24-GHz-FM-CW-Radar for Detection of Information for Traffic Purposes

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Abstract

A system is introduced, which is suitable to transmit information for traffic purposes. To store the information a reflector is developped, that may easily be mounted under the roadside boarderline. To read the information and to measure the distance between vehicle and boarderline a 24-GHz-FM-CW-radar is designed.

Introduction

This paper refers to the basic idea of detecting information inbeded in the pavement of traffic roads. The information addressed to the driver of a vehicle is stored by means of a passive microwave reflector system positioned under the roadside boarderline. To detect the information the vehicle is equipped with a 24-GHz-FM-CW-radar as shown in figure 1. In addition to reading the information the system allows the distance measurement between the boarderline M and the vehicle, which is of interest in foggy conditions.

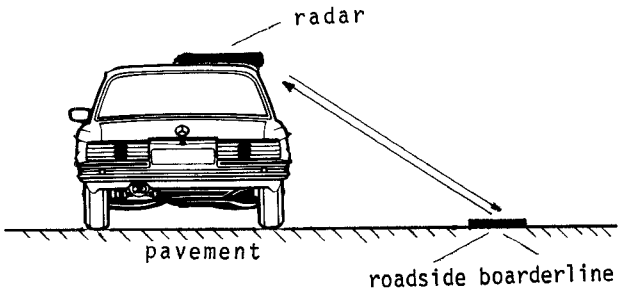

Fig. 1 Vehicle with 24-GHz-radar

The reflector system

The reflector system consists of several identically designed subreflectors lined up along the road. Organising these subreflectors in form of a digital code word any volume of information can be transmitted. The subreflector itself consists of several arrays of equally spaced short circuited dipoles arranged parallel to the direction of traffic. Each dipole array concentrates the reflected energy into n discrete focussing directions given by the angle (1)

$$\alpha_n = \arccos\left(\frac{n \cdot \lambda}{2d}\right) ,$$

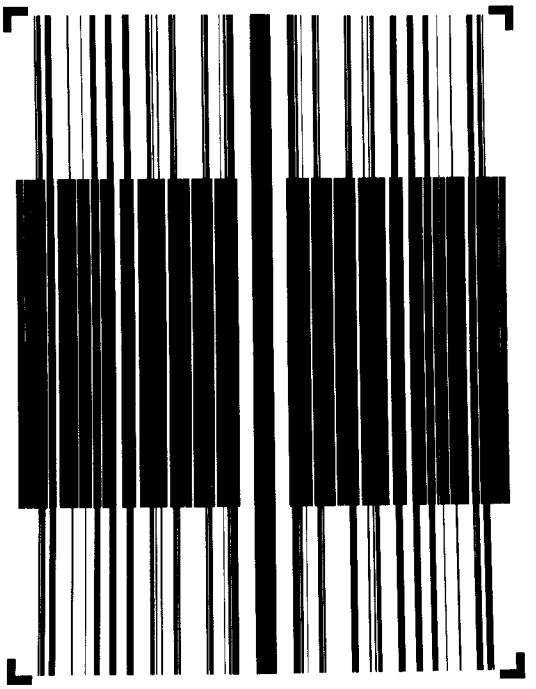

Fig. 2 Lay-out of the subreflector

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where the α_n are measured from the plane of the pavement and d/λ is the element spacing of the dipole array. Superimposing a number of dipole arrays with different element spacings a sector of nearly constant reflection can be achieved. Hence there is no dependence of the input signal of the radar on the distance variation between the vehicle and the reflector system. Figure 2 shows the lay-out of the subreflector realised in printed circuit technique.

With this subreflector design a system was established containing a maximum of 5 subreflectors for a maximum of $2^5 = 32$ different information types. The distance between the centres of adjacent sub-reflectors is 45 cm. As a representative example figure 3 shows the back-scatter diagram of the bit configuration 10111.

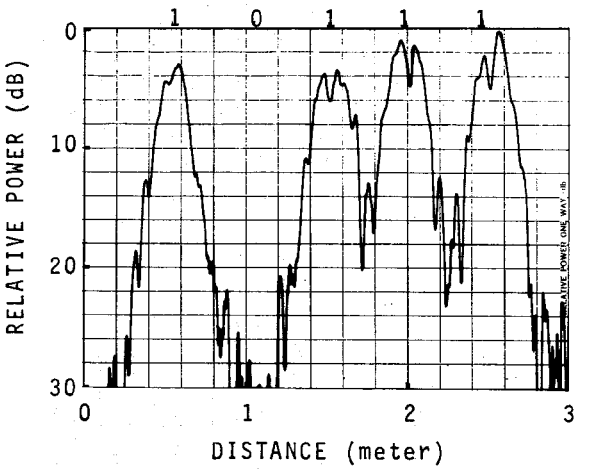

Fig. 3 Back-scatter diagram of the bit configuration 10111 in dependence of the motion in the direction of traffic

FM-CW-radar design

Figure 4 shows the microwave part of the 24-GHz-FM-CW-radar realised in waveguide technique.

