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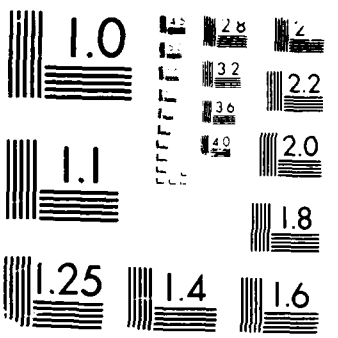

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K-PULSE ESTIMATION FROM INCOMPLETE MULTIPLE-FREQUENCY SCATTERING DATA AND TARGET IDENTIFICATION

Gonul Turhan
and
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The K-pulse waveforms of realistic aircraft models are obtained from incomplete multiple-frequency scattering data without a priori knowledge of the target complex natural resonances (CNR). The approach is based on minimization of the late-time energy content of the K-pulse response at several aspects and/or polarizations. Use of the K-pulse as an identification tool is demonstrated.

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I. METHOD

To the definition of K-pulse given by Kennaugh [1] must be added the requirement that only target complex natural resonance frequencies (CNR) should appear as zeros in the K-pulse spectrum for that target, no additional zeros are permissible. Under this condition, a unique time-limited (TL) K-pulse waveform elicits theoretically TL response waveforms for all aspect/polarization combinations of the target. As far as the dominant CNR of the target are known, there are several approaches to synthesize the K-pulse [2,3,4]. But, in general, accurate estimation of the CNR is a very difficult problem, so the applications of the CNR-based methods are quite limited. It has been demonstrated, for geometrically simple targets, that the method of minimization of the late-time energy content of the K-pulse response with respect to K-pulse excitation does not need to use CNR information [5].

The approach presented in this report has been developed for very complicated target geometries, like aircraft and land vehicles. The K-pulse waveforms were obtained from incomplete, multiple-frequency scattering data without any reference to target CNR. The data are termed incomplete in the sense that the most dominant CNR are not spanned, due to practical measurement limitations at low frequencies. The data are also termed multiple-frequency in the sense that the backscatter data at several combinations of aspects and polarizations are used when generating the K-pulse waveforms so that the the information about some CNR which are not excited strongly at one combination may be available at the other combinations.

The postulated model for the K-pulse waveforms is composed of a unit impulse at the initial time instant and a continuous time function of duration, 2L/c, where L is the maximum linear dimension of the target. The unknown sample values of the continuous part are estimated by minimizing the combined energy content in the late-time portions of the K-pulse responses at two or more aspects/polarizations.

The proposed method of target identification uses a parallel bank of digital K-pulse filters, one for each target in the class of interest. Measured broadband, incomplete spectral data from an unknown target are passed through the filter bank after being smoothed by a three-times differentiated Gaussian shaped function. When target and filter match, a severely TL response waveform showing an early-time energy content enhancement (in comparison to the impulse response from the same bandlimited data) results. Comparison of the normalized instantaneous energy variations of the impulse response and the K-pulse response for each possible K-pulse in the filter bank is used as the identification tool and it has been verified that this method of identification works well even for extremely noisy data.

II. APPLICATIONS

The targets used for the demonstration of the approach are DC-10 and Boeing 727 electroplated aircraft models where no features of the real targets were simplified. The co-polarized and cross-polarized backscattered data used to obtain the results were measured on the Ohio State University compact range. The aircraft orientation is with the

wings in a horizontal plane and 0° aspect angle corresponds to nose-on incidence. The model frequency span used for both targets is from 1 GHz to 7.4 GHz.

Figure 1-a shows an approximate K-pulse waveform for the DC-10 aircraft model using backscattered data at 0° and 90°, vertical polarization (VP). The K-pulse waveform shown in Fig. 1-b belongs to the B-727 model which was estimated using the data at 90° (VP) and at 30°/cross polarization (XP).

