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Formulae for Determining Heterodyne System Spurious Frequencies that Coincide with Desired Output Frequency

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Abstract—In this paper, formulae to determine the lowest order and other higher order spurious frequencies that coincide with desired output signal frequencies of mixers have been derived. The proposed formulae give general expressions that are suitable for any order of heterodyne mixing. The formulae have been verified using a suitable example and compared with the simulation results obtained through the radio frequency simulation software of Advanced Design System. The formulae directly reveal the order of the troublesome spurious frequencies that the designers would encounter in heterodyne systems. In comparison with these direct formulae, the results of existing spurious analysis software are based on the maximum order of simulation carried out. Based on these simulations, the coinciding spurious components have to be manually sorted out. Proposed formulae are quick tools used by the microwave system and circuit designers for choosing and finalizing heterodyne frequencies in their designs without the need for any simulations.

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1. INTRODUCTION

Frequency selection and finalization of local oscillator (LO) for RF heterodyne systems involves investigation of the spurious frequencies that arise due to the frequency mixing within the system. This is owing to the fact that many of these spurious frequencies may coincide with the desired output frequency of the system. Such a situation cannot be avoided, because the generation of product frequencies is inherent for all nonlinear devices and is evident from the current-voltage nonlinear equation as discussed in [1] and this equation can be rewritten in the form:

$$i = av + bv^2 + cv^3 + \ldots, \tag{1}$$

where voltage v corresponds to the sum of the two input signals to be mixed. Here, the exponential power of v is defined as the order of mixing.

Consider two sinusoidal input signals with respective frequencies f_1 and f_2 fed to a nonlinear device. The resultant desired output product frequencies are given by expression:

$$f_{m,n} = \pm m f_1 \pm n f_2, \tag{2}$$

where m and n are positive integers.

The desired frequency component $f_{m,n}$ originates from the $(m + n)$th order of mixing. The same frequency $f_{m,n}$ can also originate from many other mixing orders, giving rise to several such coinciding spurious components that superimpose on the desired frequency and destroy the useful information. The amplitude of the coinciding spurious component decreases as the mixing order increases [1]. Knowledge of the coinciding spurious frequencies allows the system designer to choose the mixing frequencies such that the coinciding frequencies would be of the highest order possible so that its amplitude would be minimal.

Presently, for finding the coinciding spurious components, system and mixer designers opt for various techniques such as manual calculations, spur charts, spur tables and the software based nonlinear analysis

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