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Active Projectile Defense System

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ABSTRACT

The need of a consistent, efficient and cost-efficient projectile defense system to protect an object or area from attack cannot be understated. Modern conflicts have evolved to be highly asymmetrical and tend be short-lived with high intensity. Through this project, we aim to design an Active Projectile Defense System. Such a system would serve to improve security of civilian and friendly military assets in times of peace. In times of armed conflict such a system would increase survivability of friendly military assets.

Until the 1950s guns firing unguided ballistic ammunition at airborne moving targets was the standard air defense method. This was quickly replaced by more potent guided missile defense systems for longer ranges. The advances in RADAR, power electronics and microprocessor technology has allowed air defense systems to be modular and portable. This concept has further evolved to the projectile defense system.

Index Terms: *Waveform Generator, RADAR, Anti Projectile system, Processing Unit*

1. Introduction

A Projectile defense system is a collection of individual components working in cohesion to protect a designated volume of space from potentially destructive incoming projectiles. Most projectile systems in existence include humans in the control loop. In this project we aim to eliminate the human factor and replace it with a controller that would take over decision making based on specific algorithms. This project mainly focuses on target detection and acquisition through processing of reflected radio signals. Electromagnetic waves from the microwave spectrum are used for ranging and detection. A phased array radar will be used to transmit and receive the rebounding radio signals.

2. Assumptions

The projectile defense system would be designed to function in a real time, dynamic environment. This forces us to design our system bearing in mind practical constraints. Hence, assumptions are made about the projectile, our system and the environment in which the scenario plays out. The assumptions are as follows;

- The incoming projectile is within tracking range and field of view.

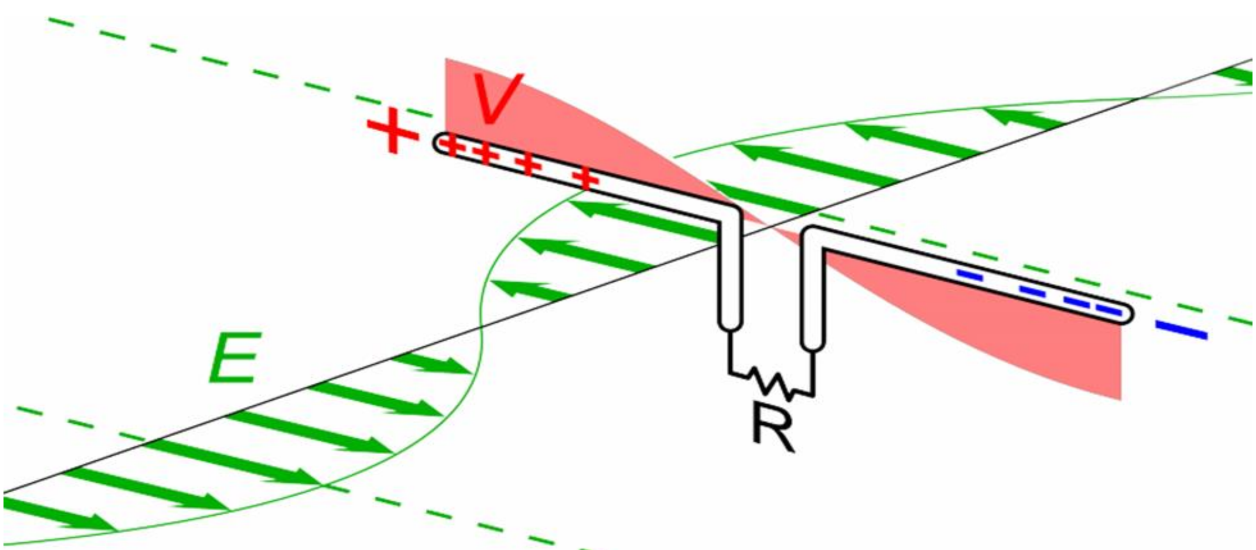
- The projectile is distinguishable from the surrounding environment.
- The projectile has sufficiently has large RADAR cross-section; thus reflecting sufficient electromagnetic energy.
- The velocity of the incoming projectile remains constant.
- There will exist a clear line of sight between the projectile and defense system at the time of firing.
- A hit will be considered successful when incoming projectile and intercepting projectile occupy the same space
- Viscous friction between air and the projectile is neglected
- Effects of wind force on the trajectory of both projectiles will be neglected
- Time taken to calculate projectile trajectory is constant
- Sampling rate is much greater than the rate of change of projectile co-ordinates

