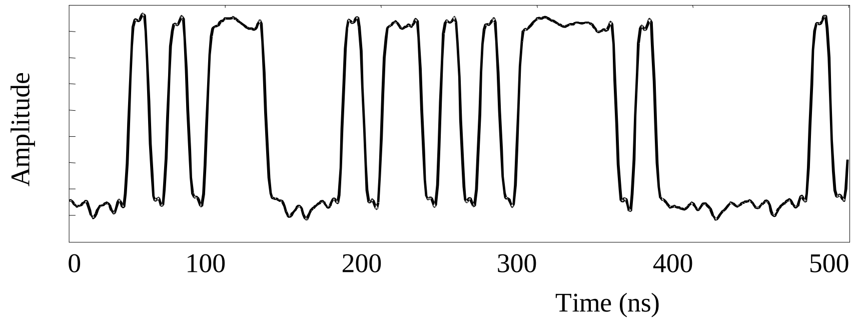


Fig. 1: Segment of the PN code.

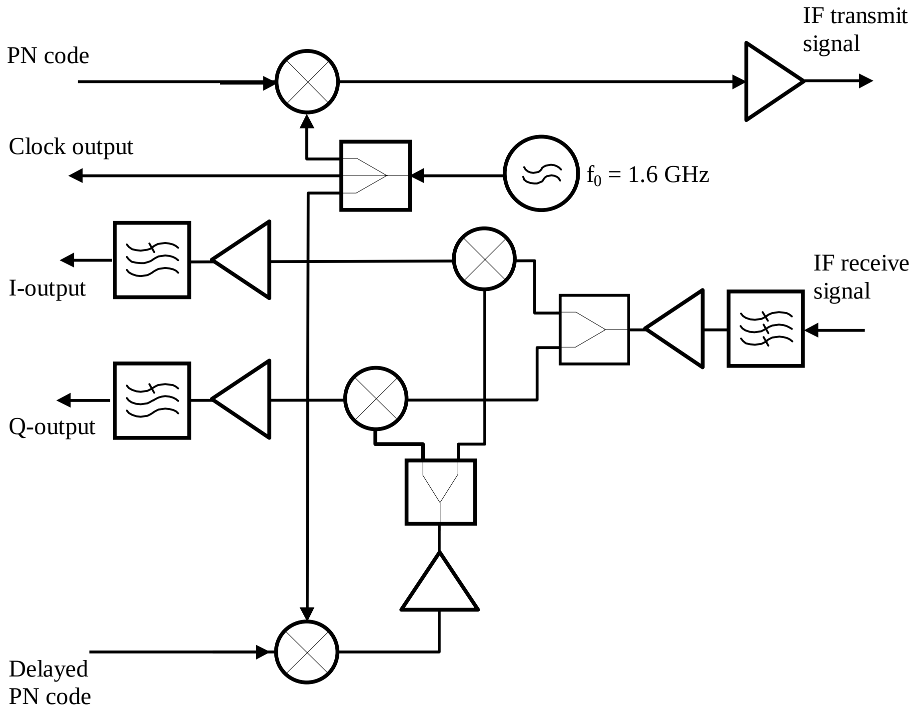


Fig. 2: Block diagram of the IF part of the radar.

