Antenna Characterization from scattered field

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Abstract- **This paper presents a new approach of antenna characterization from back scattered signal by applying Singularity Expansion Method to scattered field. Residues and poles extracted from radiated field of a dipole antenna are compared with the residues and poles extracted from scattered field of a dipole antenna under matched load condition. Also poles and residues are compared at different direction under same load condition. Poles extracted from radiated and scattered field at any direction seem to be closest to each other, only residues are varying. So this constitutes a method to obtain parameters like radiation pattern and S parameters of an antenna**

Index Terms: **complex Natural Resonance, Matrix pencil, Residues, singularity expansion method.**

I. INTRODUCTION

Singularity Expansion Method (SEM) [1], introduced by C.E Baum in 1971 represents the solution of electromagnetic problem in terms of singularities (poles).Since singularities are independent of the direction of incoming wave ,it makes this method useful for scatter identification. Targets can be identified by their natural frequencies, which are extracted from the late time scattered responses when irradiated with transient electromagnetic signals. The UWB Radar target discrimination schemes using time domain analysis have generated considerable interest recently. The most frequently used technique; called E-pulse scheme [2] can be realized in time domain, which uses the impulse response of target without converting to frequency domain. The time-domain scattered field response of a conducting target is composed of an early time forced period followed by a late time period. The late time response contains free oscillations defined by the natural frequencies of the target .More recently Singularity Expansion Method has been applied in both time and frequency domains to model antenna effective length [3] ,in order to fully describe antenna pattern ,gain and directivity using only few set of parameters (poles, also known as complex natural resonance and residues). This paper presents a method of antenna characterization from scattered signal, which allows avoiding distributing feeding cables and is very useful especially for small antennas.

II. SEM THEORY

The SEM was developed to describe the global behavior of an object's response excited by an electromagnetic wave. In the time domain, this response is composed of two successive parts. The first one is called early time response and is mainly due to excitation impulse. The second part, called the late time response, occurs after the early time response and is only due to the radiation of the induced current on the antenna after its illumination. The SEM allows modeling the late time response of an object as a decaying exponential sum as

$$y(t) = \sum_{n=1}^{M} R_n \, . \exp(s_n t) \qquad (1)$$

Where y(t) is the response, s_n is the nth pole, R_n is the residue associated with the *n*th pole and M is the number of poles. Each pole is defined as

$$s_n = \alpha_n + j\omega_n \qquad (2)$$

Where α_n is the negative damping coefficient of the *n*th pole and ω_n is resonant pulsation of the *n*th pole. Matrix pencil algorithm [4] is a method to extract poles and residue in time domain. Matrix pencil algorithm is more computational and gives the best result in the presence of noise [5].

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III. APPLICATION ON DIPOLE ANTENNA

A dipole of length L = 33.75 mm is simulated using XFdtd 7.1 between 1 and 20 GHz. Its diameter is D = 1.12 mm (L/D= 30).

A. Radiated field

Radiated field from dipole antenna is collected at far field region as shown in Fig.1.

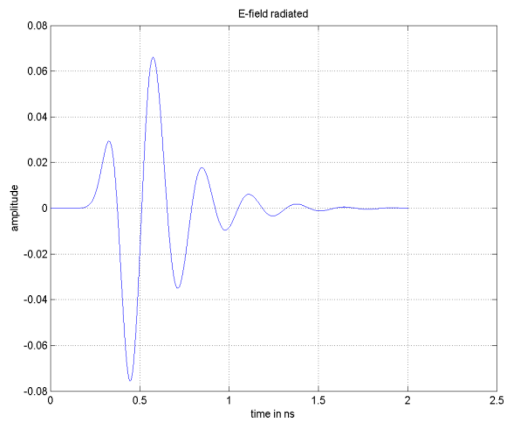

Figure 1

Then matrix pencil method is applied on this radiated field to extract the pole and residues of antenna as shown in Fig .2 and Fig .3.

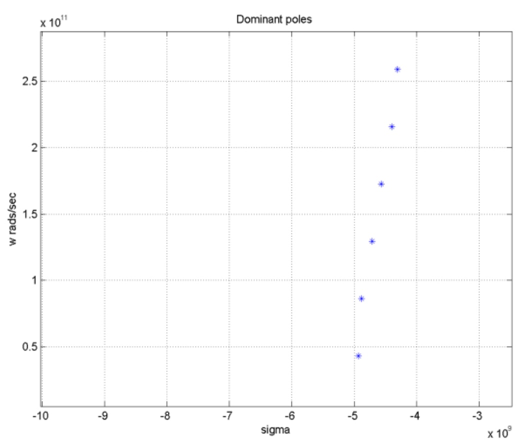

Figure 2: dominant poles extracted from radiated field

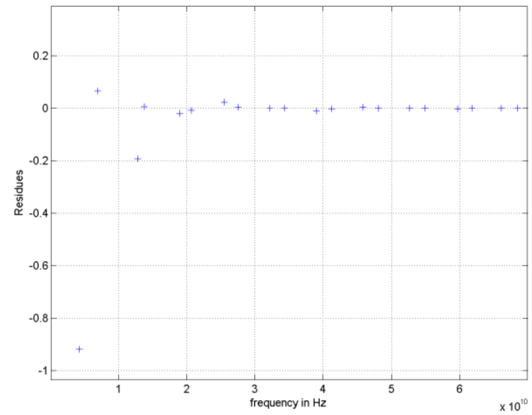

Figure 3: Resonant frequency v/s residue plot from radiated field

The imaginary part of the poles corresponds to resonance of the antenna and from Fig .3 it is evident that lower resonating frequencies are contributing more than higher resonating frequencies.

