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ELIMINATION OF BACKSCATTERING FROM A CIRCULAR LOOP.

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INTRODUCTION

Methods of reducing the backscattered wave and hence reducing the radar cross section of the object may include computer-aided modification of its geometry, or coating it with some absorbent material, or appropriate sectionalizing and loading. Recently, elimination of backscattering from a multiply loaded straight wire and a multiply-loaded parallel wire system has been considered [1,2]. This paper is devoted to the analysis of the loop scatterer loaded for zero backscattering for an incident plane wave on the loop from any direction. The scattered field from a multi-loaded loop will also be examined for zero backscattering in more than one direction of incident plane wave.

MOMENT METHOD SOLUTION

Consider a wire of radius "a" bent into a circular loop of radius "b"as shown in Fig.(1). The loop is excited by an arbitrary incident linearly polarized plane wave. The moment method is presented to determine the current distribution and the scattered field of the loop. The method is based upon integral equation formulation, with the unknown being the current along the loop. In this paper a Galerkin solution with piecewise sinusoidal basis and testing functions is employed. The radar cross section can be calculated from

$$\sigma = \frac{4\pi r^2 |E_S|^2}{|E_o|^2} \qquad (1)$$

where $|E_s|$ is the magnitude of the scattered field at the receiver and $|E_o|$ is the magnitude of the field incident on the scatterer, here taken to have unit magnitude.

LOADING FOR ZERO BACKSCATTERING

In the preceding section, the forward problem has been considered, namely, the determination of scattered field and the RCS of scatterer with a specified loading. This section will be devoted to one aspect of what may be called the inverse problem. Thus, it is required to determine the load such that the scatterer gives zero back radiation. It is difficult, however, to use eq.(1) to calculate the loading for zero backscattering because the effect of the load on the scattered field and hence on the RCS area does not occur separately. Instead of that procedure, Harrington's formula [3] is used. Using the admittance parameters, the load for zero backscattering is given by

$$Z_L = \left[\frac{y_{rs}\, y_{st}}{\Delta y_{rt}} - y_{ss} \right]^{-1}$$

where y_{rs}, y_{st}, Δy_{rt} and y_{ss}, are mutual and self admittances.

$$\Delta y_{rt} = \sum_{q=1}^{N} V_q(\theta_s,\phi_s) \quad A_q \ , \tag{2}$$

$$A_q = \sum_{p=1}^{N} y_{q,p} \ V_p(\theta_i,\phi_i) \tag{3}$$

If the loop is loaded at port o, thus,

$$y_{rs} = \sum_{p=1}^{N} V_p(\theta_s,\phi_s) \ y_{p,o} \tag{4}$$

$$y_{st} = \sum_{p=1}^{N} V_p(\theta_i,\phi_i) \ y_{o,p} \tag{5}$$

where $y_{p,q}$ are the elements of the matrix [y], where

$[y] = [Z_{mn}]^{-1}$

NULLING OF BACKSCATTERING FOR INCIDENCE FROM SEVERAL DIRECTIONS

The particular cases analyzed include a single loop with two loads with a view to achieve zero backscattering of two waves one only incident at a time, from two different angles. In all cases the incident wave is taken to have the same intensity. The analysis will end with the solution of two simultaneous equations in the two loads Z_{L1} and Z_{L2}. The two appropriate or optimum loads $Y_{L1}=1./Z_{L1}$ and $Y_{L2}=1./Z_{L2}$ yielding zero backscattering of plane waves incident from either of two directions θ_1^i and θ_2^i may be calculated from,

$$AY_{L2}^2 + BY_{L2} + C = 0 \ , \qquad \text{and} \tag{6}$$

$$Y_{L1} = \frac{[c_2d_1 - c_1d_2 - Y_{L2}(c_2b_1 - c_1b_2)]}{(c_2a_1 - c_1a_2)} \qquad \text{where} \tag{7}$$

$$A = -\frac{c_1(c_2b_1 - c_1b_2)}{(c_2a_1 - c_1a_2)} \tag{8}$$

$$B = [b_1 + \frac{c_1(c_2d_1 - c_1d_2)}{(c_2a_1 - c_1a_2)} - \frac{a_1(c_2b_1 - c_1b_2)}{(c_2a_1 - c_1a_2)}] \tag{9}$$

$$C = \frac{a_1(c_2d_1 - c_1d_2)}{(c_2a_1 - c_1a_2)} - d_1 \tag{10}$$

$a = \Delta y_{rt}Y_{22} - Y_{r2}Y_{2t}$, $b = \Delta y_{rt}Y_{11} - Y_{r1}Y_{1t}$, $c = \Delta y_{rt}$, and

$$d = Y_{r1}(Y_{22}Y_{1t} - Y_{12}Y_{2t}) + Y_{r2}(Y_{11}Y_{2t} - Y_{21}Y_{1t})$$

$$-\Delta y_{rt}(Y_{11}Y_{22} - Y_{12}Y_{21}) \tag{11}$$

and a_i, b_i, c_i and d_i, i=1,2 are equal to a,b,c and d for incident plane wave θ_1^i and θ_2^i

