

Electromagnetic Devices for Stopping Vehicles

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Abstract: An effective way to stop a vehicle is to disrupt the operation of electronic systems using high power electromagnetic pulses, which can be generated using electromagnetic weapons. This article describes the design idea of a stationary generator of electromagnetic pulses that would be useful for stopping vehicles at the entrances to the object, at checkpoints, and in front of sensitive infrastructure. An important aspect of the proposal is the comparison of contemporary devices and systems used for stopping vehicles and analysis of the requirements of technical standards for electromagnetic immunity of vehicles.

Keywords: Electromagnetic susceptibility, High power microwave, Direct energy weapons, Car, Alarm systems.

1. Introduction

Electromagnetic weapons are referred to as Directed Energy Weapons (DEW). These weapons use highly focused energy to damage targets. The energy could be delivered via electromagnetic radiation, sound, or subatomic particles. The DEW, which operate in the frequency range of 100 KHz - 1 GHz (Directed Energy Weapons - Radio Frequency DEWRF) and in the range from 1 to 300 GHz (microwave, DEWM) are devices designed to disrupt, degrade, or destroy electronic and electrical systems [1]. Automobiles contain a large number of electronic systems. Electromagnetic pulse (EMP) coupled into the electronic circuits of the vehicles can interfere with the operation of the electronic control unit [2]. Disruption of the function of the control unit may result in the engine stalling. This effect allows:

- Stopping the engine stationary or slow moving vehicles (e.g., vehicles used for bank robberies, drug-handovers, within the needs of detention

persons or identification of criminals, or when the driver breached the traffic rules);

- Stopping speeding vehicles;
- Protection of convoys (reduce the risk of attack from other vehicles - collision, shooting) [3].

Only a few companies produce electromagnetic devices for stopping vehicles. These devices are used for the needs of police, army, special operations units or protecting of important events [4]. These electromagnetic weapons are very expensive. This article describes the design idea of a stationary generator of electromagnetic pulses that would be useful for stopping vehicles at checkpoints, at the entrances to the object and in front of sensitive infrastructure. Initial ideas and design conditions of stationary electromagnetic system for stopping vehicles:

- The system will be used for stopping vehicles at the entrances to objects [5];
- Security personnel will use the system to stop suspicious vehicles [4];

- The system will be integrated with the access control system for use in security applications (this solution is missing);
- The system can be integrated with an alarm security system and video surveillance system (this solution is missing);
- The system can be activated automatically in response to a negative event (e.g., an attempt to break into the object, a vehicle in the vicinity of object, etc.);
- The power level of system will be set efficiently with a view of electromagnetic immunity vehicles;
- Possible inclusion of the system into a series of technical standards to complement alarm systems.

Project schedule should include:

- Analysis of design of contemporary DEW (USA, Germany, China, Australia, etc.);
- Comparison of contemporary devices and systems used for stopping vehicles;
- Analysis of the requirements of technical standards for electromagnetic immunity of vehicles;
- Selection of the type of generator of electromagnetic pulses (several solutions exist);
- The proposal the automatic generator control (main advantage of suggested approach);
- Simulation of the effects-similarly [4];
- Main goal-Creating a product prototype.

DEW basic description is given in Section 2. Contemporary electromagnetic systems for stopping vehicles are described in Section 3. Detailed information about the proposed system (use of alarm outputs of the access control system or cameras, detectors, wiring, etc.) will be addressed in our future work.

2. Directed Energy Weapons

Electromagnetic weapons that operate in radio wave and microwave (DEWRF and DEWM) ranges use electromagnetic impulses. These weapons use two types of the generators: narrowband (HPM- High Power Microwave) and wideband (UWB- Ultra Wide Band). UWB weapons emit radiation in a wide frequency range, but with a low energy density. These devices are suitable where it is not possible to accurately identify the characteristics of the target-especially its working frequencies. HPM weapons emit pulses at the individual frequencies with very high power. The impact on the target is very effective, because the impulse resonates with the known frequency of the attacked device [1].

High-Power Microwave (HPM) electromagnetic energy can be produced as a near-instantaneous pulse created through special electrical equipment that transforms battery power, or powerful chemical

reaction or explosion, into intense microwaves that are very damaging to electronics [2].

For the HPM systems some types of generators can be used like: MILO - Magnetically Line Isolated Oscillator, RKA-Relativistic Klystron Amplifier, TWT-Traveling Wave Tube, BWO-Back Wave Oscillator [3], MWCG- Cherenkov generator, Vircator-Virtual Cathode Oscillator, reltron, magnetron, gyrotron [4], etc. UWB Generator use as power component: special spark gaps, laser-activated semiconductor switches, quick switches for disconnecting circuits with inductance [4].

