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# Practical validation of antenna pattern measurement interference cancellation using a correlation technique

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***Abstract***. The ability of correlation techniques to suppress multipath signals that cause inaccuracies in antenna pattern measurements has been validated by experiment.

## 1. Introduction: interference cancellation

Antenna pattern measurements are often distorted by extraneous signals that reach the test zone as a result of reflections or scattering from obstacles in the vicinity of the antenna range. These "multipath" signals have to be eliminated, or their effects compensated, if accurate measurements are to be made. A number of techniques that analytically, or experimentally compensate for such effects are described in the literature [1,2] but many of them are complicated and expensive to implement. However, relatively simple experimental methods that are based on signal processing techniques, have been proposed in recent years [3-5]; one attractive possibility being based on correlation.

The principle underlying the so-called correlation technique is that the autocorrelation function of a pseudo-random binary sequence (PRBS), i.e. the long-term average of the product of the sequence and a delayed version of itself, is unity if the delay is zero and very small otherwise. Thus, in Figure 1, if the delay in the control modulation path (the feed-forward path) is exactly the same as in the direct path, the signal received via that path, i.e. the desired signal, will be strong. However, other signals, for example the reflected signal shown in the diagram, will not correlate well with the fed-forward version of the PRBS and will effectively be cancelled. Longer sequences provide better cancellation properties.

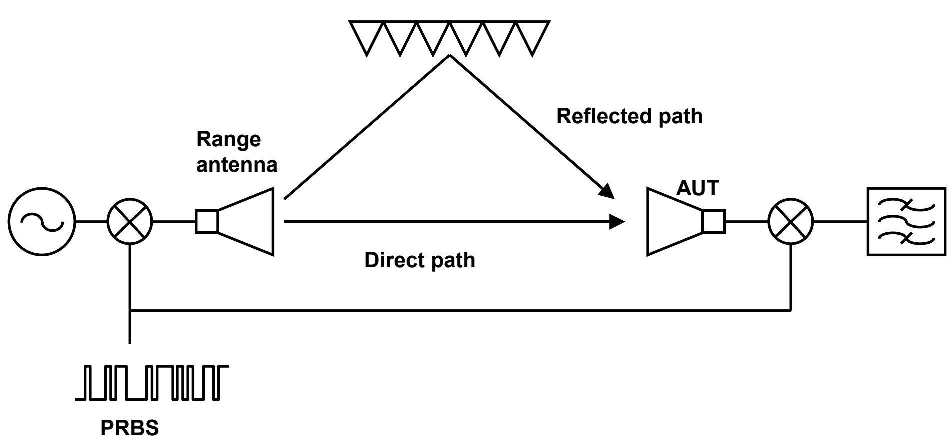


*Figure 1. Concept of the correlation cancellation technique.*

## 2. The experimental set-up

In order to validate this approach the set-up shown in Figure 2 has been devised to carry out an experiment in a controlled environment in which the presence of a reflection is simulated by an interfering signal whose amplitude can be controlled and is delayed by an arbitrarily long cable.

This approach has the advantage that the physical location of the interference, its level and its delay can all be adjusted, while performing measurements in a controlled environment such as an anechoic chamber. In this way the full extent of the technique can be assessed.

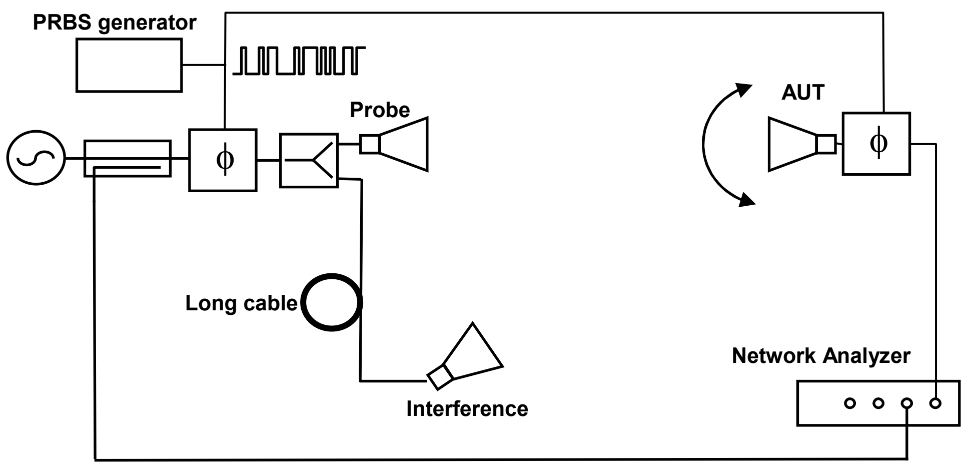


*Figure 2. Experimental set-up.*

A critical factor in the implementation of the correlation technique is the design of the modulator and demodulator. Figure 3 shows a photograph and a schematic of the modulator/demodulator that was designed for the experiment described in this paper. The modulator is based on providing two signal paths having a 180 º phase difference between them. Figure 4 shows the spectrum when a modulating signal in the form of a 4095-bit PRBS having a 1 μs chip rate is applied to the modulator. Figure 4 (a) shows the full spectrum, while Figure 4 (b) shows a close-up around the carrier frequency. Due to the periodic nature of the PRBS the resulting spectrum of the modulated signal is composed of multiple carriers.