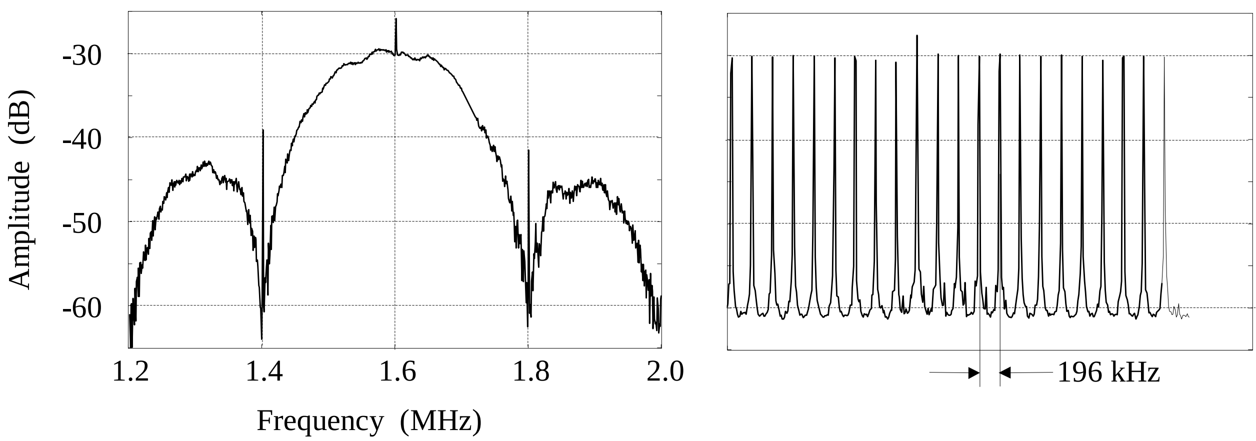
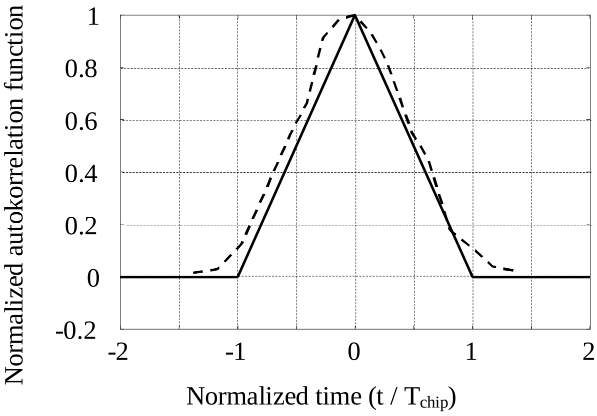


Fig. 3: IF spectrum. (Left side: wideband representation, right side: high resolution of spectrum near center frequency).



. Fig. 4: Calculated and measured auto-correlation function.

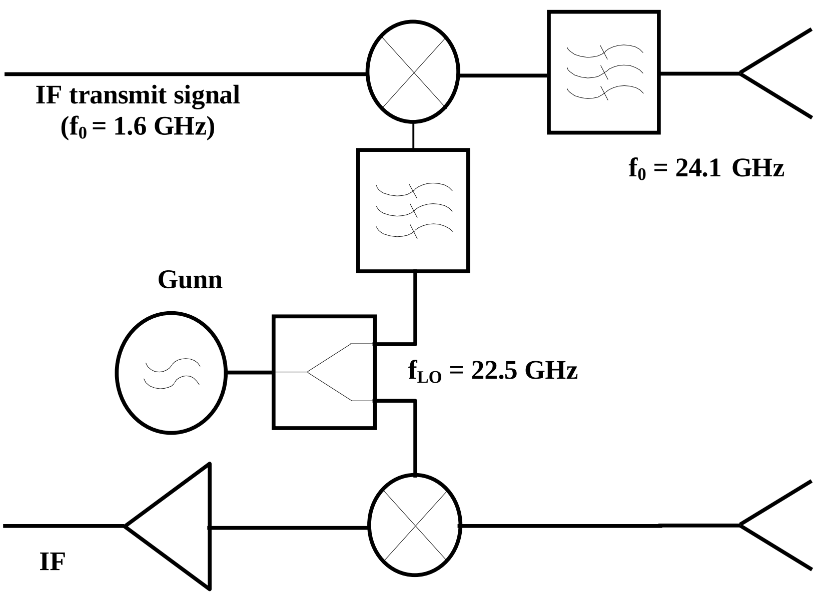


Fig. 5: Block diagram of the RF part of the radar.

