Time-Frequency Analysis of the Scattered Signal from Chipless RFID Tags

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Chipless RFID tags provide low-cost identification codes for tracking and identification purposes. Most of the researches in this area are concerned with the design considerations of chipless RFID tags. On the other hand, identification technique employed in the reader plays an important role in the detection of the tag. The data is incorporated as complex natural resonances (CNRs) of the tag. The transmitting antenna interrogates the tag, and scattered signal is affected by two different phenomena. The first part of the response in the time-domain is early-time response which emanates from the scattering centers of the tag. The local resonances in the early-time provide the global resonances of the structure in the late-time. In the frequency domain, the scattered field from the tag is the combination of the early-time and late-time responses which depends on the polarization, direction and the distance of the tag from the transmitting and receiving antennas. Based on singularity expansion method, we expect to have a maxima for each CNR in the frequency response of the late-time response, which is not the case for the total field. It will be shown in this presentation that the absolute value of frequency-domain RCS data and the group-delay analysis are not sufficient for extracting the poles of the tag. Depending on the polarization, direction of arrival and distance of the tag compared to the receiving antenna, the resonant frequencies of the tag may be mistaken or concealed by the spatial variations of the fields.

In this paper, using mathematical description, we will show that by applying a time-frequency technique, called short-time matrix pencil method (STMPM), the poles of the tag can be obtained for arbitrary polarization and detection scenario. Compared to other time-frequency methods such as wavelet, STFT, fractional Fourier transform (FrFT) and so on, it provides better resolution in time and frequency domains which enables us to obtain the turn-on times and CNRs of multi-bit tags. Some mono-static and bi-static scenarios are presented and discussed to confirm the validity and effectiveness of the method for detecting the chipless RFID tags.