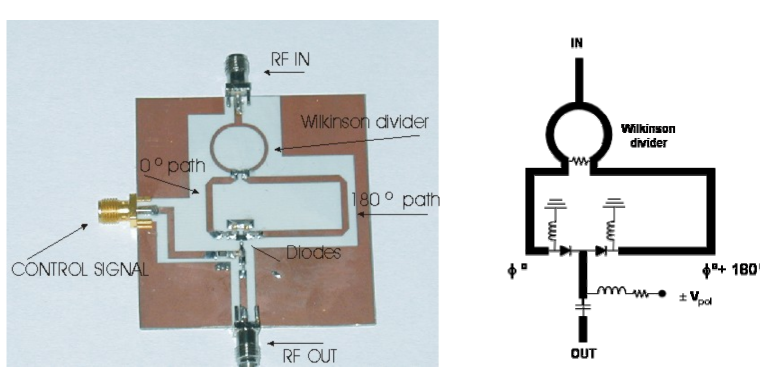


*Figure 3. Modulator/demodulator circuit – photograph and schematic.*

In the experiment, the interfering signal has been delayed so the time difference between the direct path and the interfering signal is 315 ns. A chip rate of 4.5 MHz has been used in the modulator, so the interfering signal is well decorrelated.

The measurement is based on the HP8530 network analyzer. This instrument is designed for both CW and frequency swept measurements. After the demodulation process, a residual unwanted spread spectrum remains, and this is a potential source of errors in the measurement. This residual spectrum can be removed by making the intermediate frequency (IF) bandwidth of the instrument small enough to reject the unwanted carriers shown in Figure 4 (b).

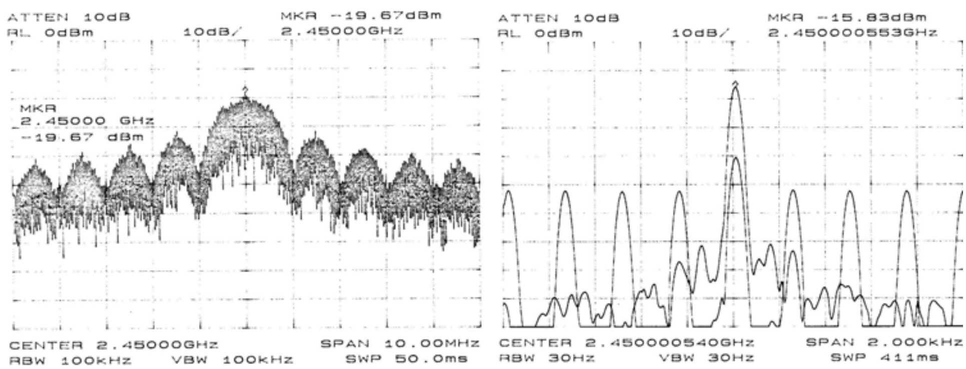


*Figure 4. Spectrum of the modulated signal.*

## 3. Experimental results

Using this experimental set-up, the radiation pattern of an 8-element slotted waveguide array has been measured under three different conditions. First, a reference measurement was made in the (physical) presence of the interfering antenna, but with no radiation from this antenna. A second pattern measurement was then made with this antenna radiating. The interferer is located at 30º from the main beam direction and its level is about 10 dB below the desired signal. These two results are shown in Figures 5(a) and (b) respectively. It is clear that the interference produces a very noticeable effect in the measured pattern.

Figure 6 shows the measured pattern when the interfering signal is cancelled using the correlation technique. A comparison of Figures 6 and 5 (a) shows that the original pattern is recovered, and therefore the effect of the interfering signal has been cancelled.

## 4. Conclusions

The feasibility of using a correlation technique to cancel multipath effects in antenna measurement ranges has been demonstrated. The experimental set-up devised for this work allows an assessment the technique in a controlled manner in an existing antenna measurement facility.


## 5. Acknowledgements

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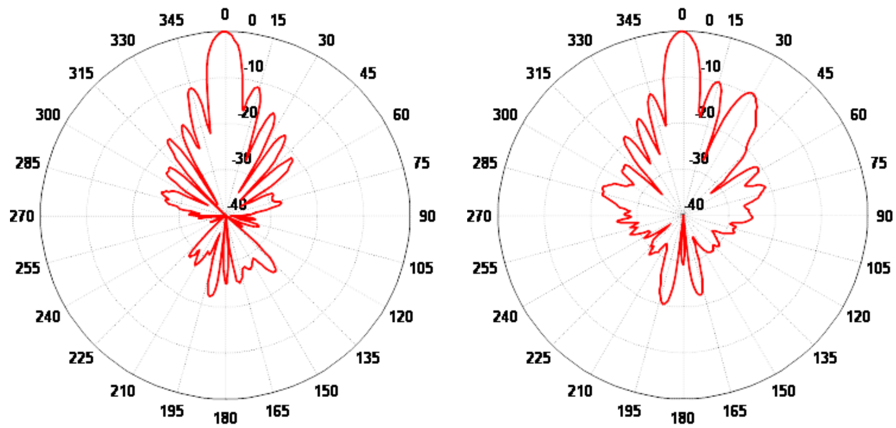


*Figure 5. a) Original pattern.* *b) With one -10dB interferer at $\theta = 30^o$.*

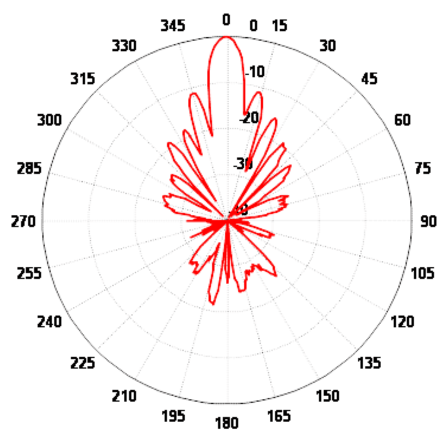


*Figure 6. Corrected pattern.*

## 6. References


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