Third and Fifth Order IMDs at Carrier Position

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Abstract **-** The third, instead of the fifth order intermodulation distortion (IMD_3), is often thought to limit the radio-over-fibre system performance as it tends to fall in-band. The Golomb Ruler based frequency plan can overcome this IMD_3 problem. However, its effect on the IMD_5 is not known. A laser model was derived based on Volterra Series with electrical parasitics to simulate the carrier position IMD_3 and IMD_5 for the Golomb Ruler and equally spaced frequency plans at low and high RF input level, supported by low bias current. The IMD_5 was more dominant than the IMD_3 for the equally spaced frequency plan at high RF input level. The opposite was observed at low RF input. The Golomb Ruler based frequency plan led to no IMD_3s but low levels of IMD_5 were still present the carrier position but they were lower than those due to the equal frequency spaced channels.

Keywords: Golomb Ruler, third and fifth intermodulation distortions

1. Introduction

The radio-over-fibre system (ROF) is used to transport fixed or mobile wireless signals by employing the optical fibre. The wide dynamic range of the wireless environment must be met by the optical portion of the ROF system, especially in the uplink as the wireless signal intercepted from the cell edge can be very weak or it can be very strong when it is close to the based station. The dynamic range can be limit by the third order intermodulation distortions (IMD_3) of type $2f_1$-f_2 and f_1+f_2-f_3 as they are liable to fall in-band for narrowband systems [1]. The electric-to-optical (E/O) conversion stage in the ROF is one of the contributors to this distortion [2]. The IMD_3 can be reduced by rearranging the channels to be used according the frequency plans in [3] and [4]. As the mobile communication system has to follow certain frequency management or channel assignment scheme and is subjected to interference issues such as co-channel interference [5], the frequency plan being exercised cannot be simply altered to reduce the IMD_3 generated by the E/O conversion. The signal extraction with frequency arrangement (SEFA) had been recommended as means to improve the dynamic range by reducing the IMD_3 through reassigning the received signals after intercepting them [2], [6]. In addition, the signal level compression (SLC) scheme that would boost the levels of weak signals was also suggested to improve the dynamic range [2], [7]. A frequency plan is needed for the SEFA scheme to be implemented. Hunziker suggested arranging the channels to be used in an unequal manner by employing the Golomb Ruler [1] as it avoids IMD_3 from appearing at the these channels. The Golomb Ruler is a set of non-negative integers or marks such that the distance between any pair of marks are unique and it begins with '0' [8], [9]. The Optimum Golomb Ruler (OGR) is a Golomb Ruler that gives the shortest length for a given number of marks [9]. The OGR for five marks is indicated in Figure 1.

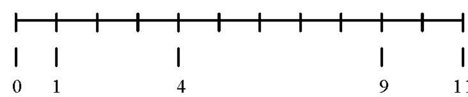

Figure 1: The Golomb Ruler for five marks.

Though the Golomb Ruler based frequency plan can lead to zero IMD_3 at carrier position, other intermodulation distortions might be present at the carrier positions. Therefore this paper aims at presenting a ROF system laser model derived using Volterra Series and compute the IMD_3 and fifth orders intermodulation distortions (IMD_5) at carrier positions for channels in the Golomb Ruler frequency plan and equal frequency spacing. The IMD_5 is looked into as it is the next odd order distortion after the IMD_3. Individual IMD_5s might be insignificant as compared to IMD_3s but their levels might escalate if their quantities increase and the input magnitude intensifies.

2. Volterra Series Laser Model

Volterra Series is used to model weakly nonlinear systems with memory. The laser diode output s(t) is expressed as (1) in Volterra Series [10]:

$$s(t)=\sum_{n=1}^{\infty}\int_{-\infty}^{\infty}\cdots\int_{-\infty}^{\infty}h_n(u_1 \ldots u_n)\cdot\prod_{l=1}^{n} i(t-u_l)\,du_l \ldots du_n \quad (1)$$