3. Contemporary Electromagnetic Systems for Stopping Vehicles

Fig. 1 shows the system HPEMcarStop, which is produced by a company Diehl BGT Defence GmbH & Co., Roethenbach/Pegnitz, Germany [5]. The company produces HPEM (High Power Electro Magnetics) effectors in the form of systems with product names: HPEMcarStop and HPEMcheckPoint.

System HPEMcarStop can be used, e.g., for activities by the police, army, special operations units or protection of important events (e.g., the Olympic Games).



Fig. 1. The system HPEMcarStop (adapted from [5]).

The system is designed so that EMP operates on the target vehicle from its front side; it means that the EMP generator is installed on a platform in the rear part of the vehicle. HPEMcarStop was successfully tested with more than 60 different types of vehicles and allows stopping the target vehicle at a distance of 3 to 15 m with more than 75 % success rate. HPEMcheckPoint is designed to the stopping of vehicles at checkpoints and in front of important objects (e.g., the critical infrastructure). It combines a system HPEMcarStop with another source HPEM, which is located on trailer.

Fig. 2 shows the next system for stopping a car with the designation HPEMcase. This mobile system

is used to influence command and data centers, computers, alarm systems control devices, surveillance installations, as well as all other kinds of electronics. Maximum peak radiated power is 365 MW and operating frequency 350 MHz [5].



Fig. 2. The System for protecting buildings and persons HPPEMcase (adapted from [5]).

Other manufacturers, which produce similar devices, are: the company Eureka Aerospace (Pasadena, California, USA, system HPEMS) or British company e2v (Chelmsford, England, system RF Safe Stop) [6] [7].

The British company e2v, as part of its production program (microwave devices for military and civilian purposes) produces RF system Safe Stop. This system is capable of bringing moving targets across land, sea and air to a controlled stop at a safe distance without collateral damage. The technology has been successfully trialled on Unmanned Aerial Vehicles, boats, cars, motorbikes and commercial vehicles [7].

Key features of the system:

- Stopping distance of up to 50 m (LAND and SEA version);
- Stopping distance of up to 400 m (AIR version);
- Narrow-band stopping capabilities across S and L bands (1 to 4 GHz).

The system is intended to stopping the vehicles within the control points, the protection of convoys and other relevant actions. This system can use the marine police for the protection entrances to harbors or stopping the motor vessels. The device has a weight of 350 kg and a working distance up to 50 m. In practice it is installed e.g. on vehicles Nissan Nevara or Toyota Land Cruisers. The device is capable of operating in a total time of 12 minutes on one charge, however, the effect of EMP with length of 3 s is sufficient for stop the vehicle [1].

Fig. 3 shows installing the system RF Safe Stop on the vehicle.

Application of the system RF Safe Stop in stationary installation on the control point shown in

the Fig. 4. The motors of vehicles are capable of re-operation after a forced stopping, but in some cases is required disconnect the battery. The device does not have a negative effect on people's health.



Fig. 3. Installing the system RF Safe Stop (adapted from [7]).

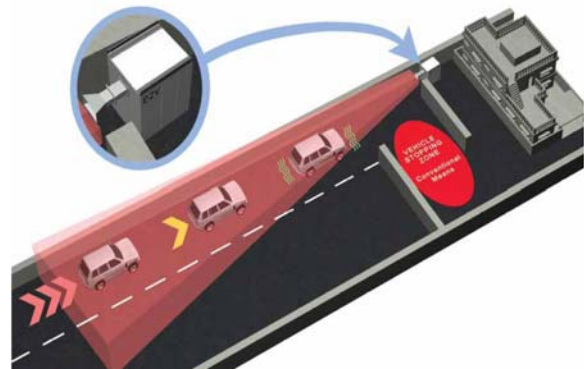


Fig. 4. Application of the system RF Safe Stop (adapted from [7]).

The company Fiore Industries Inc. (USA) has developed a device for stopping vehicles under the name EMWS Engine Stopper. The EMWS consists of multiple pulse amplifiers routed individually to their respective antenna elements. The system is capable of generating 2.4 kW, 30 μ sec pulse width and 8 kHz Pulse Repetition Frequency. The fields are launched via an antenna composed of 24 elements with a total gain of 23 dB. The system is remote controlled and is powered from two deep-cycle lead acid batteries. Fig. 5 shows scenario testing EMWS system.

Fig. 6 shows Multi - Frequency Vehicle Stopper. A number of components of the armed forces is also involved on the development of equipment that uses the EMP as a weapon instrument. Significant role in the US Armed Forces constitutes Joint Non-Lethal Weapons Directorate, which controls, supports and coordinates research and development in the field of non-lethal weapons. Within the framework of its activities is also involved in the development of means to stopping of vehicles and ships (in cooperation with the L-3 Electron Devices, USA), which include:

- Multi - Frequency Vehicle Stopper (Fig. 6);
- Radio frequency Vessel Stopper or
- Non-Lethal Unmanned Aerial Vehicle High Power Microwave Payload.