As seen in the blockdiagram figure 5 a voltage controlled 24 GHz Gunn oscillator is frequency-modulated by a saw tooth generator. A portion of the FM-signal radiated by a horn antenna is reflected by the described reflector system and received by a second identically designed antenna. Due to the time delay between transmission and reception the multiplication of the mixer input signals results in a constant frequency difference f_D at the output of the balanced mixer.

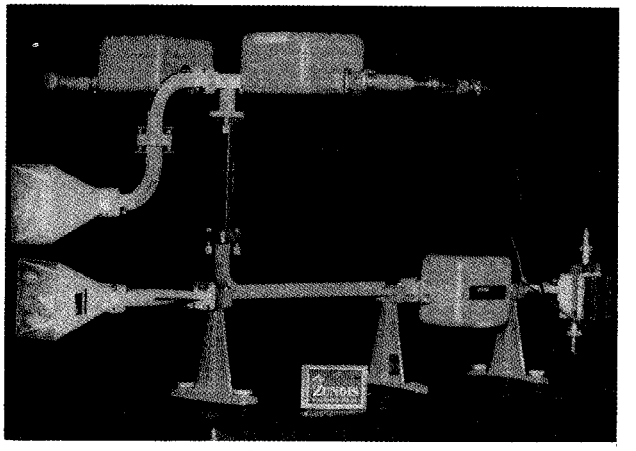

Fig. 4 24-GHz-FM-CW-radar

The distance R between radar and reflector is given by

$$R = \frac{c}{2 \cdot \Delta F \cdot f_m} \cdot f_D,$$

where c = velocity of light, ΔF = frequency deviation of VCO and f_m = modulation frequency. Since f_D is proportional to the distance R, the problem of range finding is modified to the problem of frequency measurement (2). For this purpose a microprocessor is used eleminating the non-linearity between tuning voltage and VCO-frequency. The power level of the reflected signal is determined by a low pass filter system connected to the mixer output.

Conclusion

The described system is suitable to transmit information for traffic purposes. Because of its flatness the reflector system may easily be mounted in the pavement of traffic roads. The designed 24-GHz-FM-CW-radar is able to measure both the level of reflection and the distance between the vehicle and the road-side boarderline.

References

(1) A. A. Oliner and G. H. Knittel, "Phased Array Antennas", Artech House INC., Dedham, 1972

(2) M. I. Skolnik, "Introduction to Radar Systems", McGraw-Hill Book Company, New York, 1962

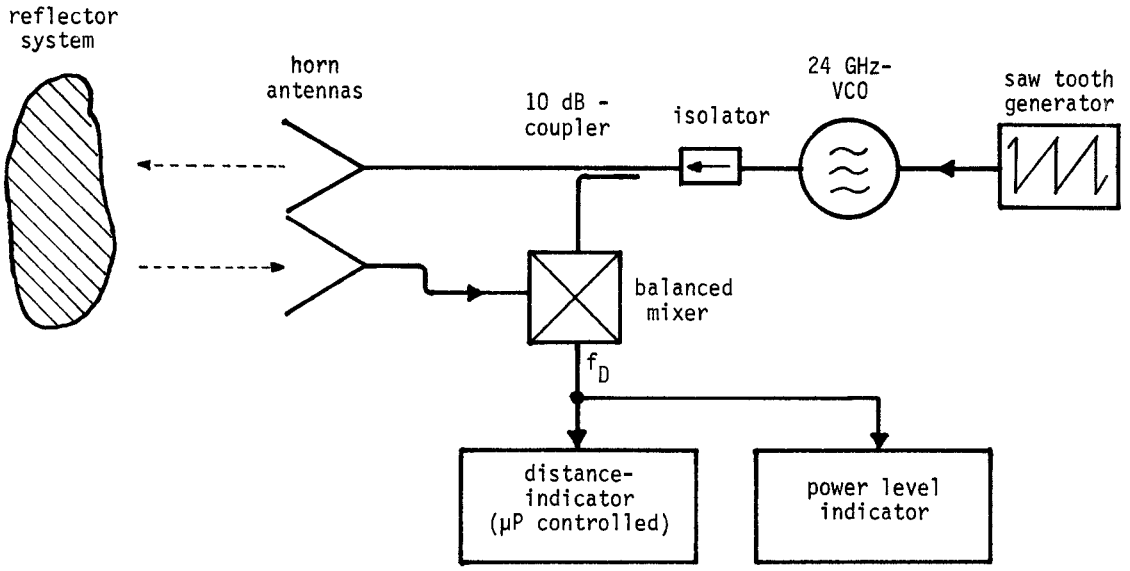

Fig. 5 Blockdiagram of 24 GHz-FM-CW-radar