MULTIBAND OMNIDIRECTIONAL TELEMETRY ANTENNA

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ABSTRACT

With the increasing sophistication of telemetry and tracking systems, an omnidirectional antenna plays a major role in assuring adequate telemetry system signal to noise ratio regardless of test platform orientation. However, the increased demands on antenna performance often impact the antenna complexity, size and weight. This paper describes a simple yet extremely rugged antenna designed to conformally mount to a large diameter missile and provide omnidirectional coverage at four discrete frequency bands while minimizing structural impact on the missile.

INTRODUCTION

In many missile telemetry systems coverage is obtained by arraying several discrete elements around the missile circumference. Depending on the element spacing, this configuration may result in deep pattern nulls which can seriously degrade the telemetry system performance. The depth and width of the antenna pattern nulls are a function of element spacing and can be significantly reduced by increasing the number of radiating elements. (1) However, good roll plane performance is obtained only if the circumferential spacing between elements does not exceed one wavelength. Clearly a large diameter missile requires a large number of discrete radiating elements. The feed network for such an array quickly becomes cumbersome and fabrication techniques demanding.

A continous circumferential slot antenna backed by a quarter wavelength cavity has several advantages over discrete element arrays as follow:

- It inherently provides better roll plane and coverage performance
- Printed circuit techniques can be used for feed network fabrication
- The feed network is an integral part of the antenna
- Construction techniques provide an extremely rugged conformal design. In fact the antenna may be designed as a structural load bearing member.
- In multiband applications, the antenna cavities can be easily stacked to reduce the antenna size and weight.

The following paragraphs will describe the configuration and performance of a circumferential slot antenna designed for the MX missile. The antenna design was driven by minimum envelope, severe environmental and stringent coverage criteria.

CONFIGURATION

Figure 1 depicts an exploded view of a typical antenna segment. The antenna segment is 4.0" wide, .5" deep and 36.1" in circumference. Complete configuration of the 92" diameter missile requires eight such segments recessed conformally to the missile skin and fed from a centrally located power divider. When arrayed, the segments form four circumferential slot antennas.

Each slot antenna is designed to resonant at a specific frequency; two L Band frequencies for GPS reception, one S Band telemetry frequency and one C Band transponder frequency. All antennas are backed by quarter wave cavities with S and C Band cavities lying above the two L Band cavities. Microstrip boards with etched power divider circuitry are bonded to the bottom of each cavity and are connected to the cavity structure by feed pins which act as current probes to properly excite the cavity.

The L Band cavities are partially loaded with teflon to reduce the cavity dimensions. In addition a Duroid radome is bonded over the external surface. The antenna is extremely sturdy with calculated structural resonant frequencies exceeding 800 Hz. The system weight is less than 80 pounds.

PERFORMANCE

Ideally each circumferential slot is excited in such a way so as to produce a uniform amplitude and phase distribution. This can be theoretically accomplished if the number of feed points is such that the cavity is fed at least every wavelength along the circumference.(2) In practice the achievable amplitude and phase distribution is limited by fabrication tolerances and feed line coupling which may excite higher order modes in the cavity.

Extensive near field probe data was taken on each segment as well as the complete system. Typical near field data for a single segment is shown in Figure 2. Obviously at the higher frequencies dimensional tolerances quickly cause perturbations in the near field performance.

Figure 3 depicts the antenna set up for pattern measurements in an anechoic chamber. Far field measurements on an outdoor facility were also conducted. Typical patterns are depicted in Figures 4 and 5 with the performance summarized in Table I.

In addition to performance tests, the antenna was subjected to environmental tests which included; shock tests (6750g), radom vibration (13.2 g^2/Hz), thermal cycling (-13°to 160°F) and temperature/humidity tests. Power tests were also conducted to verify high altitude power capability at a 500 watt level for C Band and 20 watt for S Band.

CONCLUSION

A multiband circumferential slot antenna can be manufactured which requires only a 4" by .5" antenna envelope. The total radiation sphere can be nearly covered at the -8 dBil level for L and S Band frequencies and the -10 dBil for C Band frequencies.

REFERENCES

(1) Chu, Ta-Shing, October, 1959, "On Use of Uniform Circular Arrays to Obtain Omnidirectional Patterns," IRE Transactions on Antennas and Propagation, pp 436-438.

