WIDEBAND MATCHED VOLTERRA MODELING OF HIGH-POWER AMPLIFIERS FOR SATELLITE ADVANCED AND RECONFIGURABLE NAVIGATION AND COMMUNICATION PAYLOADS DESIGN

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Abstract

The increasing demand in the communication and navigation satellite industry for i) greater throughput, ii) flexibility in terms of signal generation, iii) higher efficiency, iv) improved payload re-configurability, has generated the need to develop more accurate simulation/emulation payload models. Inaccurate modelling of payload elements induces a non-negligible risk of over- or under-designed elements as well as an incorrect prediction of the main KPIs derived from emulation/simulation tools. Therefore, assessing the accuracy of currently used models and possibly developing new, more accurate ones turns out to be an essential feature of new-generation system design tools to derive accurate performance metrics, to enable correct dimensioning of all system features, to better specify budget parameters (in particular equipment specifications), and to efficiently support engineers in payload design.

In this respect, High-Power Amplifiers (HPAs) are very sensitive components within the overall payload architecture, because they are non-linear devices that behave differently depending on

the input signal features such as occupied bandwidth, average power, Peak-to-Average Power Ratio (PAPR), etc..

This paper will focus on satellite navigation payload that consider broadband signals with no constant envelope, e.g. considering a linear multiplexing between signal components..

The new signals characteristics requires the use of suitable sufficiently representative HPA models, instead of the narrowband and memory-less one that could be a good approximation for the previous signals.

Extensive measurement and characterization activities on such devices performed in Thales-Alenia Space laboratories on GNSS payloads suggested that the standard narrowband/memoryless model of an HPA (i.e., AM/AM and AM/PM characteristics) is not sufficiently representative to derive accurate results concerning (next generation) GNSS signals featuring bandwidth up to 100 MHz or more, especially in terms of the in-band and out-of-band distortions actually introduced by this element. Such inaccuracy, initially considered insignificant, turned out to be not negligible when the payload simulation model is used to define and optimize the specifications as well the on-board Navigation Signal Generation Unit (NSGU) design; in particular an incorrect evaluation of the unwanted distortions of the amplifier can lead to errors in the characterization and in the choice of the equalizer to be used.

These conclusions led us to carry out an extensive review of the state of art of wideband HPA models, in particular Wiener, Hammerstein and Volterra one, comparing their accuracy, efficiency and easiness of application to real-world devices.

This analysis focuses on the Volterra model, which is usually considered too complicated and hard to be actually tailored to a specific device. In this study, both the issues were tackled: first, how to match the numerous parameters of the nonlinear model to the wideband Device Under Test (DUT) has been considered. Then, a way to reduce the number of significant parameters to be derived from the measurements activity has been defined, in order to guarantee a computationally manageable effort without sacrificing modelling accuracy.

Starting from the lab characterization of a specific DUT operating in the L band, this paper reports a thorough comparison between the performance of a simplified matched Volterra model and the corresponding (memoryless) narrowband equivalent (with measured AM/AM and AM/PM curves). The following metrics were considered to perform the comparison:

- Normalized Mean Square Error (NMSE), both in time and frequency domain, between the simulated HPA output and the result of the measurements after digitization of the corresponding signal at DUT output.

- Power Spectral Density (PSD) deviation, in particular the spectral regrowth, between the simulated signal and the DUT output.

The results obtained exhibit a remarkable agreement between the wideband model and the results measured on the DUT, as well as a remarkable improvement of the performance metrics of the matched Volterra wideband model as compared to those of the standard narrowband algorithm, with a manageable additional complexity.

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