B. Scattered field

In this part, the matrix pencil algorithm is applied on the scattered field of dipole antenna under matched load condition. The matched load condition corresponds to a real load of 73 Ω.

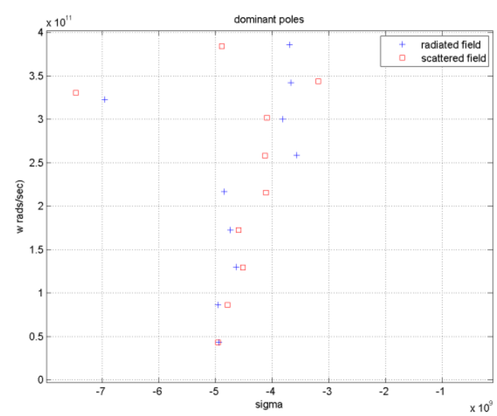

Figure 4: Comparison of poles extracted from scattered field and radiated field.

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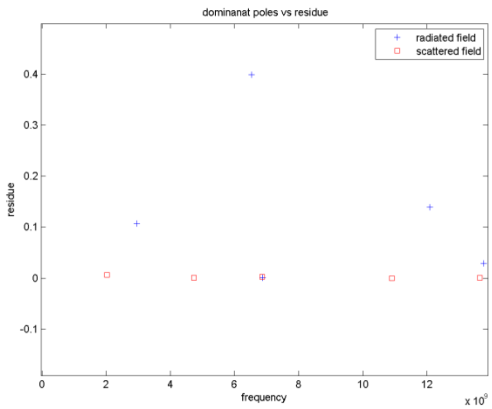

Figure 5: Comparison of resonant frequency v/s residues extracted from scattered field and radiated field.

From Fig.4, it can be interpret that poles extracted from scattered field have almost same resonating pulsation as those from radiating condition but damping coefficients are slightly different at higher resonating frequencies. Fig.5 shows that residues of scattered field have lesser amplitude than residues of radiated field. This is because scattered field is having lesser amplitude than radiated field.

C. At different direction

In this section poles are extracted from scattered field collected in different direction. This enables us to characterize the antenna from any direction, by collecting scattered signal.

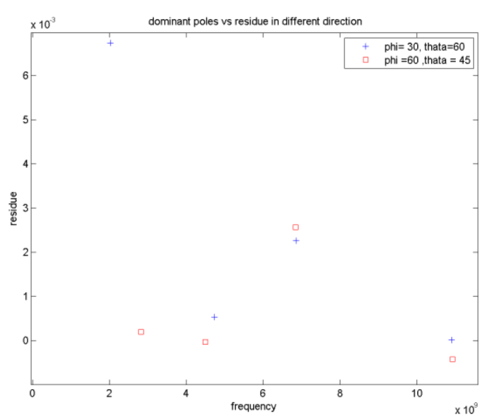

Fig.6 ues are ch

Figure 6: Comparison of resonant frequency v/s residues extracted from scattered field in different direction.

IV. APPLICATION ON BROAD BAND ANTENNA

The matrix pencil algorithm is applied on dipole antenna of different length and in each simulation the frequency obtained from extracted poles corresponds to resonating frequencies of dipole antenna. So the algorithm is now applied on a broadband antenna. Fig.7 and Fig.8 shows the Transfer function v/s frequency and gain v/s frequency of a impulse radiating rugby ball antenna (Frequency band 0GHz-15 GHz) derived from radiated and scattered field

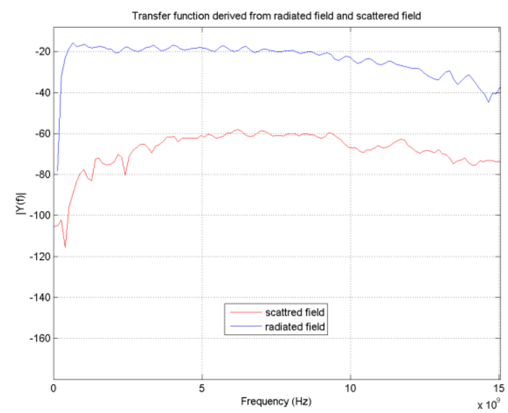

Figure 7: Comparison of transfer function derived from radiated field and scattered field.

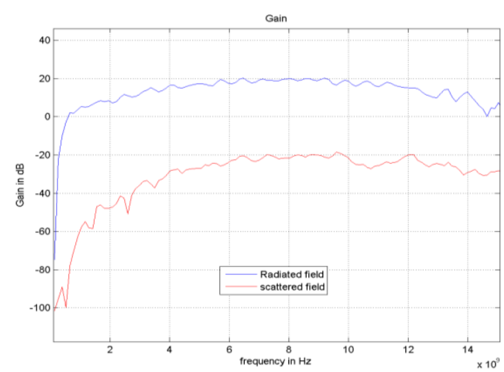

Figure 8: Comparison gain obtained from radiated field and scattered field .

It can be seen from Fig.7 and Fig.8 that transfer function [6] and gain [7] for radiated field and scattered field follows same shape, but scattered field has lesser amplitude than radiated field. This is because amplitude of residues in scattered field is less than the amplitude of residues in radiated field and shape remains

V. CONCLUSION

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We have shown that, for a matched dipole antenna, it is possible to obtain same poles from radiated field and scattered field in different direction. This is because poles are due to antenna behavior [1] and it should remain same. But in radiation condition and scattered condition residues are modified. So this constitutes a method to obtain parameters like radiation pattern and S parameters of an antenna.

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