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Nasr Alkhafaji
Portland State University

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SPACE-ANGLE SIGNAL PROCESSING USING A MODULATED SCATTER ARRAY
PORTLAND STATE UNIVERSITY-ELECTRICAL ENGINEERING DEPARTMENT
NASR ALKHAFAJI, RICHARD CAMPBELL, MADELEINE ROCHE

Abstract
A UHF signal processing technique is described in the Fourier Space-Angle domain that uses an array of scattering elements with reflection coefficients modulated at baseband. The illumination arrival angle distributes a UHF phase across the array, and the baseband modulator phase at each of the array elements determines the radiation angle of the desired scattered product. Undesired products are re-radiated in different directions. Example 1, 2 and 4 element arrays operate at 432 MHz array with 700 Hz modulation. 2 element arrays cancel one sideband, and the 4 element array cancels both the undesired sideband and 2nd order products. Reflection coefficient modulation uses slow electronics, and scattered signals are summed in space, so this technique is attractive at much higher frequencies.

I. Theoretical Background
Spatial diversity-frequency diversity transformation is a process to assign an angular scattered beam in the space for each different frequency, requiring a multi-frequency generator and a multi antenna radiator (antenna) array. Referring to Figure 1, a CW signal at 432MHz illuminates the array, arriving at an angle θ. The relative distributed phase among antenna elements is related to element spacing d and arrival angle θ. The induced signal will be modulated by 700Hz sine wave signal at the RF diode switches, leading into intermodulation distortion generation IMD due to inherent nonlinearities in semiconductor devices.

\[ y(t) = a_1 x(t) + a_2 x(t)^2 + a_3 x(t)^3 + a_4 x(t)^4 + \cdots \]

The input signal consists of two tones the illuminated and the modulating signals, and the output signal will have the desired IMD ones and undesired products. Antenna array works to cancel or boost the specific frequency-angular scattered beam in the desired directions. The procedure of space-angle signal processing is illustrated by the help of the block diagram in Figure 2. Figure 2 illustrates that more IMD products can be cancelled at a specified direction if we increase the No. of circuit paths (i.e. No. of antenna array elements). In the space angle domain, the undesired IMD products are not suppressed, it just re-radiates at different angles. Figure 3 shows an array pattern with illumination angles labeled according to which modulation product adds in phase at the receiver. The center lobe is the backscatter direction.

II. Experimental setup & Measured Results
Signals at the receive antenna in Figure 1 are converted to the 0 to 20 kHz baseband output of an instrumentation receiver without automatic gain control and 100 dB noise floor to clipping level dynamic range. Figure 4 depicts the single diode modulator and the 4-element array scatter inside the anechoic chamber. Figures 5, 6 and 7 show the output spectrum plots of the received signals for a single scatter, a two element scatter, and a four element scatter respectively. The modulation sidebands are symmetrical around the down converted illuminating signal and harmonics of 700 Hz out to the 5th are significant, as shown in Figure 5.

III. Conclusion
This necessarily brief treatment of early results with arrays of modulated scatters at UHF shows the practicality of this concept. From basic Fourier Theory the advantages of arrays with more than 4 elements are evident, and our ongoing work is at higher frequencies where such arrays are practical in our anechoic chamber. The desired output signals are added in space, without the need for electronics, waveguide, or transmission lines.

IV. References