Figures 2-a and 2-b show the normalized impulse responses and the K-pulse responses (to the K-pulse in Figure 1-a) for the DC-10 model, at the combinations 0°/VP and 90°/VP, respectively. Similarly, Figures 3-a and 3-b show those results for the B-727 model (the corresopnding K-pulse shown in Figure 1-b) at the combinations 90°/VP and 30°/XP, respectively. The common observation to all these results is that the K-pulse response has a minimized late-time energy content with respect to the impulse response at the same aspect angle and polarization but the early-time energy content has not been reduced much. In other words, response of the target to the matched K-pulse has an early-time energy enhancement feature.

The examples given in Figures 4 and 5 demonstrate not only the target identification capability of the K-pulse method but also show that the approximate K-pulses obtained for DC-10 and B-727 aircraft models work well at aspect angles and polarizations other than those used for the synthesis of these K-pulse waveforms.

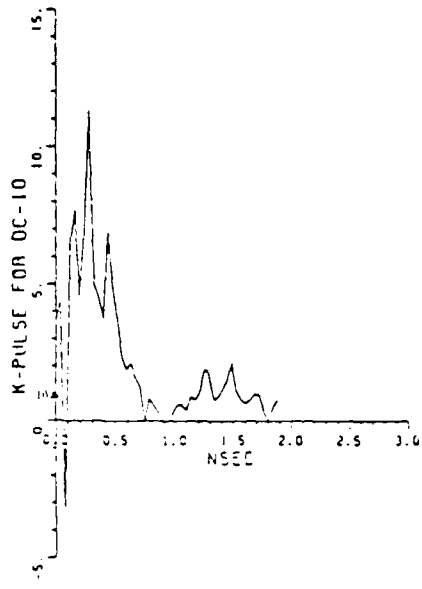
Figure 4 shows the responses of the B-727 model, at 0° horizontal polarization (HP), to the K-pulse of the B-727 (in Figure 4-a) and to the K-pulse of the DC-10 (in Figure 4-b). While the expected results are observed in the matched case, the mismatched K-pulse response in Figure 4-b does not show any reduction of energy in the late time.

The effect of random noise in target identification and the use of normalized instantaneous energy curves are presented in Figure 4. The impulse response waveform of the DC-10 aircraft at 30°/vertical polarization, shown in Figures 4-a and 4-c, has a signal-to-noise ratio of 13.6 dB. Figures 4-a and 4-b were obtained by using the K-pulse for the DC-10, and Figures 4-c and 4-d show the results for the K-pulse of the B-727 aircraft. The results shown in Figures 4-a and 4-c demonstrate that the identification method works quite well even for extremely noisy radar returns. Figures 4-b and 4-d present the normalized instantaneous energy curves for the K-pulse responses and the impulse responses where it is possible to see the enhancement of the early-time energy content of the K-pulse response, in comparison to that of impulse response, when the target and the K-pulse match.

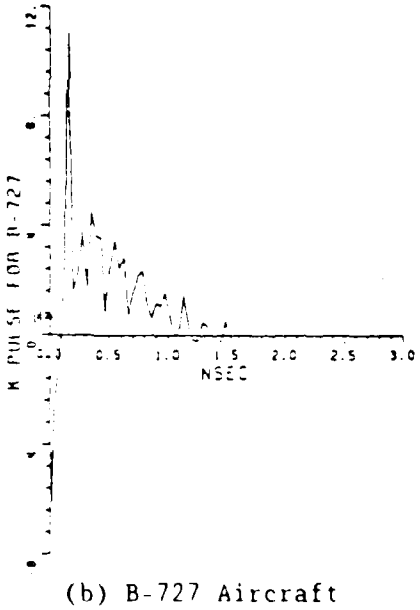
III. CONCLUSIONS

It has been demonstrated that generally useful K-pulse waveforms can be obtained for geometrically complicated target structures even when using incomplete scattering data. Multiple-combination data has been found to be quite useful to handle these types of problems. It has also been shown that the K-pulse method is a significant target

identification tool, since the K-pulse of a target is aspect and polarization independent. The fact that the K-pulse concept can be made to work for incomplete scattering data shows promise that K-pulses may also be feasible for substructures of the target. Research on the K-pulse and its application to ships and land vehicles is continuing on Contract N00014-87-K-2011.

