The New Vector Fitting Approach to Muliple Convex Obstacles Modeling for UWB Propagation Channels

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Abstract— **The paper presents the new approach to time-domain modelling of UWB channels with multiple convex obstacles. It uses vector fitting algorithm (VF) for deriving the closed form impulse response of multiple diffraction ray creeping on a cascade of convex obstacles. We focus only on the diffraction phenomena because the results obtained for the diffraction case can be easily adopted for the reflection case. Vector fitting algorithm uses new arguments of approximation in order to obtain the closed form impulse response.**

Keywords- UWB; UTD; time-domain (TD); frequency-domain (FD); vector fitting (VF), inverse Fourier transform (IFT).

I. INTRODUCTION

We deal with theoretical effective time-domain modeling of UWB channels that comprise obstacles (e.g. people) which can be modelled by convex objects (cylinders in 3D case or arcs in 2D case – analysed in the paper). The goal is to present the procedure for obtaining the closed form impulse response of a multiple diffraction creeping ray. This problem was considered in [1]. The main disadvantage of the solutions given in [1] is that they give two separate formulas for two specific cases. The first of them ($\xi_d(\omega,R,\theta)\leq\xi_{dth}$, [1]) relates to the transmission problem of an UWB pulse for e.g. smaller values (fulfilling the above condition) of "creeping distance" θ while the second of them ($\xi_d(\omega,R)>\xi_{dth}$, [1]) concerns the problems in which an UWB pulse wave may creep the obstacle on much longer distances (arc lengths), e.g. in radar, sensor problems. In this paper we present the way for obtaining the general case closed form impulse response of an obstacles cascade. The procedure incorporates VF [2] with appropriate determination of the approximation arguments.

II. THE DERIVATION OF THE NEW IMPULSE RESPONSE OF A MULTIPLE DIFFRACTION RAY

A. UTD Diffraction Coefficeint of a Convex Obstacle

The exact UTD expression for FD diffraction coefficient for convex obstacle 2D model (arc) is given in (1) [1].

B. Vector Fitting Algorithm Application

$$H_C(\omega)=m\sqrt{\frac{2}{\beta}}e^{-j\frac{\pi}{4}}\frac{F(X_d)}{2\xi_d\sqrt{\pi}}-m\sqrt{\frac{2}{\beta}}e^{-j\frac{\pi}{4}}\begin{cases}p^*(\xi_d)\\q^*(\xi_d)\end{cases}=H_1[F(X_d)]+H_2(\xi_d) \tag{1}$$

We rearrange $H_1[F(X_d)]$ and $H_2(\xi_d)$ and the their derivatives with respect to θ (transition zone case) to the products of two functions: the first is independent on ω ($H_2(\xi_d)$ case) or dependent on ω^w ($H_1[F(X_d)]$ case), the second is dependent only from the new variable ξ_{sub} or X_{sub}. The second function is approximated with VF. The VF provides the constants (poles and residues) for approximating Laplace transform. The number of poles depends on the required accuracy and desired domain limits. Finally the approximated products have the forms given in (2) ($\xi_{sub}=\theta^3\omega R/2v$, $X_{sub}=\omega L\theta^2/2v$, v is the speed of EM wave propagation, n is an integer and $|b|<<1$):

$$\begin{cases}H_1(jX_{sub},N)\\H_2(j\xi_{sub},N)\end{cases}\approx\begin{cases}F_1(R,L,\theta)\cdot\omega^{n+b}\\F_2(R,\theta)\end{cases}\left[\begin{cases}D_1+E_1\cdot jX_{sub}+\sum_{n=1}^{N}\frac{C_n^1}{jX_{sub}-A_n^1}\\D_2+E_2\cdot j\xi_{sub}+\sum_{n=1}^{N}\frac{C_n^2}{j\xi_{sub}-A_n^2}\end{cases}\right] \tag{2}$$

The expressions outside the square brackets and the new arguments (ξ_{sub}, X_{sub}) are derived according to the fallowing. Firstly the VF performance quality must be sufficient (not all functions are well fitted). Secondly (2) must be easily applied for finding the impulse response of an obstacles cascade.

C. The New Impulse Reponse of Convex Obstacles Cascade

Time-domain equivalents of (2) can be find easily. In order to find the impulse response of the obstacles cascade we take the advantage of the fallowing. The product of the rational functions from (2) is the sum of similar rational functions. The one-sided IFT of ω^w give the function proportional to $1/t^{(w+1)}$, which let an application of the algorithm given in [1].

III. CONCLUSIONS

The derived new impulse response for a convex obstacles cascade can be used for arbitrary UWB scenarios, transmission and radar, sensor problems. It provides an effective way (with very good accuracy and relatively low complexity) of the detailed analysis of realistic UWB propagation channels.

REFERENCES

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