3. RADAR

The RADAR would be used for data acquisition. It works by sending out radio waves from a transmitter. These waves reflect off objects and return to be collected in a receiver. The radar would be an array of dipole antennas arranged vertically and horizontally to form a grid.

3.1 Dipole Antenna

A dipole antenna is a type of antenna that is constructed from two identical conductive elements. The antenna is bilaterally symmetrical in design. The antenna input or output, depending on whether the antenna is a transmitter or receiver, is taken at the midpoint of the line. Each side of the feed line to the transmitter or receiver is connected to one of the conductors. Dipoles are resonant antennas, hence the length of the antenna depends on the wavelength of the electromagnetic wave. Dipole antennas have an omnidirectional radiation pattern and hence radiate equal power in all directions perpendicular to the axis of the antenna.



3.2 Frequency spectrum

The operating frequency that has been selected lies in the UHF range of 300MHz-3GHz, this corresponds to a wavelength ranging from 1m – 10 cm. The frequency bands have been selected considering the following parameters of this project;

- Operation distance
- Resolution of projectile image
- Accuracy
- Size of antenna

Bands of lower frequencies correspond to longer wavelengths. Such waves are not suitable for smaller sized targets under the proximity constraints of this project. As frequency increases the operational range of the radar; for fixed power output, decreases.

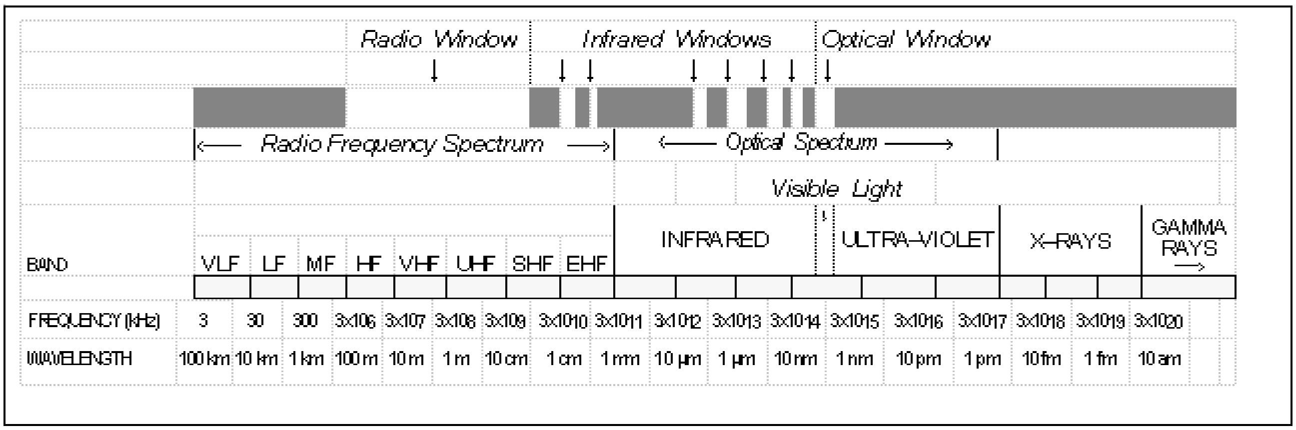
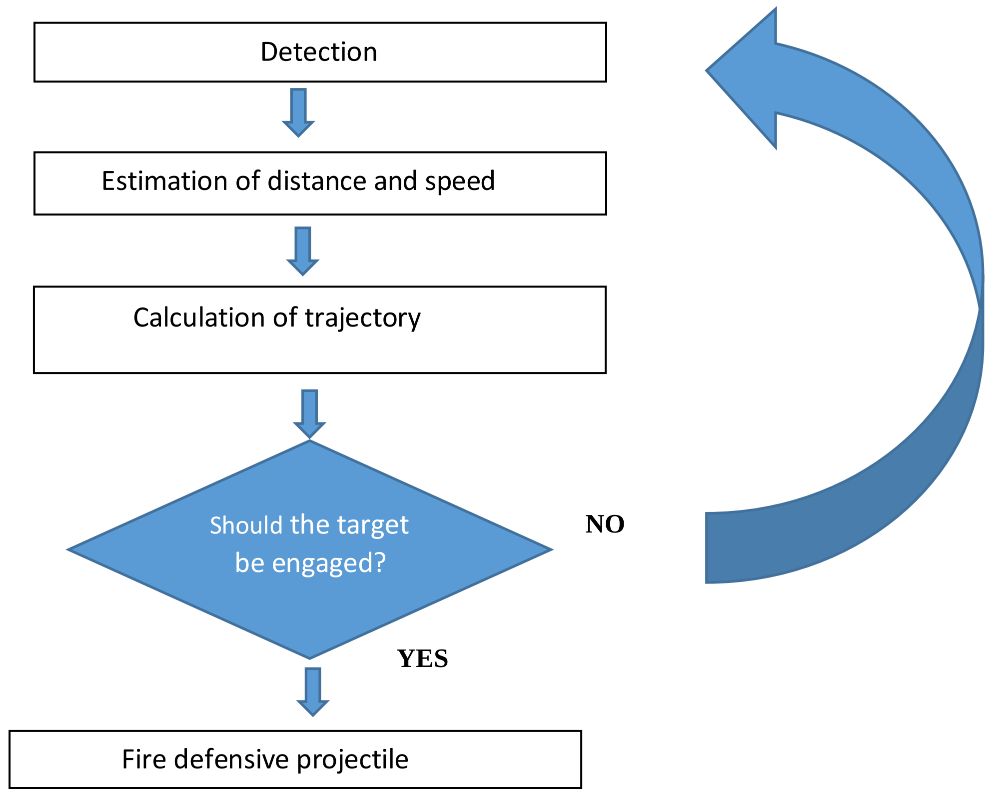