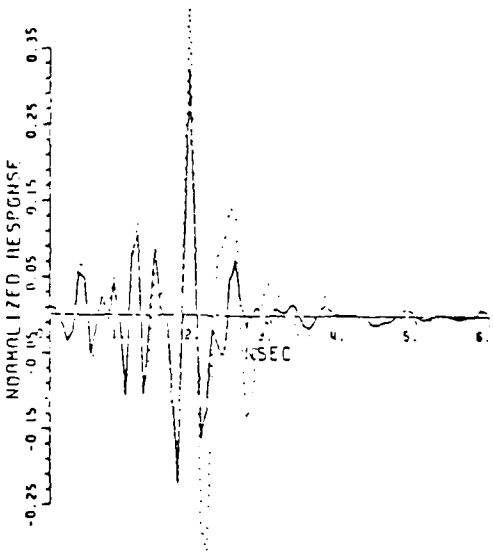


(a) DC-10 aircraft model

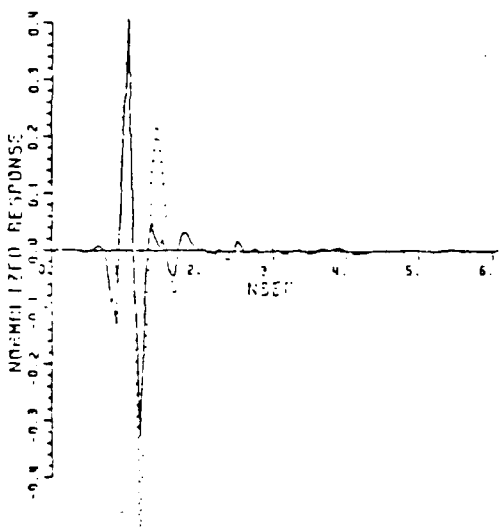


(b) B-727 Aircraft

Figure 1. K pulse waveforms for DC-10 and B-727 aircraft models.

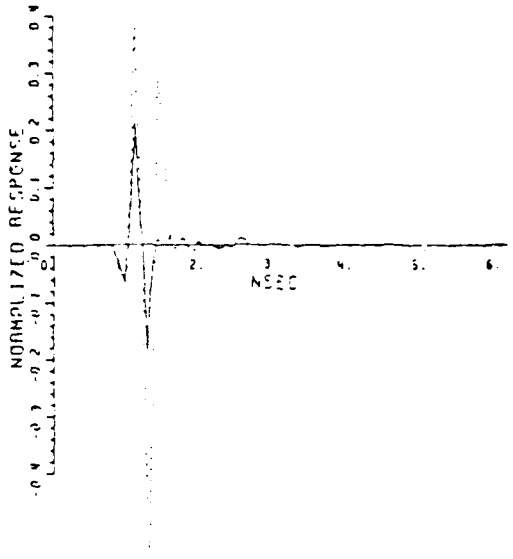


(a) 0°, Vertical polarization

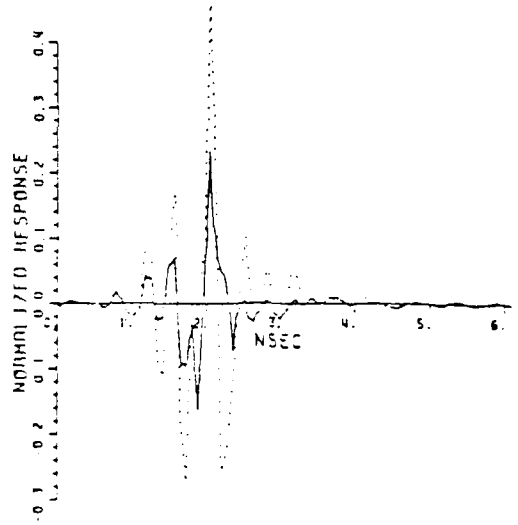


(b) 90°, Vertical polarization

Figure 2. Impulse response (·····) and the matched K-pulse response (————) of DC-10 model at 0° and 90°, vertical polarization.

