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MEASURED TRANSMIT NULLING PERFORMANCE IN WIDEBAND ARRAYS

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ABSTRACT

An important performance requirement for future naval phased array radars is the ability to form nulls in the sidelobe region of the transmit pattern. This problem is similar to adaptive beamforming and has been studied extensively in the literature. The most practical of the available transmit nulling techniques compute small phase perturbations that when applied to each array element create a null in the antenna pattern. However, the performance of these techniques quickly degrades as the transmitted signal deviates from the array center frequency. This paper presents measured data to illustrate null performance as a function of transmit signal frequency in a wideband array. Results are compared to theory, and the benefits of a wideband array architecture using tapped delay lines (TDLs) placed behind each array element are discussed.

1. INTRODUCTION

Nulls created in the sidelobe region of an antenna pattern are useful for mitigating electromagnetic interference in dense operating environments and for reducing the unwanted backscatter from clutter. In most practical systems, amplitude and phase control is not available at the array element level. Instead, independent phase commands are applied at each array element to form the desired spatial null, with the amplitude weight at each element set to a fixed value. Some common techniques for computing transmit nulls are described in [1] – [4].

Typically, the phase weights to be applied at each element are computed for the center frequency of the array, which corresponds to half-wavelength spacing between array elements. Furthermore, the phase shifter behind each element is calibrated for the array center frequency. As a result, over the entire bandwidth of the transmit signal, the phase shift at each array element will deviate from the optimal value, causing the transmit null to change pointing direction, and the null depth to vary at the desired spatial location.

The purpose of this study is to measure the deviations in the pattern of a uniform linear array (ULA) at a desired null location over the entire bandwidth of a wideband transmit signal. To maintain a stable null depth and pointing direction over a large signal bandwidth, a wideband array architecture is proposed. This architecture has been described in the literature and consists of a tapped delay line (TDL) placed behind each array element [5]. The coefficients of the TDLs allow the frequency response of the array to be controlled. The transmit nulling performance of the TDL architecture is measured using a hardware test bed.

2. TEST CONFIGURATION

Preliminary measurements demonstrating the sensitivity of transmit nulls to the signal frequency have been taken using the test configuration described in Fig. 1. This diagram illustrates a ULA transmitting a tone at 3 GHz into a wideband receive horn. The array elements are driven by a narrowband signal source, and the peak power at the output of the receive horn is measured using a power meter. Only the 4 center elements of the ULA are active while the 8 edge elements are terminated. The separation between the transmit and receive antennas exceeds the minimum far field distance of both antennas. The entire test configuration was placed in a compact antenna range, and radar absorber material was placed along the floor between the antennas to prevent multipath bounce from entering the receiver.

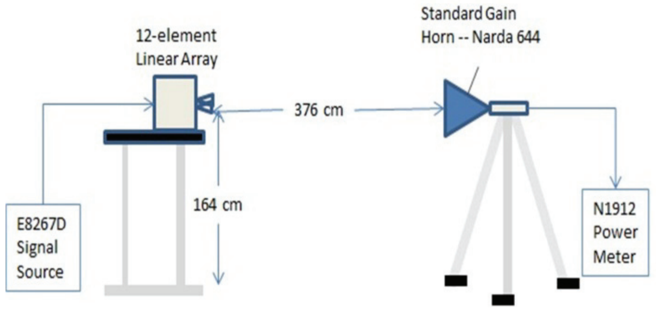

Fig. 1. Test Configuration

Figure 2 is a picture of the wideband transmit array. The specified operational bandwidth of the transmit array is 2 to 4 GHz. The specified operating range of the receive horn is 2.6 to 3.6 GHz.

