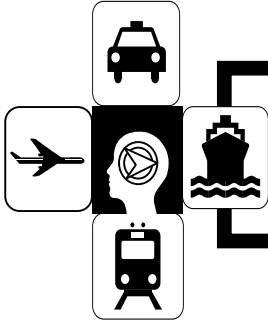


JERSEY DOT'S

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Tech Brief

Clearance Detection, Evaluation and Reporting System (CDERS)

FHWA-NJ-2001-026

May 2003

SUMMARY

Real time measurement of clearances between vehicles can help to alert the driver and reduce possible collisions along the highways. The Clearance Detection, Evaluation and Reporting System (CDERS) has been developed based on microwave and vision technologies. The prototype demonstrated that sub-centimeter resolution was achieved in measuring the lateral clearances using Ultra Wide Band (UWB) microwave technology. Alternatively, the autonomous vehicle vision guidance problem based on the sequential images taken by a camera mounted in the front of the vehicle was studied. Employing the difference image and the optical flow, a real time computer vision scheme to autonomously navigate the vehicle following the lane and avoiding collision with the leading vehicle was studied.

INTRODUCTION/BACKGROUND

A major goal of this project was to design an inexpensive clearance monitoring device for vehicles while in motion. This device was to alert the driver of the presence of vehicles in the vicinity of his/her vehicle leading to avoid accidents.

RESEARCH APPROACH

An approach based on time domain radar in K-Band (18-26.5 GHz) with a practical antenna size is chosen. This approach works in most diverse weather conditions; insignificant attenuation due to heavy rain (16 mm/hr) 0.2 dB for a 30 meters range and

negligible attenuation of less than 0.05 dB due to heavy fog or cloud (2.3 gm/m^3).

The prototype system shown in Figure 1 has been developed to operate at 23 GHz to obtain a high resolution.

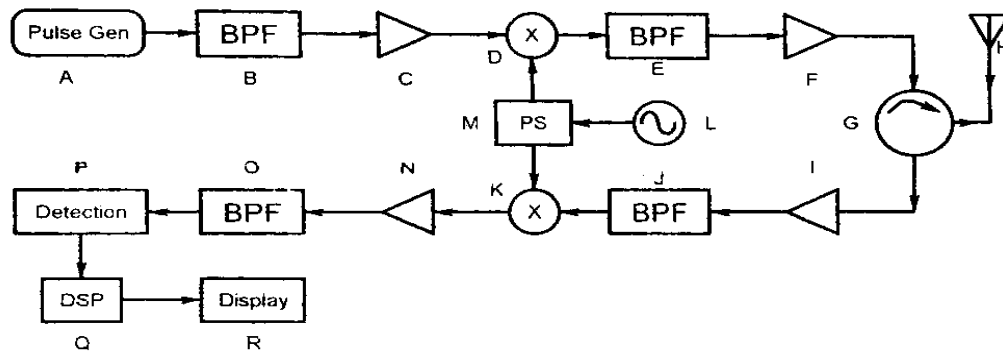


Figure 1. Block diagram of the developed prototype system.

The transmitter is composed of a Fast Rise Time Pulse Generator (A) followed by a Band Pass Filter (B) centered at 1.75 GHz. As the pulse is applied to the filter, a 1.75 GHz burst with a bandwidth of 500 MHz is generated which is amplified by amplifier (C) and up-converted by the Frequency Mixer (D). The Oscillator (L) signal is divided by the power splitter and supplied as the Local Oscillator for the Frequency Mixers (D) and (K). The Band Pass Filter (E) allows only the upper side band to be supplied to the Microwave Amplifier (F). The burst is routed through the circulator (G) and transmitted to the space by the Antenna (H). The returned bursts from the targets are received by the Antenna (H) and routed to the receiver via the circulator (G). The bursts are amplified by the Low Noise Amplifier (I). The Band Pass Filter (J) passes the bursts and suppresses the noise at the image frequency band. The Frequency Mixer (K) down-converts the burst to 1.75 GHz. The signal is amplified by the Amplifier (N). The Band Pass Filter (O)

suppresses the out of band noise. Due to wide bandwidth of the signal, a sampling detection scheme is used via Detector (P). The Digital Signal Processor (Q) is used to estimate the distance of the surrounding targets. The relative locations of targets are displayed on a Graphical Display (R). Audio alerting signals could aid the operator of the vehicle of possible collisions.

FINDINGS

MICROWAVE BASED CLEARANCE DETECTION SYSTEM

Field tests were performed. Figure 2 is a photograph of the installed proto-typed system constructed from waveguide components. The preliminary tests indicated the following:

- The radar responded well to vehicles, human targets and buildings. This confirms the appropriate choice for the selected frequency band for avoiding accidents with humans, objects, other vehicles and buildings.
- A range of 15-20 meters was obtained for cars which is unaffected by rain.



Figure 2. Field tests were performed using a radar, constructed with waveguide components installed on the front bumper of the vehicle.

VISION BASED CLEARANCE DETECTION SYSTEM

As a precursor to the vision based clearance detection system, the autonomous vehicle vision guidance problem based on the sequential images taken by a camera mounted in the front of the vehicle was studied. Employing the difference image and the optical flow, it was proposed a real time computer vision scheme to autonomously navigate the vehicle following the lane and avoiding collision with the leading vehicle. To test the scheme, a simulator was built with OpenGL, a popular graphic language. The result showed that this scheme is reasonable.

CONCLUSIONS

Major milestones of the projects were completed successfully. A prototype was made and achieved the desired performance confirming the validity of the proposed concept using Ultra Wide Band microwave technology. The most important parts still remaining are the development of flat electronically steerable antenna and implementation of MMIC design for further miniaturization and cost reduction. The feasibility studies that were performed indicate that using a 8×8 element provides a sufficiently narrow beam width necessary for the intended application. In addition, further work in signal processing and software development is necessary to finalize the concept into a commercially viable product. Vision based clearance detection has proven to be feasible.

RECOMMENDATIONS

Further work have to be carried out to develop miniaturized microwave based Clearance Detection, Evaluation and Reporting System (CDERS). Similarly, vision base system has to be further developed for implementation in vehicles. Comparative studies have to be made to assess the superior and inferior aspects of the performance parameters of the various systems that have been developed based on microwave and vision technologies.

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A final report is available online at

<http://www.state.nj.us/transportation/research/research.html>

If you would like a copy of the full report, please FAX the NJDOT, Division of Research and Technology, Technology Transfer Group at (609) 530-3722 or send an e-mail to Research.Division@dot.state.nj.us and ask for:

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NJDOT Research Report No: FHWA-NJ-2001-026