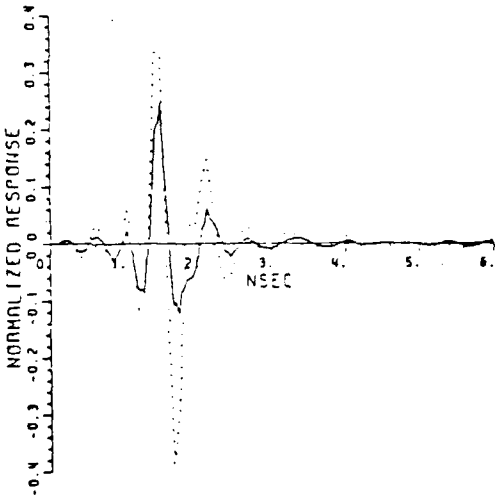


(a) 90°, Vertical polarization

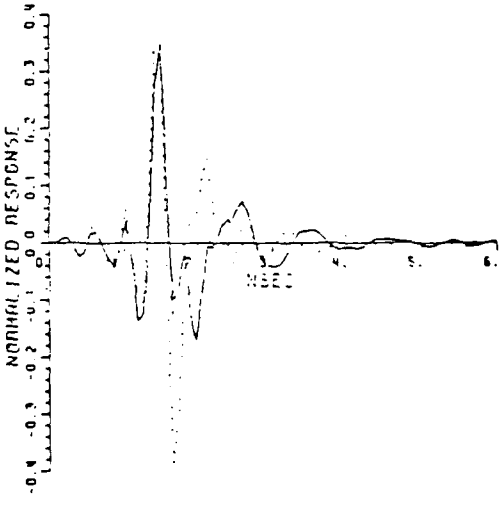


(b) 30°, Cross polarization

Figure 3. Impulse response (·····) and the matched K-pulse response (————) of B-727 at 90°, vertical polarization and 30°, cross-polarization.

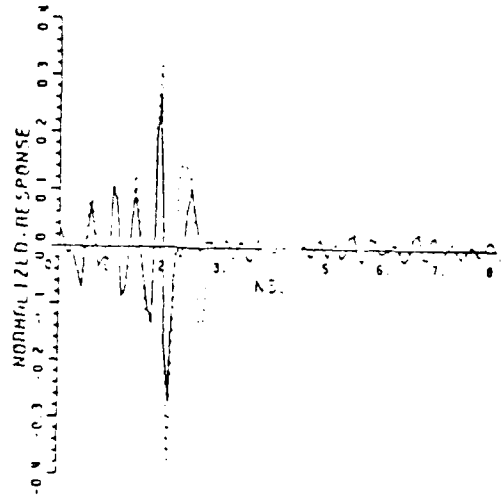


(a) matched K-pulse of B-727

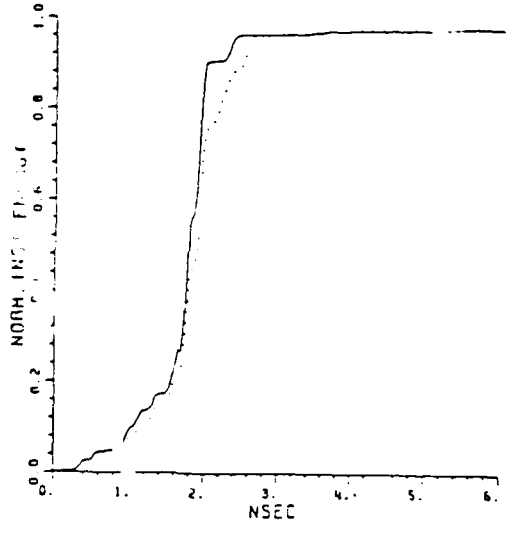


(b) mismatched K-pulse of DC-10

Figure 4. Impulse response (·····) and K-pulse response (————) of B-727 at 0°, horizontal polarization.

