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Modeling of Trap Induced Dispersion of Large Signal Dynamic Characteristics of GaN HEMTs

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Abstract

We propose here a non-linear GaN HEMT model for CAD including a trapping effects description consistent with both small-signal and large-signal operating modes. It takes into account the dynamics of the traps and then allows to accurately model the modulated large signal characteristics that are encountered in telecommunication and radar signals. This model is elaborated through low-frequency S-parameter measurements complementary to more classical pulsed-IV characterizations. A 8x75µm AlInN/GaN HEMT model was designed and particularly validated in large-signal pulsed RF operation. It is also shown that thermal and trapping effects have opposite effects on the output conductance, thus opening the way for separate characterizations of the two effects.

II. IMPACT OF TRAPS ON LARGE SIGNAL CHARACTERISTICS

One convenient way to identify the impact of trapping effects is to monitor the average drain current of the transistor versus an increasing RF input power. It has already been reported in [1] and [3] that this drain current under class-AB conditions decreases as the input power increases, contradiecting the expected characteristics. Clearly, this behavior cannot be explained by thermal behavior as far as the channel temperature stays at a constant temperature. This leads, at least for moderate power, to an average drain current enhancement.

Fig. 1. Representation of the mechanism induced by traps on the average drain current.
Modeling of Trap Induced Dispersion of Large Signal Dynamic Characteristics of GaN HEMTs

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Abstract—We propose here a non-linear GaN HEMT model for CAD enabling a trapping effects description consistent with both small- and large-signal operating modes. It takes into account the dynamics of the traps and then allows to accurately model the modulated large signal characteristics. This model is elaborated through mathematical expressions based on numerical and experimental investigations of GaN HEMT devices. It is shown that thermal and trapping effects have non-generally symmetric effects on the output characteristics, thus opening the way for separate characterization of these two effects.

1. Introduction

Gallium nitride (GaN) high electron mobility transistor (HEMT) is now recognized as a good candidate for a number of RF applications and mobility amplifiers. In millimeter-wave circuits, however, its high breakdown voltage, its high thermal efficiency as well as its high temperature capability is important. Furthermore, GaN devices can be used in harsh environments, such as high frequency and especially trapping effects. These trapping effects have been extensively studied using a number of techniques such as optical measurements, pull measurements, and pull displacement measurements. At the same time, models have been developed to take these effects into account [1],[2],[3], and with the effect of the traps, a full model, including an extended circuit, is needed to study the impact of large signal performance and dependence on the presence of trapped charges. These effects are the main source of the discrepancies between the trap effects. In this paper, we propose a semi-empirical model for the dynamics of the trap effects using large-signal simulations to pull measurements. The model is then validated by comparison with experimental data. The model is further improved by taking into account the influence of the traps on the output characteristics, thus opening the way for separate characterization of these two effects.

2. Current Density

3. Voltage Dependence

Figure 1: Representation of the behavior induced by traps over the gate voltage

Passive RF measurements were performed on a DC bias, on GaN HEMTs with different amount of gate length L. The gate length was varied from 5 to 10 mm, and the drain voltage was varied from 0 to 10 V. The model is then compared with experimental data in order to validate its accuracy. The model is further improved by taking into account the influence of the traps on the output characteristics, thus opening the way for separate characterization of these two effects.
{Introduction}

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\caption{A frog}
\end{figure}
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Artem Kaznatcheev
Researcher at McGill University

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Minimizing Average Passenger Waiting Time

Abstract

Personal Rapid Transit (PRT) is an alternative to a conventional hackney taxi system, in which vehicles travel between stations in a dedicated network, operating in 2010 and 2011. In both cases, passengers do not book ahead. Perfect information about future requests, including statistical information on waiting times, enables passenger wait times to be reduced significantly. The passenger waiting time, one baseline study showed, was reduced by 70%, and average waiting time was reduced from 40 min to 5 min. This study shows that these lower bounds can be reached by using a conventional traffic light system, which allows the speed at which the vehicles travel to be controlled. A system that allows the vehicles to travel at different speeds, such as in a conventional network of roads, can be used to reduce waiting times. The results also show that low waiting times are achieved using a conventional traffic light system, which allows the speed at which the vehicles travel to be controlled. A system that allows the vehicles to travel at different speeds, such as in a conventional network of roads, can be used to reduce waiting times.

Introduction

Personal Rapid Transit (PRT) is an alternative to a conventional hackney taxi system, in which vehicles travel between stations on a dedicated network.
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