DEVELOPMENT OF A CORRELATION SPEED MEASUREMENT FOR AUTOMOTIVE APPLICATIONS

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Introduction

This paper shows the results of a Matlab/Simulink model, which determines speed measurement applying a correlation method (see Fig.1). The scheme is based on passive detection of heat radiation in the microwave range [1], [2]. It demonstrates that it is possible to detect heat profiles from objects with nowadays available standard components. As there are no active components used in this high accuracy measurement method, it is possible to reduce the sensor size. Moreover this enables us to create the measurement setup in a more economic way and without harmful effects on the human body [1].

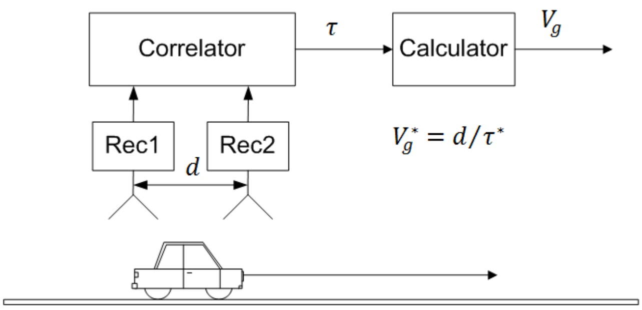

Fig. 1 Principle action of the speed sensor [1]

After Max Plank described the radiation law in 1900, it is known that a body with a temperature above absolute zero (-273.15 °C) is emitting an electromagnetic radiation which is temperature- and frequency-dependent [4]. This radiation range comprises very short wavelengths (gamma rays) up to the long radio waves. Out of this range we consider solely the micro wave part. This area emits just a small percentage of the total range power. Nevertheless it is possible to apply today´s technology, to detect and to analyze this noise signal. This signal represents the temperature of the investigated body. This technique is already used in some satellites for microwave remote sensing of the earth temperature behavior [3]. We receive a signal having a white noise spectrum.

The radiant energy can be explained by two complementary approaches – the classic electromagnetic wave theory and the quantum theory of radiation. The specific radiate of a black body (ideal radiator) [3] [4] is given by Planck's Law. Black body spectrum (see Fig.2) is based on this law.

It is also known that microwave radiation is passing the atmosphere almost unaffected in the frequency range of our interest (see vertical line in Fig 2). Experimental results show a resistance against further influences like rain, snow and fog [6]. The knowledge about this frequency range evokes high interest on speed measurement systems for automotive applications.

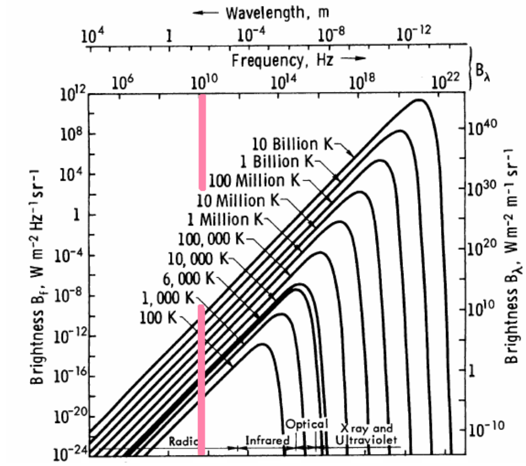

Fig. 2 Black Body Spectrum by Planck´s Law [7]

Model

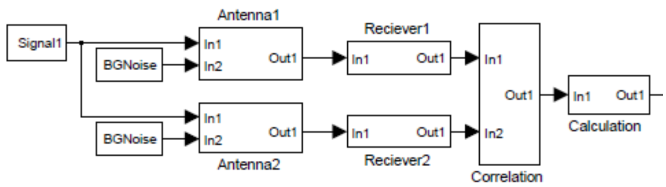

Fig. 3 Principle Matlab structure

The model of the correlation method for speed measurement is based on two identical receiver units (antenna and receiver) mounted in movement direction. Both units receive the same noise temperature profile of the object. The signal of the second unit has a time delay with respect to the first one [2].

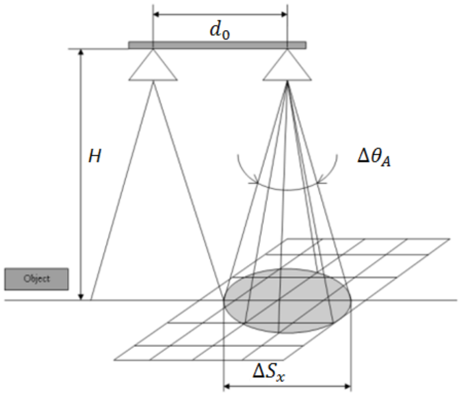

Fig. 4 Basic system geometry [2]

The antenna filed size is given by the system design (see Fig. 4). The antennas receive a continuous background noise during the measurement procedure.
The signal matrix is a two dimensional field like the antenna field. The shape and values contain information on body radio emission, temperature and object size. Figure 5 shows a simulation of an object passing the two dimensional antenna fields. The object evokes a higher emission compared to the

background noise surrounded passing the two dimensional antenna fields.