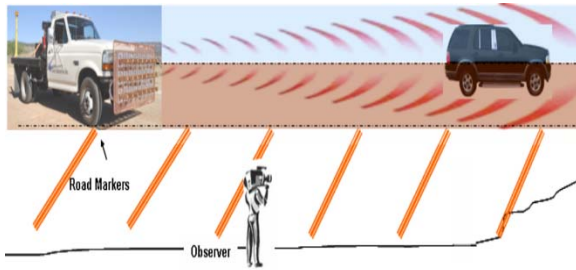


Fig. 5. System for stopping vehicles EMWS (adapted from [8]).

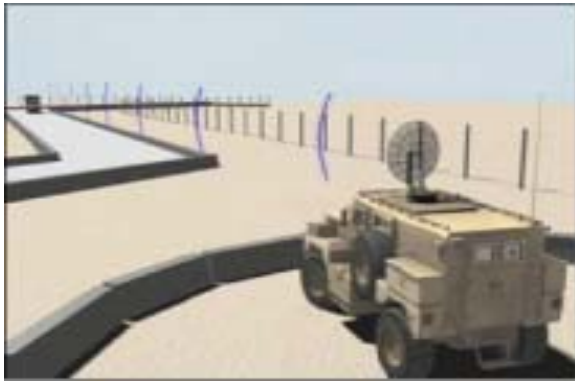


Fig. 6. Multi-Frequency Vehicle Stopper (adapted from [1]).

The system Vehicle Stopper is designed primarily for the protection of the army and it is expected deployment on the access points, checkpoints, at roadblocks or for mobile patrols. The system will be designed as a portable simultaneously are developed systems for stopping the motor vessels that will be installed on a ship or on air pilotless devices [1].

In 2012, European Commission set up a research project SAVELEC. Savelec (Safe control of non-cooperative vehicles through electromagnetic means) aims to provide a solution for the external, safe control of a non-cooperative vehicle without any consequences on the persons inside the vehicle or other persons and objects nearby. The proposed solution is based on the use of electromagnetic means, electromagnetic pulses (EMP) and high power microwaves (HPM), in order to disrupt the proper behaviour of the electronic components inside the vehicle, which will lead it to slow down and stop.

The project has 9 partners from European institutes and organizations, including universities, research and technology organizations, industrial and small - medium enterprise partners (Institute of Mobile and Satellite communication Technology, Technological

Educational Institute of Piraeus, MBDA France SA, Recherche Assistance Intervention Dissuasion Hellenic Aerospace Industry, The Armed Forces Academy of General Milan Rastislav Štefánik, etc.).

4. Electromagnetic Immunity of Automotive Technology

During the research, it is necessary to analyze the requirements of the standards for electromagnetic immunity of automotive technology. Verification of Electromagnetic Compatibility (EMC) requirements is performed for automobiles, e.g., in compliance with European Directive 2006/28/ EC and with standards ISO 11451, 11452, 7637, CISPR 12, CISPR 25, SAE J1133, etc.

Vehicle manufacturers also use their own standards (e.g., BMW- GS 95002, Jaguar, Land Rover- CS2010JLR, Renault- 36.00.808, etc.). These standards are stricter than international standards. These standards contain information about the requirements of testing electromagnetic immunity (type tests, signal levels, etc.) for automotive components [9].

5. Conclusions

We development of automobile technology is associated with the increase of application of electronic elements. One possible method to stop the vehicle is to disrupt the operation of electronic systems using a high power electromagnetic pulse. We presented the idea to use a stationary generator of electromagnetic pulses for stopping vehicles at checkpoints and at the entrances to the object. An important aspect of the proposal is the comparison of contemporary devices and systems used for stopping vehicles and analysis of the requirements of technical standards for electromagnetic immunity of vehicles. A novelty is the possibility of automatic generator control through integration with the alarm system. The output signal of the alarm system can trigger a HPM generator. The engine of vehicles within the radiation zone will stop and will not work as long as the HPM source is switched on. Another possibility is to use a camera system to identify the type of vehicle and its speed [10]. This is one of the possible ways to adjust power of generator. It is not advisable to calibrate HPM generator for one type car. Suitable orientation of the antenna HPM generator is important, regardless of the car construction (cars with metalized windows and a full steel body or cars based on carbon fiber and aluminum). To achieve the best possible result (vehicle stop), target cars must be radiated from the front. Exposure time of HPM signals required to stop the vehicle is dependent on the vehicle type, construction, speed, etc.

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