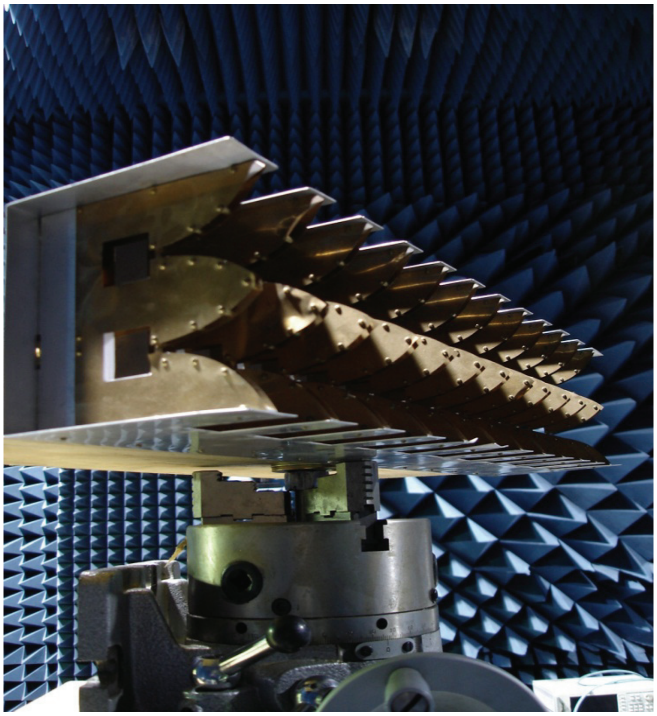

Fig. 2. Transmit Array

3. PRELIMINARY RESULTS

An azimuth cut of the array pattern was measured over a 60° sector in 1° increments and is compared to the theoretical result. The element pattern was assumed to vary as cos(θ). The electrical paths from the signal source to the radiating elements were calibrated such that each had the same phase differential and gain. No additional phase shift was applied to each element so that the main beam was effectively steered to broadside. Figure 3 illustrates the agreement between the measured and the predicted array patterns. The simulated array pattern does not account for any mutual coupling effects or array element position errors. Note that the measured null appears to reach a minimum at 27° although the theoretical pattern has a minimum at 30°. This discrepancy is likely due to the fact that the measured depth of the null in the antenna pattern is limited by the noise floor of the power meter. To mitigate this source of measurement error and to enable the more precise location of deep nulls, a planned upgrade to the testbed will include an amplifier before the power meter.

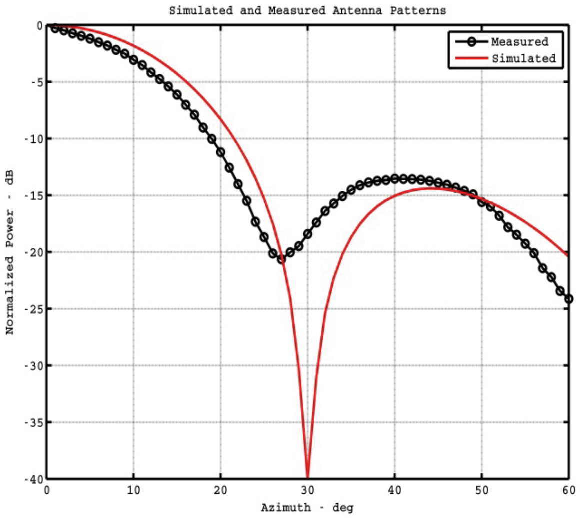

Fig. 3. Measured vs Predicted Array Pattern

To ascertain the dependence of the measured null at 27° azimuth on transmit frequency, the array's pointing direction was held fixed while the transmit frequency was varied from 2.6 GHz to 3.6 GHz in steps of 50 MHz. Figure 4 illustrates a substantial change in null depth as a function of frequency.

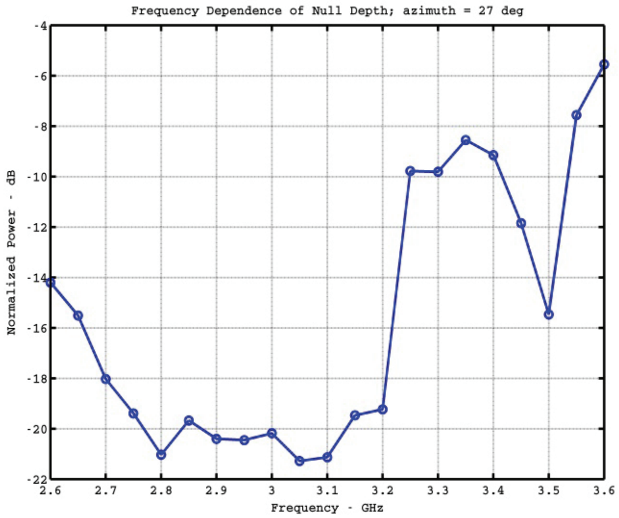

Fig. 4. Null Depth vs Frequency

4. WIDEBAND ARRAY ARCHITECURE

To maintain a near constant null depth over signal bandwidths greater than 25% of the array center frequency, the array architecture in Fig. 5 is proposed. The transmit nulling performance of this architecture will be explored using the ULA test bed, and the results will be described in the conference paper.

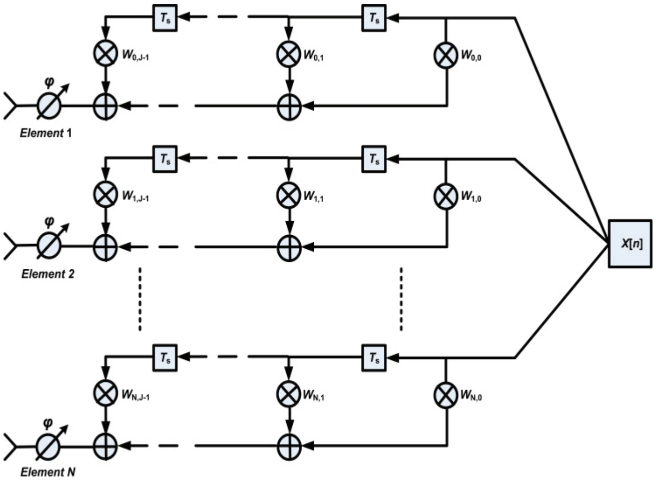

Fig. 5. TDL Array Architecture

5. CONCLUSIONS

In this paper, preliminary measured results using a wideband ULA testbed are provided for nulls formed in the transmit pattern of the array. The data show a deterioration in null depth as the transmit frequency varies over a signal bandwidth. The improved performance of a wideband array utilizing TDLs behind each element will be explored.

6. REFERENCES

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