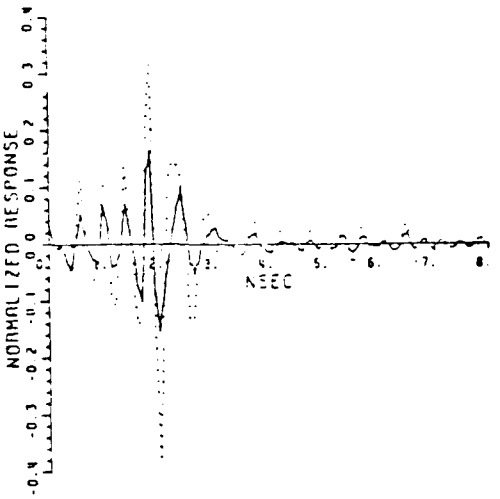


(a)

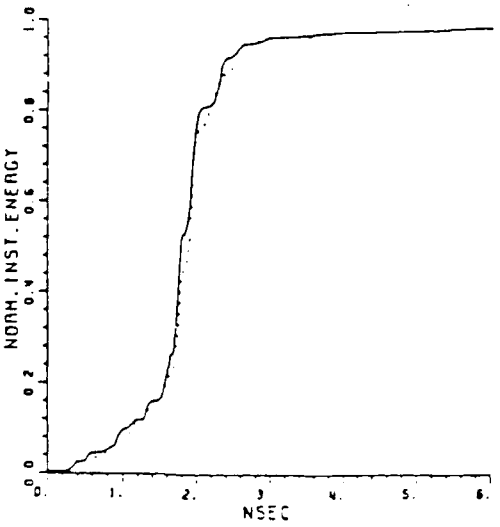


(b)

Figure 5. Impulse response (·····) and K-pulse response (————) of DC-10 at 30°, vertical polarization for (a) matched K-pulse of DC-10 and (c) mismatched K-pulse of B-727, and the normalized instantaneous energy curves for the impulse response (·····) and the K-pulse response (————) for (c) matched, (d) mismatched cases. (Signal-to-noise ratio of the impulse response is 13.6 dB.)



(c)



(d)

Figure 5. Continued.

REFERENCES

[1] E.M. Kennaugh, "The K-Pulse Concept," IEEE Trans. Antennas and Propagation, AP-29(2), pp. 327-331, March 1981.

[2] H.T. Kim, D.L. Moffatt and N. Wang, "K-Pulse and Response Waveforms for a Thin Circular Loop," IEEE Trans. Antennas and Propagation, AP-33, pp. 1403-1407, December 1985.

[3] E.M. Kennaugh, D.L. Moffatt and N. Wang, "The K-Pulse and Response Waveforms for Nonuniform Transmission Lines," IEEE Trans. Antennas and Propagation, AP-34(1), pp. 78-83, January 1986.

[4] G. Turhan and D.L. Moffatt, "Expansion of K-Pulse in Terms of Lejendre Polynomials for an Arbitrary Target," IEEE AP/URSI Symposium, Philadelphia, June 1986, and in preparation for submission to IEEE Trans. Antennas and Propagation.

[5] F.Y.S. Fok, D.L. Moffatt and N. Wang, "K-Pulse Estimation from the Impulse Response of a Target," accepted for publication in IEEE Trans. Antennas and Propagation.

[6] E.K. Walton and J.D. Young, "The Ohio State University Compact Radar Cross-Section Measurement Range," IEEE Trans. Antennas and Propagation, AP-32, pp. 1218-1223, November 1984.

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