AUTOMOTIVE RADAR AT 80-90GHz

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ABSTRACT

The idea of equipping cars with radar has been around for a long time, but it is only with the arrival of low cost compact millimetre-wave radars that such systems have become practicable. The paper will discuss a technology for low-cost mass production of automotive radar sensors and two systems applications for such sensors. The systems applications are an Intelligent Cruise Control (ICC), which uses a relatively simple forward-looking sensor, and the other is as a more sophisticated Obstacle Warning Radar (OWR).

FREQUENCY ALLOCATION

The use of millimetre-wave frequencies allows good angular resolution to be obtained from antennas which are small enough to be used in a car. The use of higher frequencies means that the system can also operate in a less crowded part of the electromagnetic spectrum, so that it can use a wider bandwidth for its transmissions in order to obtain the required range resolution and to provide adequate protection against interference. Many preliminary experiments have been done at around 90GHz, because equipment is more readily available at the preferred military frequency of 94GHz. The demands of different applications for spectrum allocations mean that practical automotive radar systems will probably operate at slightly lower frequencies, around 80GHz. A band of 76-77GHz has been made available for DRIVE and PROMETHEUS automotive radar in Europe. The technologies at 80GHz and 90GHz are very similar, hence the frequency span referred to in the title of the paper.

MILLIMETRE-WAVE TECHNOLOGY

It is essential that the millimetre-wave transceiver of any automotive radar be made as economically as possible. In the short-to-medium term the best technology is to use E-plane components mounted in an injection moulded plastic waveguide housing to make a simple FMCW radar transceiver. Figure 1 shows the inside of a compact metallized plastic 94GHz radar sensor made by Philips Microwave, Hazel Grove. All the circuitry is defined by the moulded split-block waveguide.

It is recognized that the target cost of the sensor should be less than $200 in the automotive subsystem market, and our work is currently addressing that target.

INTELLIGENT CRUISE CONTROL

An ICC system uses a sensor with a staring antenna to measure the distance and closing velocity between a car and the vehicle in front, and uses this information to control the car's throttle and brakes to keep a safe headway between the two vehicles.

Figure 2 shows a 94GHz radar head and antenna which have been used for Intelligent Cruise Control experiments. The radar head is about 100mm long and the antenna achieves an angular resolution of 1.5 degrees from an aperture of only 15cm. The output power is 10mW which is much more than is required to detect a car at the maximum indicated range of the system of 128m. This experimental sensor is itself compact enough for it to be able to be successfully integrated into a car, and has been mounted in the front of a car and used as an open-loop headway monitoring sensor, to show that the data obtainable from it would be suitable to control an ICC system.

ICC EXPERIMENTS

The system shown above has been used as an open-loop headway monitoring device. Figure 3 shows the current form of the data display used for the headway monitoring device. The display shows the track of the vehicle being followed as a plot of range (the abscissa) against time (the ordinate, with more recent events at the bottom). The time period covered by the display is about 45 seconds. The alphanumeric display shows the current range to the target in metres.

The display is purely for test purposes and is not representative of type of Man Machine Interface which would be possessed by a real ICC system. This trace shows the very good quality of the data obtained from the sensor and indicates how easy it is to form a good track of the vehicle in front.

Although our research is aimed principally at improving the radar sensor itself, some earlier experiments had involved mounting the radar in a van and successfully implementing a closed loop ICC, in order to prove the principal. The high aerodynamic drag of the van made implementation of the ICC particularly easy in this case.

OBSTACLE WARNING RADAR

An OWR would give the driver warning of any possible hazards ahead of the car. A similar sensor to that used in the ICC would be used, but with a scanning antenna to view the area in front of the car. The sensor generates a radar map of the scene, which is passed to the processor. The processor then extracts information about possible hazards and conveys this to the driver via a suitable Man Machine Interface (MMI).

Some examples of how such a system might operate have been published before (1), but figures 4 and 5 show a further example of the processing which might be used. Figure 4 shows the radar picture of a scene, with the azimuth angle as abscissa and the range as the ordinate, which gives the picture an appearance of perspective. The picture was made in the car park at our laboratories, looking between the lines of parked cars which form the main features of the picture. The gap up the middle is the clear roadway between them, which is partially blocked by an obstacle, a so-called 'sleeping policeman' which is designed to keep down the speeds of vehicles using the car park. This obstacle was at about 50m range and had a radar cross section of about 0.1m². It is clearly visible, but its low cross section means that it can, if necessary, be distinguished from the cars, which have cross sections of the order of $10m^2$ (1).

Figure 5 shows how this data might be processed to recognize the presence of the obstacles. It recognises the returns at the edge of the clear roadway, which are shown in the hatched colouring, and plots a path through them. The obstacle which blocks that path is then detected, and is shown in white, in the figure. Its presence can be reported to the driver using a properly designed MMI, so that he can take appropriate action. In this case he have to ensure that his speed was sufficiently slow for him to be able to negotiate the obstruction in safety, but he would not need to stop. The complexity of the decision which needs to be made indicates why an OWR must give warnings to the driver, rather than operate automatically as can the simpler ICC sensor.

CONCLUSION

The results which are now being obtained with automotive radars show that modern technology has made it possible to fulfil the long-standing dream of making practicable, economical, radar systems for automobiles which will be able to significantly reduce the driver's workload so that driving can be made safer and less tiring.

ACKNOWLEDGEMENT

The work of Mr I.M. Simmons in writing the software to process the headway monitoring data is gratefully acknowledged.