(2) Munson, R. E., October 18-20, 1977, "Omni Directional Telemetry Antennas", International Telemetering Conference, Los Angeles, California.

TABLE I
MEASURED ANTENNA PERFORMANCE

BAND	FREQUENCY	BANDWIDTH 2.0:1	GAIN (95% SPHERE)	ROLL RIPPLE	PHASE VARI- ATION	MAX. PHASE SLOPE	BAND ISOLATION	POLARIZATION
L_2	1227 MHz	63 MHz	-7.3 dBil	3.5 dB	29°	3.5°/deg.	<-20 dB	Linear
L_1	1575 MHz	123 MHz	-7.5 dBil	4.3 dB	22°	2.0°/deg.	<-20 dB	Linear
S	2209 MHz	100 MHz	-7.3 dBil	4.0 dB	25°	- - - -	<-20 dB	Linear
C	5765 MHz	100 MHz	-10.0 dBil	7.5 dB	56°	- - - -	<-20 dB	Linear

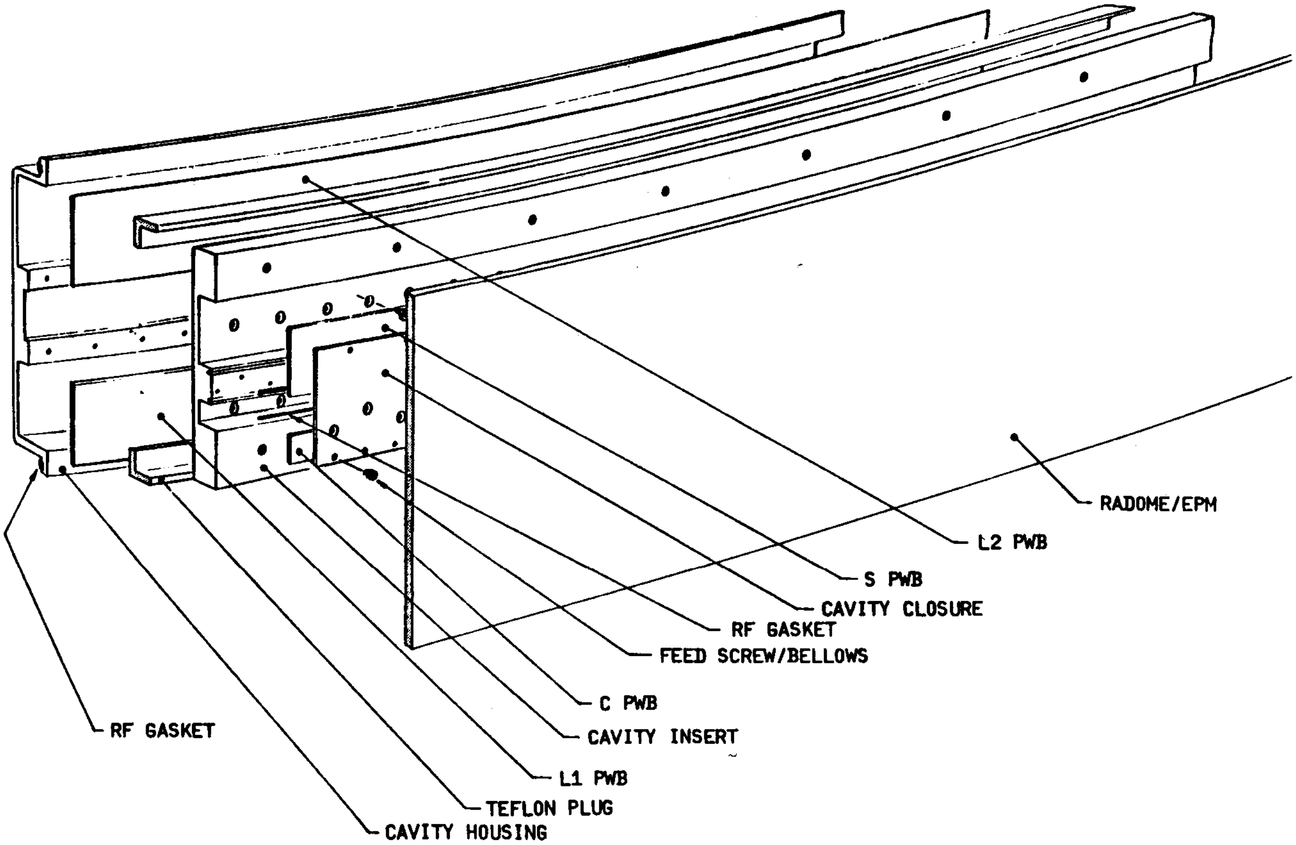

FIGURE I   ANTENNA SEGMENT CONFIGURATION

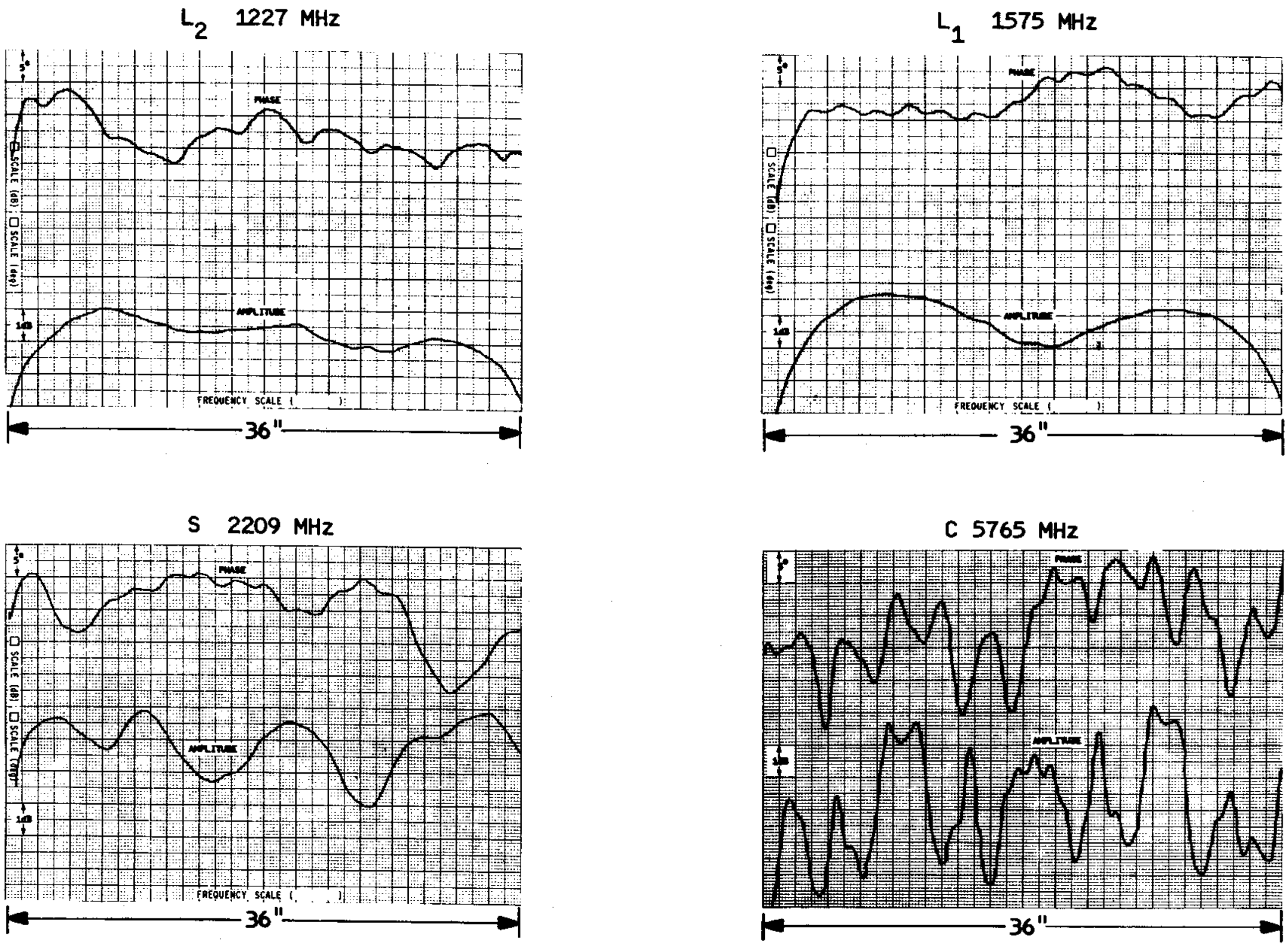

