Design of A Simple Pulsed Radar Tool

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1 introduction

Road accidents have been very common in the world today and over speeding is one of the leading causes for these. It has therefore become necessary for law enforcement officers to monitor speeds of vehicles. This project proposes a system that detects the vehicles driving at above maximum speed limits along the highways roads.

1.1 Aims

- To design a radar speed gun
- To explore the relationship amongst parameters needed for calibrating the speed gun.
- To explore the relationship between RCS of different vehicle sizes and the minimum signal power

2 System Design and Implementation

2.1 System Specification

In this project we are designing a simple speed gun that will be used by police officers to track the speed of vehicles travelling on the road especially the highways. For the purpose of this project we shall assume that the cars are travelling on a straight road towards the speed trap and that the gun is mounted on a stationary police vehicle in such a way that it faces the oncoming vehicles. This allows us to focus mainly in the magnitude of the velocity of the vehicles under surveillance. In order to operate the gun, the officer will have to specify the speed limit for the area in which they are operating. For the purpose of this project, the maximum speed limit is set to be 180 km/h(50 m/s). We want to be able to design a portable device that can easily be mounted on the police car or be hand-held during the operation. Vehicles differ in terms of size and shape. For this reason the cross sections for vehicles differ from one type to another and they range between 2.7 square meters to 9.29 square meters. In order to be able to detect and track these targets more accurately, they must be tracked at distances between 152.4m and 1609m.

On average the antenna sizes for speed guns range about 5 cm in diameter. We shall use a conical horn antenna of this size for this project,with an area of 0.02 square meters. Again, a small radar of this sort will be best to work in the X-band with the frequency ranging between 8 GHz to 12 GHz. Normally devices of this nature operate at a peak power of close to 10MW.

We need to keep track of the targets state in position, angle in elevation and azimuth, the Doppler shift and other parameters.In order to accurately measure the instantaneous values for these parameters, we need to constantly send pulses towards the oncoming traffic hence it will be best to use a continuous waveform for this application. The main specifications for this application are stated below:

- Operating range in meters: 152-1609 m
- Transmitter power : 10MW
- Operating Frequency: 10.525 GHz
- Antenna Size : 5 cm
- Antenna Area: 0.02 square meters.
- antenna efficiency=0.511
- Beam width: 24 degrees
- Target cross section : 2.7 - 9 meters squared
- Maximum speed limit: 180 km/h
- Radar speed:0 m/s Stationary

The Doppler shift caused by a moving target and the speed of the moving target are related by the formula below:

$$doppler = 2 * velocity/wavelength \tag{1}$$

For example, if an operator sets the maximum speed as 50m/s, then the doppler shift would be 3508 Hz and any vehicles that would produce this amount of shift and above would be fined.

Again the maximum range the the radar can produce reliable information is 1609m and from this we can determine the PRF of the application, which is:

$$Rua = c/(2 * PRF) \tag{2}$$

Hence the PRF of the system will be 10.7e-6 Hz.

2.2 Implementation

The following subsections describe the modules that were implemented for this project.

2.2.1 Transmitter

This is the part of the project that is important for transmitting the the signal and has major parameters including the operating frequency and the peak power. The choice of a power source to use for the system depends on the system is coherent or non coherent and our system is coherent. Hence we decided to build a relatively low-power solid state transmitter for our speed gun.

With the aim of coming up with a very reliable, efficient and safe system, there are a number of factors we had to consider when designing this project.Losses occur at all stages of the process where prime power is turned into RF energy that is to be radiated toward the target. These losses are usually manifested as heat, which further reduces efficiency, since additional effort must be expended to eliminate the heat and prevent it from damaging or destroying the radar. Thus, cooling the components in a radar system, especially those comprising the transmitter, is paramount to ensuring the reliability of the system. For this reasons we have decided to use normal air-convection currents to reduce the losses to negligible values.

2.2.2 Antenna

An antenna in this case propagates the transmitted signal throughout to the atmosphere to the target and passes the signal reflected back from the target through to the receiver. The main parameters for this module are the antenna gain, the area and the efficiency of the antenna. For this part of the project we have decided to use a conical horn antenna

2.2.3 Receiver

The receiver is an integral part of the radar system. it provides the necessary down-conversion of the receive signal from the antenna and the inputs required to the signal and data processors.Since were building a low cost continuous wave system ,we used a homodyne receiver. For this type of receiver, a portion of the transmit signal is coupled from the transmitter and is used as the local oscillator input to the receiver mixer. The received signal at the antenna is coupled to the receiver while providing isolation to the transmit port of the circulator.

3 Conclusion

The project was completed successfully. The speed gun operates according to the mentioned specifications and allows the user to specify the parameters they wish to measure. We were also able to observe the relationship between the vehicle cross sections and minimum signal power. We noticed that less power is required for vehicles with greater cross section for a fixed range. We also managed to explore the relationships between different parameters.