Double-Pulse Technique for Defending from Hostile Systems

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Abstract**—** In this paper, we have addressed a promising way of defending from a hostile system, using two electromagnetic pulses. The first pulse is a hyperband signal meant to interrogate the target system to determine its vulnerabilities in terms of the frequencies that can penetrate the system. The second pulse is then tailored to contain the electromagnetic energy in the appropriate frequency band in an attempt to disable the hostile system. The possibility of such a double-pulse technique has been raised by many and we have decided to look into this further. In a representative example considered in this paper, we find that a single equation can lead to both external and internal resonances of the target system.

Keywords-Hyperband, narrowband, vulnerabilities, resonances

I. INTRODUCTION

A promising way to defend against a hostile system in air, on water or land (ex: an incoming missile, speed boat or a ground vehicle with hostile intention) is to send a powerful electromagnetic pulse to disable the electronic control system [1]. It is the purpose of this paper to discuss one aspect of such a defense. In order to disable the electronics some of the energy of the electromagnetic pulse must penetrate to the interior of the incoming system. If the outer shell of the hostile system is not highly conductive, this penetration can be accomplished with relative ease. Even if the outer shell is metallic, there are unavoidable points of entry consisting of junctions of metallic surfaces, slits around moving surfaces, inadvertent apertures etc, where the electromagnetic pulse can penetrate. Points of Entry (PoEn) for electromagnetic energy can also serve as Points of Exit (PoEx).

Such penetration into the system is more easily accomplished at some frequencies of the electromagnetic pulse than other frequencies. Therefore, the disabling of electronics can be more easily carried out if the pulse can be tailored to contain most of its energy in these frequencies. From this point of view, the defense can be accomplished in two successive stages.

1) We first send a moderately powerful electromagnetic pulse. Over certain frequency ranges, this pulse contains significant energies. We analyze the return signal to determine the frequencies that may have penetrated the target system, which are likely to be the frequencies where the system is vulnerable. It is noted that coupling of certain frequencies into the system is necessary, but may not be sufficient to accomplish the necessary damage. We will discuss this aspect further in the presentation.

2) We send a second pulse to disable the electronics of the system. This second pulse is much more powerful than the first electromagnetic pulse and is tailored to contain as much energy as possible in the frequencies that coupled into the system.

This procedure of using two electromagnetic pulses has another side benefit. It is conceivable that systems of the same type can be individualized so that their responses to electromagnetic pulses are different from each other. Such a discriminating program does not have any effect on the present procedure of using two pulses. The double-pulse defense has been suggested in the past by researchers including the first author of this paper. A general intuitive response has ranged from “this technique is not practical” to “it cannot give the interior resonances”. The implied pessimism and finality of the responses has motivated us to look into this problem, in some detail.

II. AIRBORNE TARGET SYSTEM

We have considered a canonical problem representative of the missile defense in this paper. We find that in an idealized case, it is possible to write a single equation that yields both ***exterior*** and ***interior*** resonances. We believe this is a new result opening the door for pursuing this problem. We consider a perfectly conducting cylinder of radius “a” and the same cylinder coated with a reactive surface. The exterior and interior regions are coupled by a scalar parameter α. We find both sets of resonances are given by

$$J_n(ka)\,H_n^{(1)}(ka) = \frac{2\,i}{\alpha\,a} \qquad (1)$$

If there is no coupling between the two regions, the interior resonances are given by the real zeros of the Bessel function and the exterior resonances are given by the complex zeros of the Hankel function. On the other hand, for finite values of α, no matter how large, there is no such factorization, and the interior resonance and the exterior resonance are not separate. We have numerically solved the above equation for the cases of n = 0, 1, 2 and 3 and for $1 \leq a \leq 100$. The numerical results at least for this idealized situation indicate that there is no problem in separating the interior and exterior resonances.

In our two pulse procedure, the return signal from the first Hyperband illumination is analyzed for the resonance mix. We then look for identifying the interior resonances which are likely to be in the fourth quadrant of the complex k plane with small imaginary parts. In the simple problem considered here, there are no difficulties in separating the interior and exterior resonances. This delineation of interior and exterior resonances is likely to hold for the realistic missile return signals. Identification of the interior resonances leads to the more important second-pulse excitation (narrow or moderate band signals) with its energy concentrated in the interior resonance bands.

[1[This presentation is based on Interaction Note 602 of the same title by D.V.Giri and T. T. Wu, which can be downloaded from www.ece.unm.edu/summa/notes