Antenna Modification for In-Flight Projectile Fuze Data

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ABSTRACT

Microstrip antenna designs have gained importance due to the requirements and restrictions of projectile size and desired data. Most projectile testing programs require in-flight data during the entire trajectory. Original microstrip antenna designs created extensive variations in the antenna radiation pattern as the projectile was rotated about its axis. These variations led to distortion and total loss of data during critical events of a projectile fuze test. Developments and data that have led to modified designs in order to reduce these nulls will be discussed in the following sections.

BACKGROUND

In 1985, ARDEC acquired an in-progress stockpile reliability test program for an artillery fuze. This test program required data collection during the entire projectile trajectory. After reviewing previously collected data, it was determined that a new antenna could provide an improved radiation pattern yielding better data in the field. A modified antenna was installed on the first two quantitative telemetry equipped test projectiles and a second modification was implemented on the succeeding test projectiles. These redesigns proved to be extremely successful in the field due to the collection of excellent data. The gain and radiation patterns emitted from these new antennas reduced the importance of the receiving telemetry ground station location.

ORIGINAL ANTENNA

The antenna originally designed for this fuze telemeter was mechanically competent to endure the harsh environment imposed on a projectile during a gun firing. The electrical aspect was comprised of two one-half wavelength slots with a coaxial feed network. This design created large nulls at 0 and 180 degrees about both the phi (Φ) and the theta (Θ) axis. The coordinate system for pattern measurements is given in figure 1. Telemetry station location became critical due to these nulls.

FIRST MODIFICATION

The first telemeter antenna modification designed and developed by Physical Science Laboratories, N.M.S.U. was implemented on the first two qualification test projectiles instrumented by ARDEC. This antenna was comprised of a continuous thin slot fed in four equally spaced locations by an integrated stripline feed network as shown in figures 2 and 3. The feed network provides a balanced signal with pattern nulls occurring directly behind and in front of the projectile. The telemetry ground station could now be set-up anywhere along the side of the projectile trajectory.

SECOND MODIFICATION

An improved version of the previously mentioned L-band (1510 MHZ) antenna was redesigned using eight(8) instead of four(4) feed points thus reducing the magnitude of the nulls significantly as can be seen from the Table below. This design allows for a simple conversion of the stripline feed network to utilize higher frequencies such as S-band (2200-2300MHz). If an array has equal half-wavelength spacings than there is precisely one period of the array factor that appears in the visible region. The visible region has a length of $2\beta d$

where: β is defined as $2\pi / \lambda$
d is the element spacing
λ is the wavelength

Let us assume that exactly one period appears in the visible region. The period is 2π therefore $2\pi=2\beta d= 2(2\pi/ \lambda)d$ or $d/ \lambda=1/2$. For the first modification, f= 1510 MHZ, antenna diameter= 6.0 in.: therefore: λ=7.882 in., circumference = 18.85 in. and $d\approx 0.6\ \lambda$. For the second modification, $d\approx 0.3\ \lambda$ however, if we now use an average S-band frequency of 2250 MHZ, λ =5.25 in. and d= 0.45 λ. The ideal antenna would be designed to have element spacings of one-half wavelength. This insures uniform roll plane patterns and reduces the amplitudes of undesired major lobes.

Both of the modified antennas are protected from the gun launch environment by a radome constructed of polyester weave material impregnated with epoxy resin.

CONCLUSION

These two modified telemeter antennas have provided excellent data from previous field test firings compared to the original two slot design. These new designs will be incorporated into the recently acquired projectile fuze stockpile reliability program due to begin next year. The second modification will allow a smooth transition to the redesign proposed for both of these previously mentioned fuze programs in which an S-band transmitter will be implemented.

Gain Variations in the Original and Modified Antennas

	Maximum Variation (db)	
Theta (degrees)	Original	Modified
10	8.00	4.00
20	8.00	4.50
30	6.00	2.00
40	6.50	3.00
50	12.50	5.00
60	20.00	5.00
70	8.00	7.00
80	11.00	7.00
90	22.00	5.50

REFERENCES

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3. Stutzman, Warren L., Thiele, Gary A., “Arrays”, Antenna Theory and Design, John Wiley & Sons, Inc., New York, 1981, pgs.121-123.

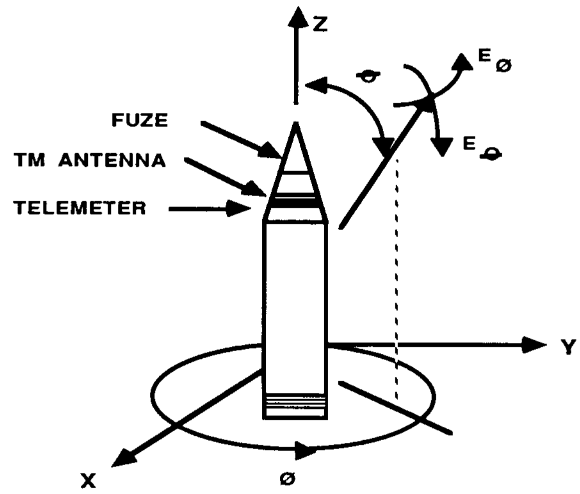

Figure 1 - Coordinate System for Pattern Measurements

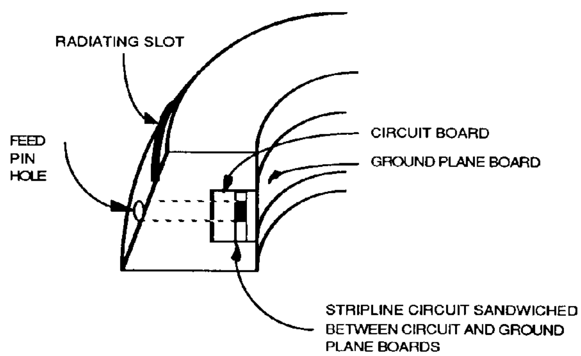

Figure 2- Integrated Stripline Feed Network

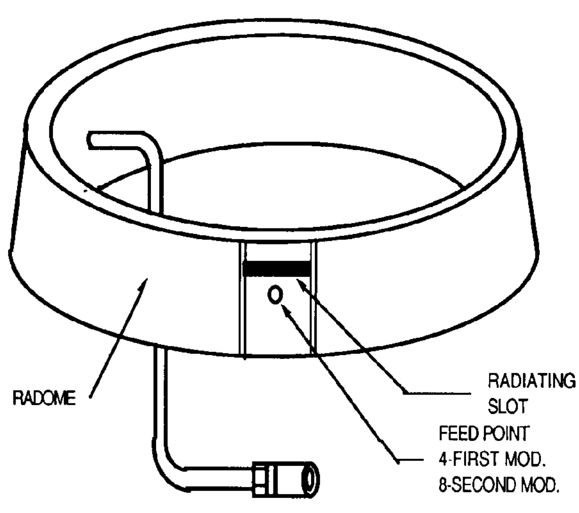

Figure 3- Modified Antenna