Evaluation of Adaptive Space-Time-Polarization Cancellation of Broadband Interference

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Abstract: It is demonstrated that an array of N dual-polarized antennas can cancel up to 2N-1 broadband interferers, while still maintaining a high probability of GPS satellite availability.

INTRODUCTION

It is highly desirable to use as small an antenna array as possible to cancel any interference affecting GPS receivers. Using a fully-polarimetric space-time adaptive array offers the possibility of nearly doubling the number of interferers that can be cancelled by an antenna array occupying a given area. That is, a conventional N element adaptive array can cancel N-1 broadband interferers, whereas if each antenna element is dual polarized the same N elements can potentially cancel 2N-1 broadband interferers. This offers the possibility of cancelling broadband interference .

In this paper we will evaluate (by simulation) the performance of an adaptive array of dual-polarized elements, under the following assumptions:

1) The interference consists of M broadband interferers, each of which is either circularly polarized or linearly polarized with a randomly-oriented polarization vector. These interferers are randomly located in azimuth (0 to 360^o) and randomly located within a 20^o elevation band above the horizon.

2) The antenna is a planar array consisting of N dual-polarized microstrip patches. The center-to-center spacing between patches is one-half wavelength at midband, unless otherwise noted.

3) Each interferer is sufficiently strong so as to produce an interference-to-noise ratio of 40 dB at each antenna port.

4) The operating bandwidth is 24 MHz.

5) The adaptive algorithm used to set the weights applied at the output of each antenna port is power minimization. That is, the weight on one of the 2N antenna ports is set equal to unity and the weights on the other (2N-1) ports are adaptively adjusted to minimize the output power of the array

6) Each point on the figures is the average of 200 realizations of interferer locations.

SIMULATION RESULTS

In Figure 1 we show the increase in the noise floor after adaptation for the case when the antenna is a single dual-polarized microstrip patch. Note that the single dual-polarized element completely cancels one arbitrarily-polarized broadband interferer down to below the noise floor, but cannot cancel two or more interferers. Figure 2 shows that the interferer is cancelled without any significant loss in availability for GPS satellites in the upper hemisphere (minus a 10^o elevation mask at the horizon).

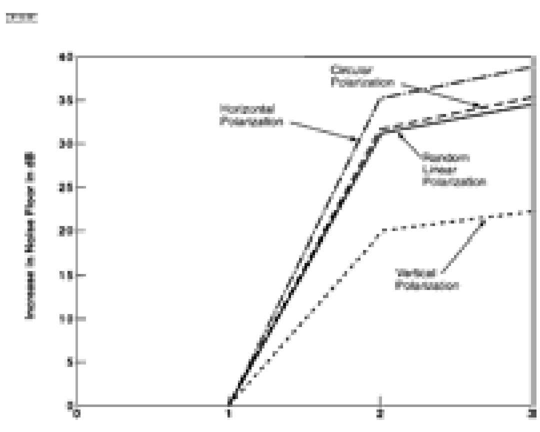

Figure 1. Performance of One Dual-Polarized Antenna

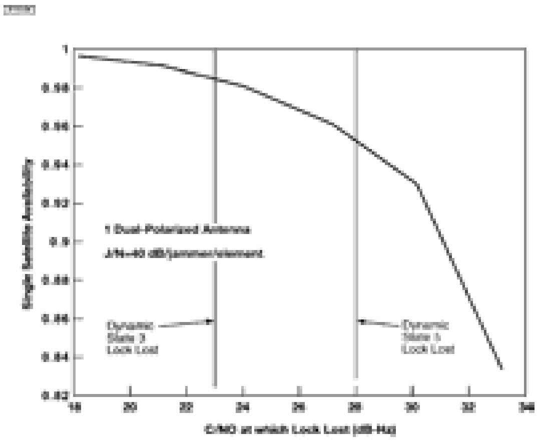

Figure 2. Availability in the Presence of One Broadband Interferer

In Figure 3 we demonstrate that an array of two dual-polarized antennas can cancel up to three broadband interferers.