NUMERICAL RESULTS

Figure.2 depicts the variation of the values of the load impedance for zero backscattering positioned at $\psi=180^\circ$. for ϕ - polarized incident plane wave in plane $\phi=0^\circ$. The loads may thus be active or passive loads as may be expected [1]. The negative resistance values can be obtained either by using the negative resistance diodes (NRD) such as tunnel diodes or Gunn diodes [4], or by using equivalent voltage sources appear at the position of the negative loads which need practically an adaptive array processor to set their values. Fig.3 shows the induced current along the loop after loading the loop at $\psi=180^\circ$ by a load giving zero backscattering field at $\theta^i=30^\circ$ & $\phi^i=0$. compared with the short circuit (unloaded) case. The magnitude of the current have more fluctuations near the position of the load. Fig.4 shows the scattered field in three dimensional plot. It may be deduced that the effect of loading has more influence in the plane of incidence of the wave at which it has been computed and this effect on the shape of the pattern gradually decreases but the amplitudes of the scattered field change according to the plane of incident plane wave. Results for case of a doubly-loaded single loop in order to achieve zero backscattering for incidence from either of two directions, are depicted in Fig.5 ' This figure shows the backscattering field pattern of a doubly-loaded loop of radius 0.2λ and wire radius 0.005λ with a load Z_{L1} located at $\psi=90^\circ$ and a load Z_{L2} located at $\psi=180^\circ$ giving two nulling of backscattering of waves (ϕ-polarized) incident in either of two directions $(-10^\circ, 60^\circ)$.

CONCLUSION

Elimination of backscattering from a single and multiply-loaded circular loop has been considered. The loads have been determined yielding zero backscattering of specified frequency for a wave incident on the loop at one direction or from either of two directions. It is quite interesting to note the optimum loading effect on the distribution of the current and its amplitude along the loop perimeter and hence the scattered field and the dependence of this change upon the plane of incidence at which the loads are determined. Three dimensional patterns are used to illustrate the results and explain the behavior of the scattered field in the entire space around the loop.

REFERENCES

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4. R.Janaswamy and Shung-Wu,(1988) " Scattering from Dipoles Loaded with Diodes," IEEE Trans. on Antennas and Prop., Vol.36, No.11, Nov.

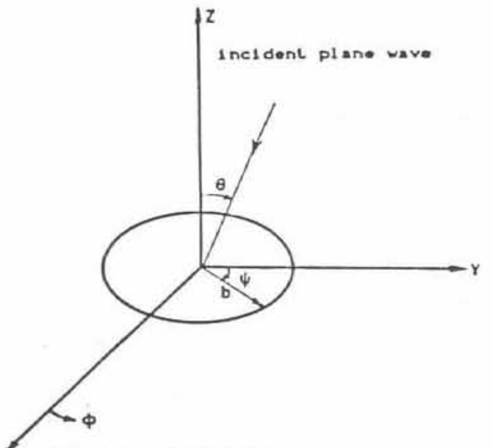

Fig.(1) Geometry of a circular loop.