REFERENCE

(1) Mallinson, P. and Stove, A. G., "Car Obstacle Avoidance Radar at 94GHz," Proc. 1989 IMechE Automotive Electronics Conf, pp297-302

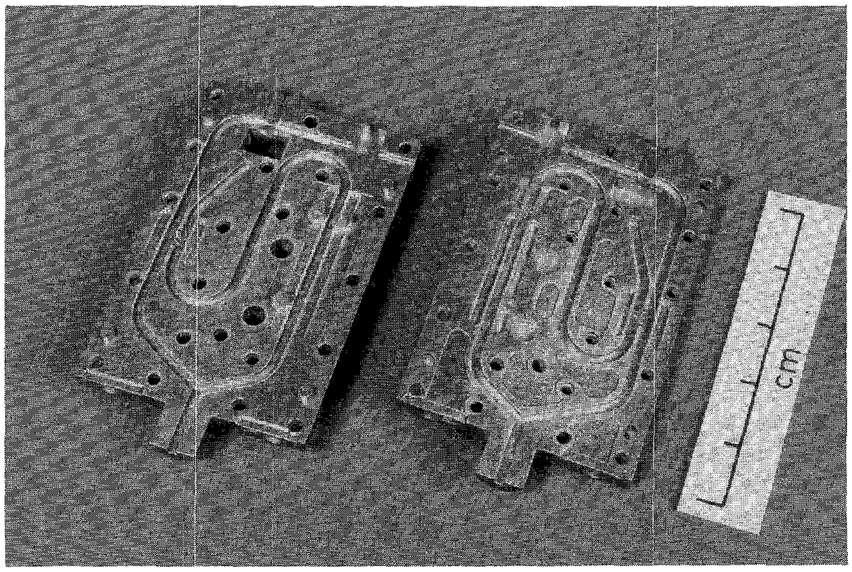

Figure 1: Injection Moulded Metallized
Plastic Radar Head

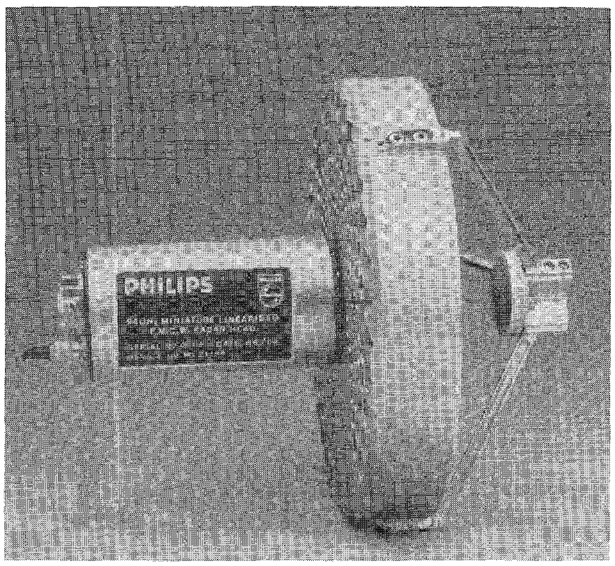

Figure 2 Experimental Radar Head

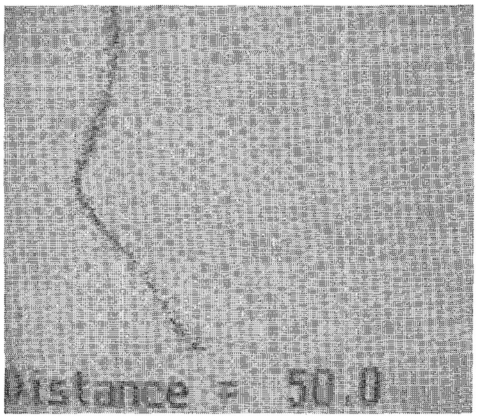

Figure 3: Trace of Headway Monitoring Sensor

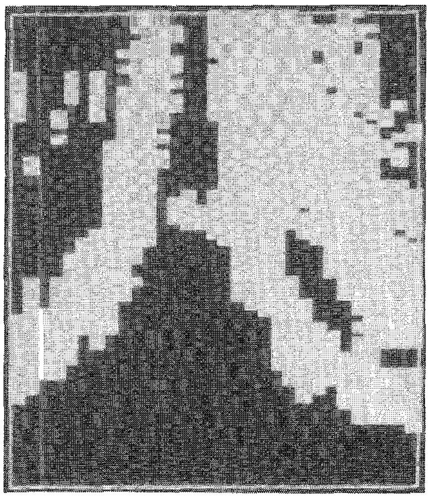

Figure 4: Perspective Radar Picture of Car Park with Obstacle

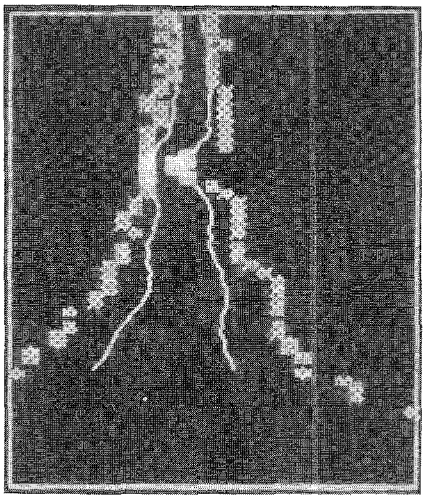

Figure 5: Identification of Obstacle