Digital Signal Processing Applied to Radar Sensors Operated in Active Defense Systems

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***Abstract*— The active defense (AD) is deemed a very promising way how to protect military vehicles, especially in contemporary fight against terrorism in the Third world countries. Cheap and easily accessible hand-held cumulative missiles (e.g. RPG-7) are able to penetrate up to 300 mm of the hard-hardness armour (HHA). Thus light transport military vehicles equipped typically with less than 10 mm thick armours, used frequently e.g. in Afganistan are very vulnerable. The AD systems are based on radar sensors that detect approaching missiles and activate a suitable counter-measure able to destroy the threatening missile. The article describes the microwave curtain, which is one of the radar sensors applicable in AD systems, and signal-processing methods used for generation of ignition signals from its output signals. Practical results obtained at army shooting range are also presented.**

***Index Terms* — Active defense, missile detection, microwave curtain, signal processing.**

I. INTRODUCTION

The fundamental descriptions of microwave radar sensors used in the developed AD system can be found in [1] and [2]. The same articles also show two basic types of threatening missiles. Very fast kinetic energy missiles are formed by thin wolfram arrows, and are shot off tank barrels. Their typical velocities v_1 are 1600 - 1800 m/s, while their kinetic energy can reach levels higher even than 6 MJ. When hitting the target, they are able to penetrate 500 – 1000 mm of the best HHA. In general, they are used against tanks or vehicles that are armoured to a similar extent.

Since contemporary conflicts are closer to a bush-fighting, it is typical to utilize substantially lighter transport vehicles instead of tanks. In this case, hard war losses are caused by attacks of cumulative missiles that are very cheap, relatively slow (typical velocity v_2 around 150 m/s), hand-held and able to penetrate up to 300 mm of the best HHA; see Fig. 8. Since standard light military vehicles are employed typically with only less than 10 mm-thick armours, they have very little chances against the aforementioned type of missiles. The AD systems seem to represent one of the most efficient ways how to solve this problem.

All AD systems are based on either microwave or optical sensors that detect the approaching missiles and generate the ignition impulse for activating appropriate counter-measure. The developed and tested AD system is based on two basic types of radar sensors, see Fig. 1.

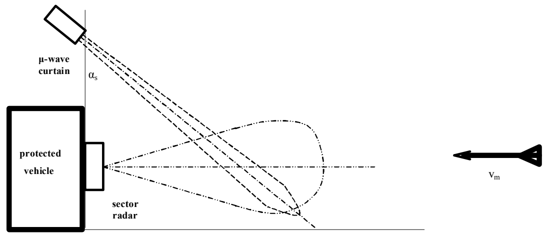

Fig. 1 Radar sensors used in developed active defense system.

The sector radar sensors monitor wider space angles and detect the approaching missiles. The main purpose of these sensors is to prepare other sensors for the arrival of the threatening missile and to perform its preliminary identification. The second set of microwave sensors form a kind of a “microwave curtain”, which is “uncurled” around the protected vehicle and detects flight of the approaching missile through a defined plane.

II. MICROWAVE CURTAIN

The microwave curtain consists of narrowband Doppler radar sensors, digital processing units, and couple of antennas having a wide pattern diagram in the horizontal plane and a narrow radiating pattern in the vertical plane.

Fig. 2 shows the microwave antennas of one section of the microwave curtain fixed at a test stand. The 11 GHz radar sensor is hidden in an armoured box and connected to the antennas by co-axial cables. The antennas of the microwave curtain define a tilted plane; the missile passing through this plane generates a sharp impulse at the output of the sensor.

Apart from the useful signals corresponding to the flight of the missile through the curtain, strong interfering signals can also appear at the output. This concerns many different, both unintentional and intentional, interferences. For example, strong interfering signals are generated by a movement of the protected vehicle with respect to the ground. Therefore it is essential to perform a careful signal processing that can guarantee the required (i.e. very high) probability of the correct detection.