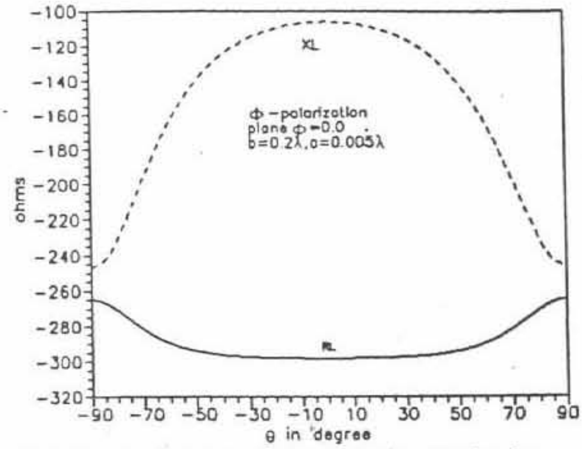

Fig.(2)Load impedance for zero backscattering for various angles of incidence

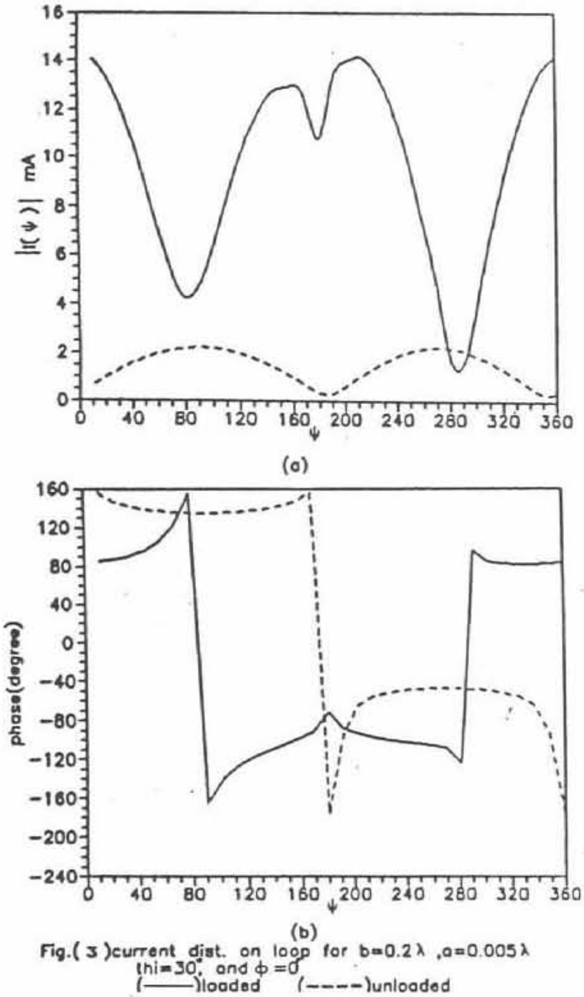

Fig.(3)current dist. on loop for b=0.2λ, a=0.005λ thi=30, and φ=0
(——)loaded (----)unloaded

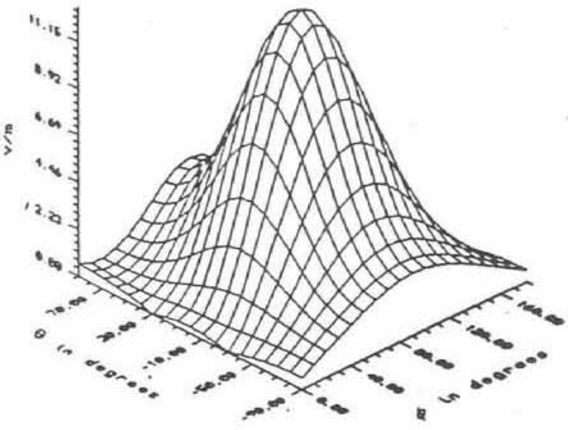

Fig.(4) Three dimensional scattered field pattern (φ-polarized) for single loaded circular loop of radius b=0.2λ and wire radius a=0.005λ, thi=30,&φ=0.

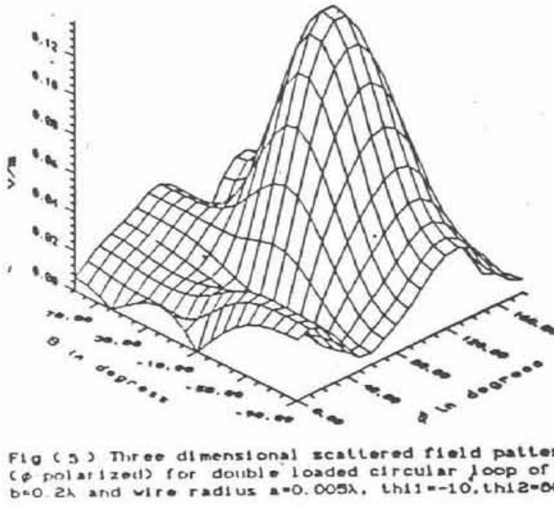

Fig (5) Three dimensional scattered field pattern (φ polarized) for double loaded circular loop of radius b=0.2λ and wire radius a=0.005λ, thi1=-10,thi2=60 &φ=0.