Impulse Response and IEMI Susceptibility of Commensurate-Line Filters

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***Abstract*—In this paper we analyze the relation between the impulse responses of microwave filters with periodic spurious passbands obtained under ideal and realistic conditions. For the latter, we show analytically that increasing the number of passbands taken into account, the impulse response approaches a sequence of delta functions. We conclude that considering the spurious passbands is necessary when evaluating vulnerability to IEMI, because a significant portion of the energy can penetrate into the system through these passbands.**

Keywords-impulse response; microwave filters; spurious passbands

I. Introduction

An exact evaluation of the impulse response (IR) is possible only theoretically, on simplified models of real devices. Under realistic conditions of limited spectrum (or, equivalently, finite duration of excitation pulses) the obtained IR may be inaccurate and may leave out important information. We refer to this IR as quasi-impulse response (QIR). Despite these limitations, the QIR is used in many applications: to evaluate the applicability of microwave filters for radars, in analyzing pulse compression, to eliminate reflections in antenna measurements, etc.

The aim of this paper is to investigate QIR properties for devices whose frequency-domain parameters exhibit a periodic variation, such as commensurate-line filters. In addition to its main passband, such a filter has a sequence of spurious passbands, which are often neglected in computations and measurements. However, they are weak points of any system that uses these filters, as IEMI energy can penetrate the system through the spurious passbands.

The QIR can be evaluated in two ways. One way is to perform computations or measurements in the time domain. The other way is to obtain results in the frequency domain first, and then implement the inverse Fourier transform to obtain the time-domain response. Clearly, the QIR depends on the bandwidth; here we analyze this dependency.

II. Impulse Response

We derive a mathematical relation between the QIR and the exact IR for band-pass filters. To that purpose, we assume a periodic network function $S(f)$ of period f_0. The central frequency of the filter is $f_0/2$. The IR, $s(t)$, is the inverse Fourier transform of $S(f)$ covering the complete spectrum. If, however, we consider only the main passband, we obtain:

$$s_1(t) = \int_{-f_0}^{f_0} S(f) \exp(2\pi \mathrm{j} f t)\, \mathrm{d}f \ . \qquad (1)$$

We refer to the impulse response $s_1(t)$ as the first-order QIR (QIR1). Similarly, by taking n periods of $S(f)$, where $n = 2, 3, \ldots$, we obtain the n-th order QIR (QIRn),

$$s_n(t) = \int_{-nf_0}^{nf_0} S(f) \exp(2\pi \mathrm{j} f t)\, \mathrm{d}f \ . \qquad (2)$$

When $n \to \infty$, $s_n(t)$ yields $s(t)$, which is a sequence of delta impulses. All responses have similar envelopes, but the energy of the response $s_n(t)$ is proportional to n. Therefore, significant IEMI energy can penetrate through the spurious passbands.

III. Experimental Verification

We verify the theoretical predictions on an interdigital filter designed for medium-power UHF TV transmitters. To evaluate the scattering parameters, we perform both modeling and measurements, obtaining excellent agreement of the results. Fig. 1 shows the computed quasi-impulse responses QIR1 and QIR4, which confirm the theoretical predictions.

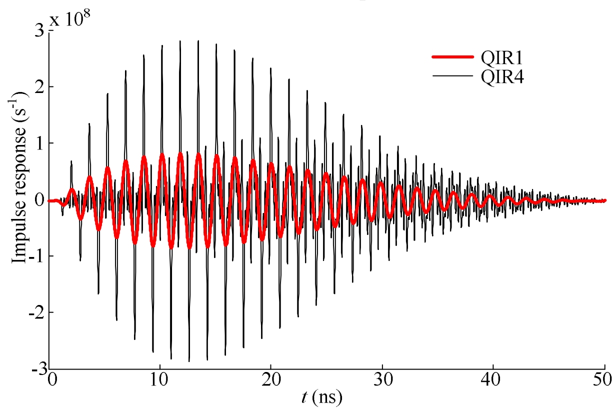

Figure 1. QIR1 and QIR4 for scattering parameter s_{21} of an interdigital filter.

The research leading to these results was supported in part by the Project STRUCTURES, co-funded by the European Union Seventh Framework Programme under grant agreement no. 285257, and by the Serbian Ministry of Education, Science, and Technological Development under grant TR32005.