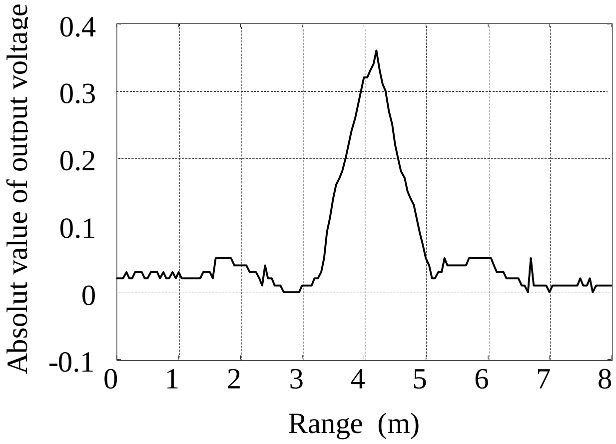


Fig. 6: Output signal for a target at 4 m distance.

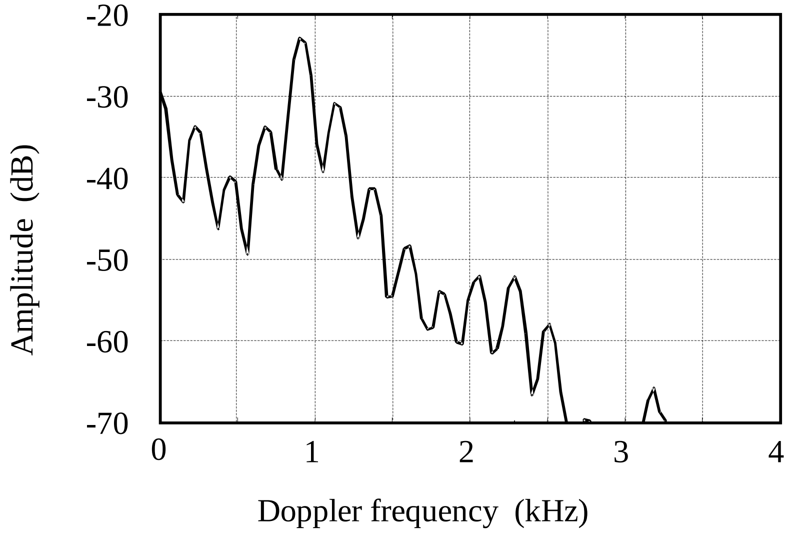


Fig. 7: Typical Doppler spectrum of a fan.

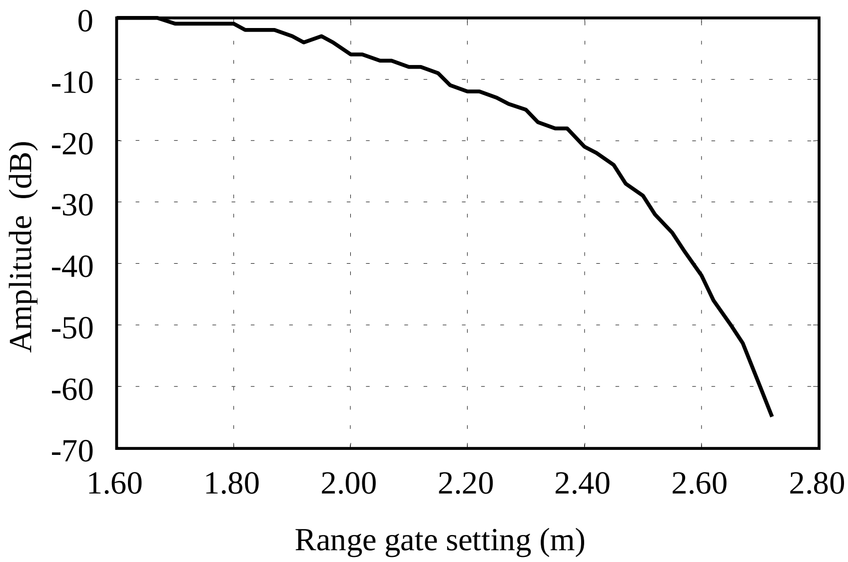


Fig. 8: Dependence of the maximal amplitude of the Doppler spectrum as a function of the target distance (range gate set at a distance of 1.6 m).