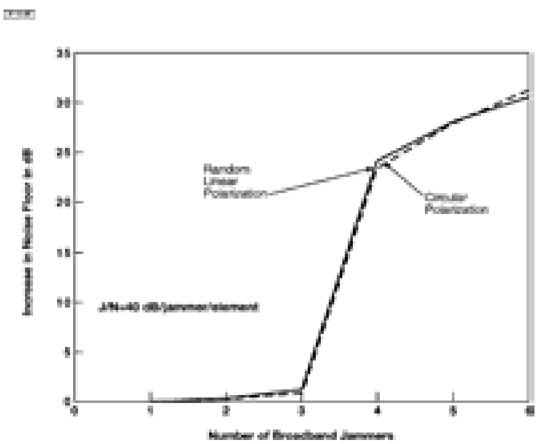

Figure 3. Performance of Two Dual-Polarized Antennas

In Figure 4 we demonstrate that when two dual-polarized patches are used, the GPS satellite availability in the presence of three broadband interferers remains high, even if the array size is decreased by decreasing the spacing *d* between patch centers below $\lambda/2$ (λ = wavelength). Thus, it should be possible to shrink the array size without a significant deterioration in performance.

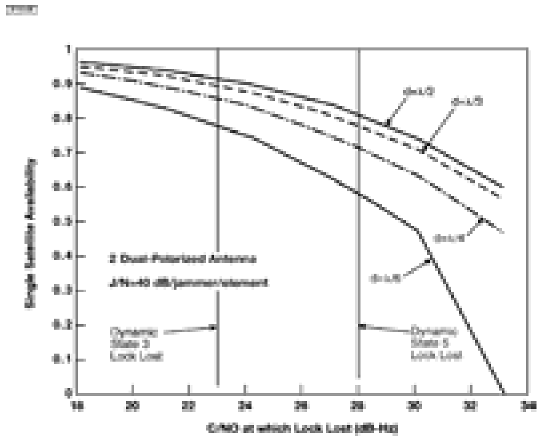

Figure 4. Availability in the Presence of Three Broadband Interferers

In Figure 5 we show that four dual-polarized antennas can cancel up to six very strong (interference-to-noise ratio = 50 dB) interferers to within 3 dB of the noise floor. We also show that the inclusion of mutual coupling between elements does not significantly affect the results.

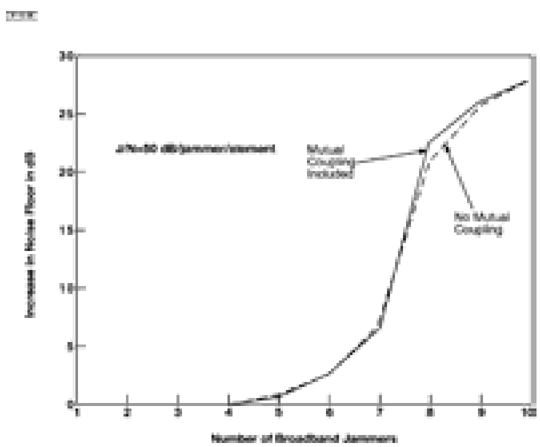

Figure 5. Performance of Four Dual-Polarized Antennas

In Figure 6 we show the GPS satellite availability in the upper hemisphere (minus a 10^{o} elevation mask at the horizon) for the case of four dual-polarized patches. Note that even under dynamic conditions state 3 lock can be maintained in over 80% of the upper hemisphere, even in the presence of seven broadband interferers.

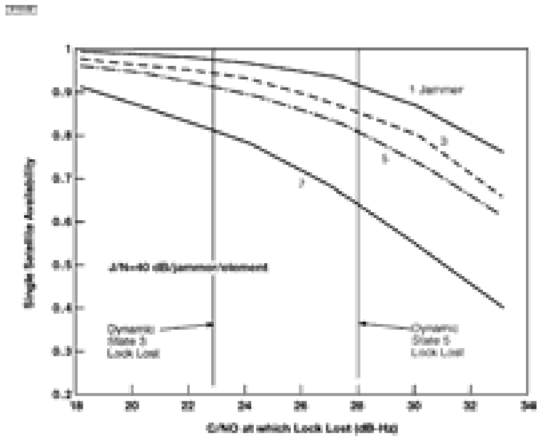

Figure 6. Availability for Four Dual-Polarized Antennas

SUMMARY AND DISCUSSION

We have demonstrated that by combining dual-polarization with spatial degrees of freedom one can significantly enhance the ability to an antenna array to cancel interference without any real loss in array performance. An experimental evaluation of this approach has been completed and will be presented in a future session.

REFERENCES

[1] R. Fante & J. Vaccaro, "Wideband cancellation of interference in a GPS receive array", IEEE Trans. AES-36, pp. 549-564, April 2000.