FIGURE 2 SEGMENT NEAR FIELD DATA

FIGURE 3 MX TRIBAND ANTENNA

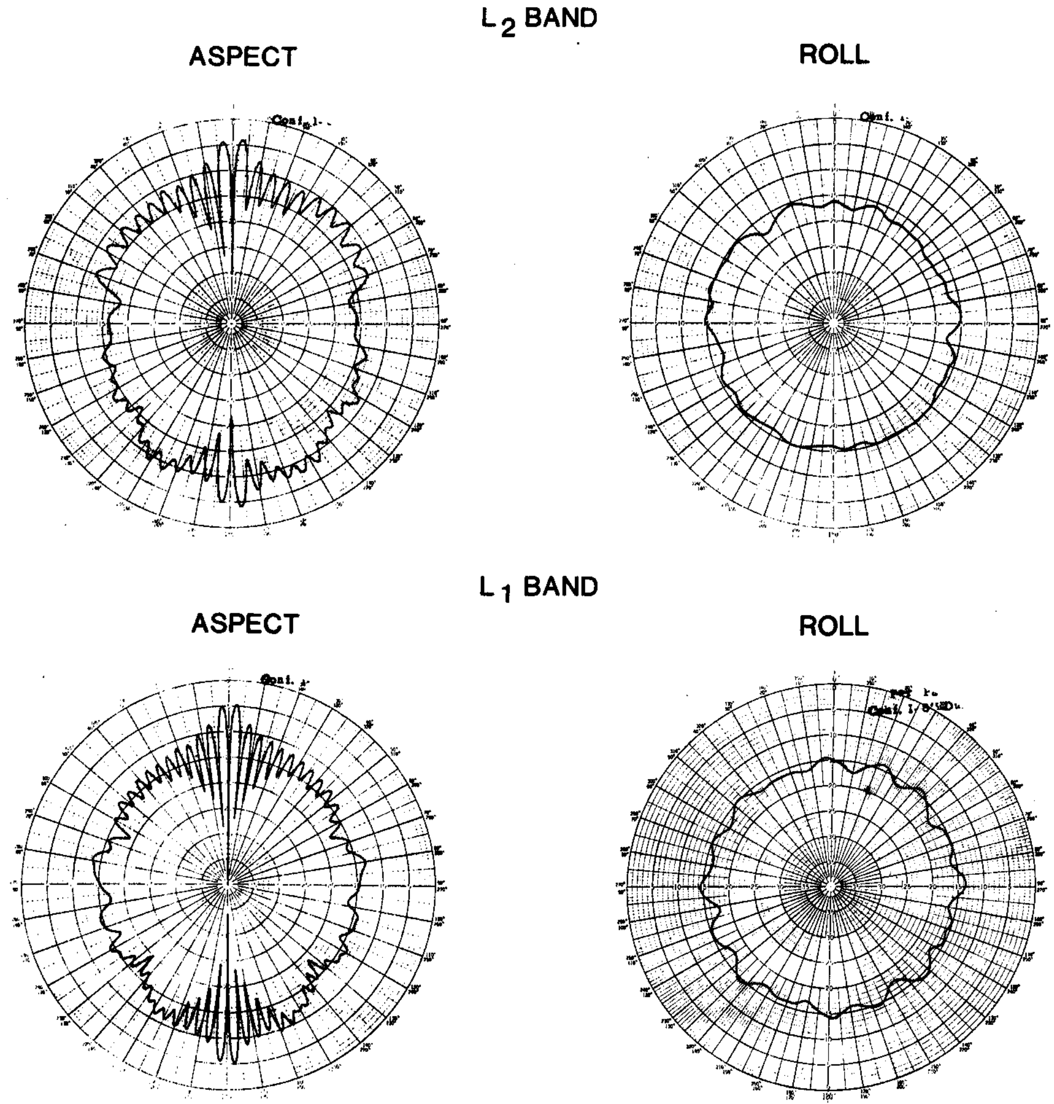

FIGURE 4. MEASURED ANTENNA PATTERNS, L_1 AND L_2

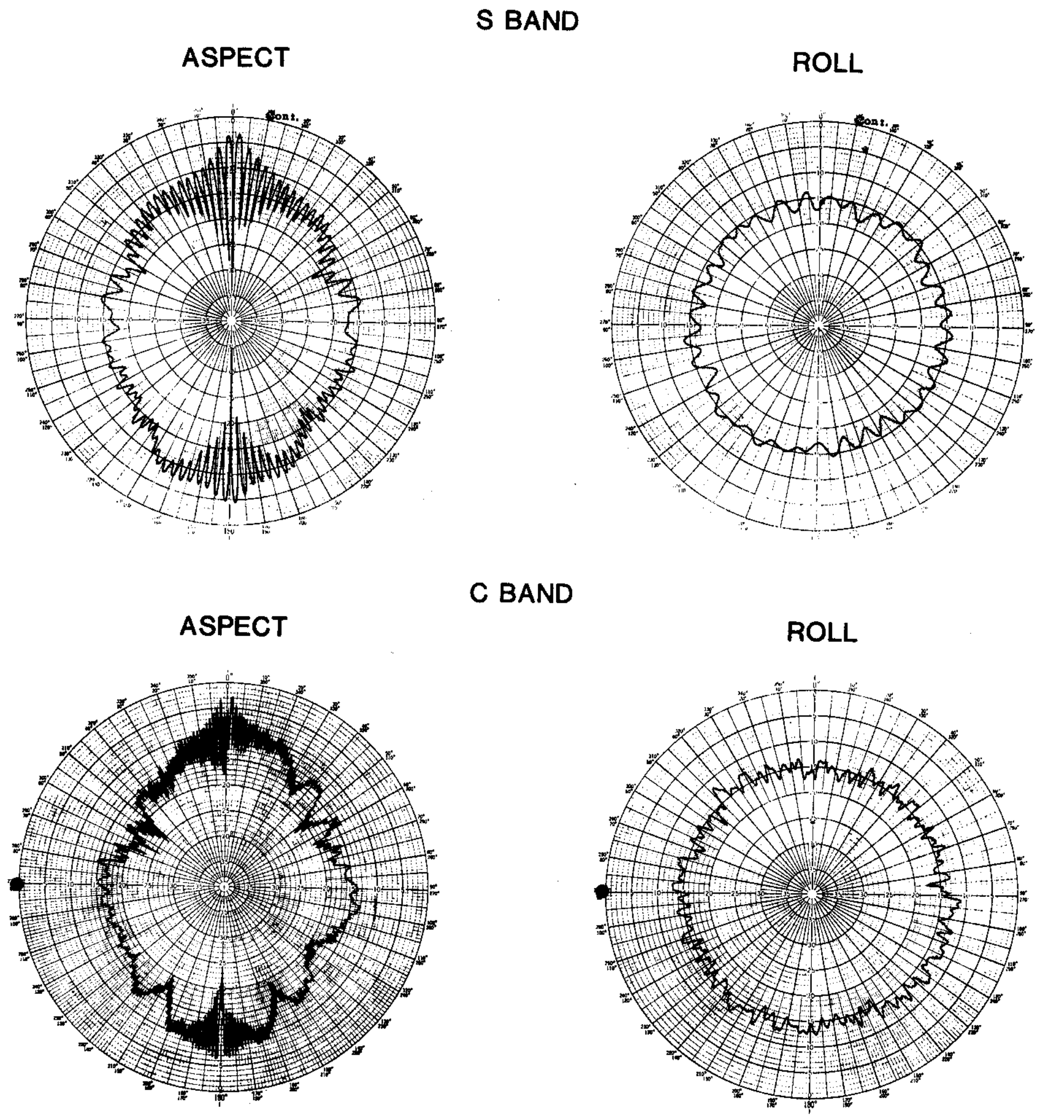

FIGURE 5. MEASURED ANTENA PATTERNS, S AND C