Figure 3–1. The Electromagnetic Spectrum.

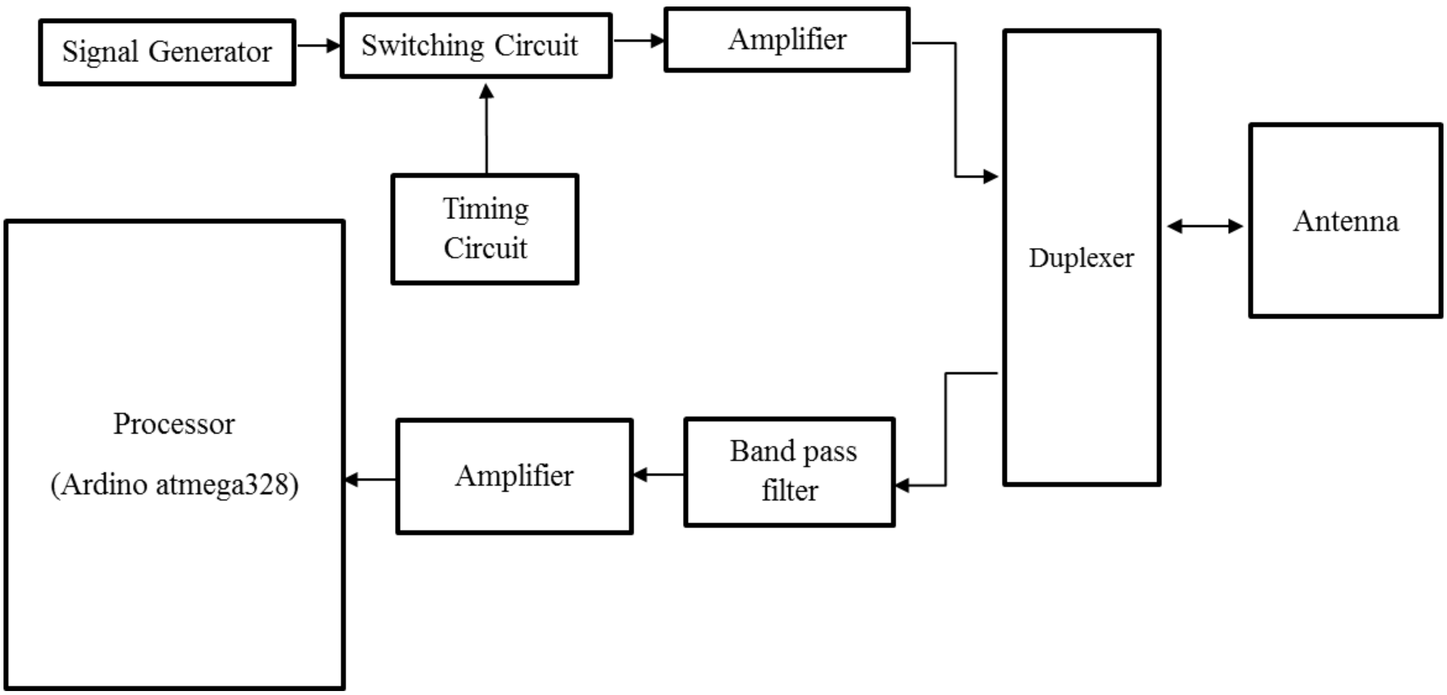
4. Literature Survey

Sr.no	Title	Year of Publishing	Inference
1	Archie to SAM: A Short Operational History of Ground-Based Air Defense by Kenneth P. Werrell	2001	Scope of applications for both present and future scenarios.
2	J. C. Toomay and Paul J. Hannen. Radar Principals for the Non-Specialist. Third. Scitech Publishing Inc.,	2004	Introduction to basic principles and mathematical tools required for radar design.
3	Radar Signal Processing, Robert J. Purdy, Peter E. Blankenship, Charles Edward Muehe, Charles M. Rader, Ernest Stern, and Richard C. Williamson	2000	Processing algorithms and circuit design principles for signal processing.
4	Stutzman, Warren L.; Thiele, Gary A. Antenna Theory and Design. John Wiley and Sons. pp. 74–75. ISBN 0470576642	2012	Significance, advantages and working of dipole antenna.

5. Methodology



4.1 BLOCK DIAGRAM



4.2 Algorithm

1. Start
2. Set firing angle of switching circuit.
3. Initialize signal generator
4. Set duplexer to transmit mode
5. Transmit generated pulse train
6. Set timer ON
7. Set duplexer to receive mode
8. Wait for echo signal
9. Amplify filtered signal
10. Stop timer
11. Calculate projectile distance
12. Repeat steps 5 to 11; obtain second position vector.
13. Calculate velocity
14. Calculate trajectory of projectile
15. If trajectory and positional co-ordinates coincide ; proceed to next step , else repeat step 5
16. Optimize firing sequence
17. Fire defensive projectile

5. APPLICATION

Such a system can be used to enhance the security of areas and objects of importance; military or civilian. In a military scenario such a system would greatly improve survivability of battlefield assets. Minimized human factor allows for more efficient and accurate defense system, while high portability allows for quick implementation of a precision security measure.

5.1 FUTURE SCOPE

The current system is a prototype, the core components of which could serve as a base for systems that must be highly adaptive in nature. The fundamental parameters of the microwave signals would have to be changed based on the change in operating environment. Frequency shifting techniques could be employed to reduce susceptibility to electronic countermeasures and jamming. A faster and powerful processor could be used to counter guided trajectory shifting maneuvers of projectiles; this would prove extremely useful in the civilian automation industry.

6. Conclusion

An autonomous active projectile system would prove to be an invaluable asset in defense of territory and assets in both peacetime and armed conflict situations. Such a system would make it extremely hard for enemy ballistics to reach intended targets thus greatly affecting outcome. Thus, such a system has broad future scope not only in military but in civilian surveying applications as the technology can be modified to suit any required need.

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