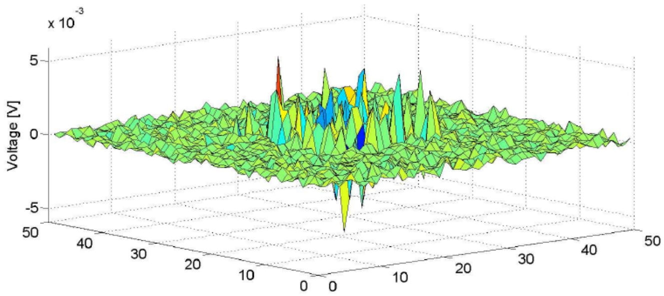

Fig. 5 Matlab/Simulink, object in antenna field, x-y local coordinates

The antenna field represents the Main-Lobe of the antenna. It is characterized by their parameters and the system geometry. The lobe characteristic is freely selectable like all further parameters in the model. It is simplified assumed to have a Gaussian shape in this example (Figure 6). The antenna is used only as a spatial filter. The frequency selection is realized by a high frequency filter incorporated in the receiver.

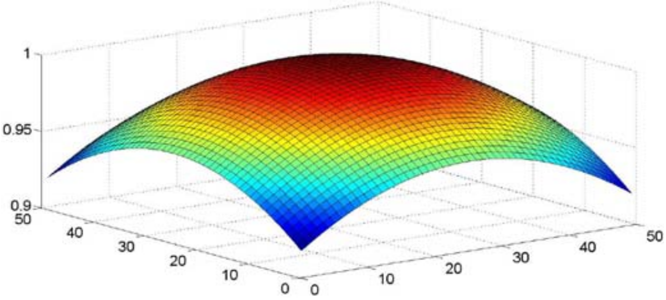

Fig. 6 Main-Lobe-Gain with x-y local coordinates

The two antennas convert electromagnetic waves into receiver input electrical signals (Fig. 7).

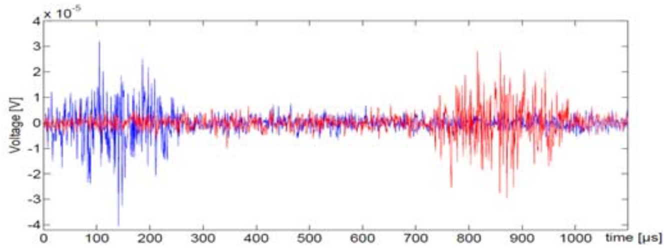

Fig. 7 Two antenna signals receiving an object

The signals in the receiver are filtered by a UHF bandpass-filter regarding the desired microwave frequency range. After that the signals are passing a square law detector, a low noise amplifier at the output (Fig. 8) followed by a frequency filter. Thus, we get a smooth amplitude for the correlation operation (Fig. 9). The main task of the applied cross-correlation function is to compare the two antenna signals, in order to measure their time difference. This will be determined by the total receiving time (B) and the time corresponding to the maximum of the correlation function (A). The time difference between A and B represents the time delay between the first and the second signal (Figure 9). As we know the local spacing between both antennas we can easily calculate the speed of the object passing the antennas.

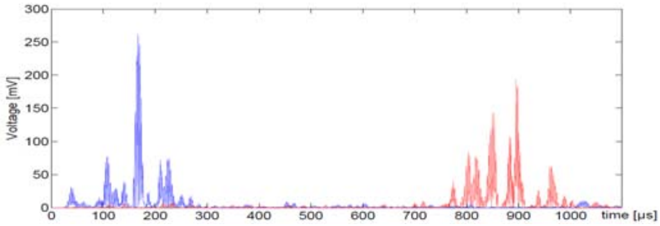

Fig. 8 Signal after Band-Pass-Filter and gain/square function

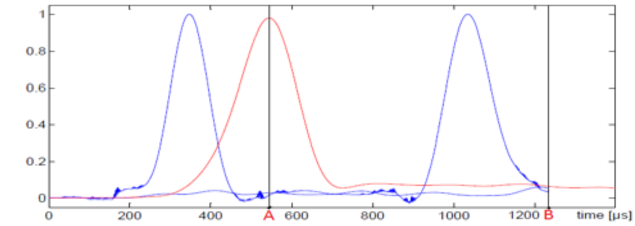

Fig. 9 Both signals and the correlation function

Conclusions

We presented a Matlab/Simulink model of a correlation method for speed measurement allowing a variation of all known parameters. Thus, we achieve a realistic simulation using different components. We are able to take into account object, antennas, receivers and system geometry. Furthermore interference effects caused by antenna- background- and receiver noise have been investigated. This enables the model to be a very powerful tool. Future emphasis will be laid on investigations to determine speed measurement accuracy. First results promising a maximum deviation below 1% can be expected.

References

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