URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019

Generalized Probability Density Function for Intermodulation Distortion Components Generated by Power Amplifier

Yasunori Suzuki and Hiroshi Okazaki
NTT DOCOMO, INC., Kanagawa Japan 239-8536, e-mail: yasunori.suzuki.ws@nttdocomo.com

This paper presents statistical properties of intermodulation distortion (IMD) components generated by power amplifier (PA) in cellular base station transmitter. We provided the probability density function (PDF) of third-order IMD component for real random values such as binary phase shift keying [1]. In this paper, we provide the generalized PDF for complex random values for such as orthogonal frequency division multiple access signals.

It is well known that the input-output performance of PA can be expressed by the power-series model [2]. The output signal, y, is given by $y = \sum_{n=1}^{N} a_n x^n$, where a_n and x are n-th order coefficient and input signal, respectively. The y and x are complex random values. The PDF of x is two-dimensional Gaussian distribution. Therefore, the PDFs of amplitude and phase random values are Rayleigh and uniform distributions, respectively. The PDFs of phase random values under IMD conditions becomes uniform distribution. This paper only deals with the PDFs of amplitude random values. The PDF of n-th order amplitude random values, $p_{yn}(r_{yn})$, can be expressed as follows. The r_x and r_{yn} of the input and n-th order output amplitude random values.

$$p_{yn}(r_{yn}) = p_x(r_x)/\left|dr_{yn}/dr_x\right| \tag{1}$$

The $p_x(r_x)$ is Rayleigh distortion. Eqn. (1) becomes as follows. The σ^2 is variance of r_x.

$$p_{yn}(r_{yn}) = \frac{1}{\left|na_n r_x^{n-1}\right|}\frac{r_x}{\sigma^2}\exp\left(-\frac{r_x^2}{2\sigma^2}\right) \tag{2}$$

The $p_{yn}(r_{yn})$, can become as follows.

$$p_{yn}(r_{yn}) = \frac{1}{na_n^{2/n}\sigma^2 r_{yn}^{(n-2)/n}}\exp\left(-\frac{r_{yn}^{2/n}}{2\sigma^2 a_n^{2/n}}\right) \tag{3}$$

Figure 1 shows the calculation results of Eqn. (3). The $p_{yn}(r_{yn})$, {n=2, 3, 4, and 5}, have peak values around r_{yn} = 0. The $p_{yn}(r_{yn})$ have larger values compared with Rayleigh distribution, when r_{yn} is more than about 2.5. This feature caused by IMD components means to degrade of error probability on radio channel.

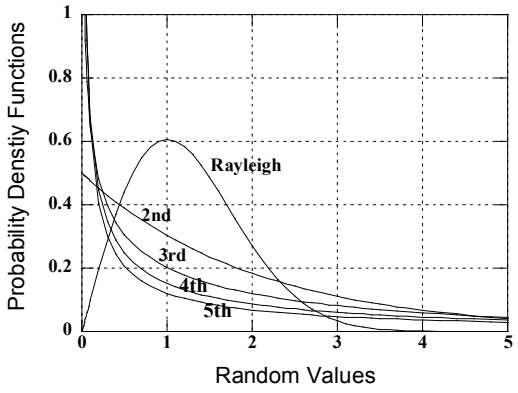

Figure 1. Calcuation results of derived PDFs.

This paper presented the statistical properties of IMD components generated by PA. We derived the PDFs of IMD components. The calculation results show that the PDFs of IMD components have different statistical properties compared with Rayleigh distribution. This investigation can evaluate the error probability of radio channel under the adjacent channel interference caused by PA.

1. Y. Suzuki, S. Narahashi, and T. Nojima, "Bit error probability in the presence of third-order intermodulation distortion component from power amplifier of different mobile systems," *IEEE Commun. Lett.*, **15**, 10, October 2011, pp.1041-1043, doi: 10.1109/LCOMM.2011.080811.11064.
2. S. C. Cripps, RF Power Amplifiers for Wireless Communications, Artech House, 1999.