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RESEARCH ARTICLE

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An ambient temperature dependent small signal model of GaN HEMT using method of curve fitting

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Abstract

In this article, ambient temperature effect on small signal model of AlGaN/GaN HEMT has been explored. Based on the study, an analytical method to understand the ambient temperature dependence on device behavior has been developed. Effectiveness of the proposed method has been illustrated through comparison with measured data. Moreover, comparison with other analytical methods has also been carried out illustrating its acceptability threshold.

KEYWORDS

ambient temperature, curve fitting, GaN HEMT, small signal model

1 | INTRODUCTION

Present day wireless technology needs reliable semiconductor devices with high power handling capacity operating at a wide temperature range at microwave frequencies. High Electron Mobility Transistor based on gallium nitride (GaN) technology has aligned itself with such requirement, making it an indispensible for cutting edge technology. Subsequently, a lot of effort has been put forward for creation of accurate model for GaN based HEMTs.[1-13] Moreover compact small signal modeling is quite essential in understanding the device performance when implemented in circuit and is an interesting area of research. However these modeling efforts do not consider ambient temperature dependence of the device resulting in partial compactness of the models. Consequently, it is necessary to include ambient temperature dependence in modeling facilitating accurate prediction of device performance over operating temperature range.

Subsequently, in Reference 14 temperature dependent nonlinearity of GaN/AlGaN HEMTs have been reported. Investigation has been carried out using a physics based large signal model. The model parameters are derived as function of bias voltages and ambient temperatures. Though the method has been able to predict the effect for some of the intrinsic parameters, it fails to highlight the same for other parameters. Temperature effects on DC and Rf parameters on AlGaAs/GaAs HEMTs have been reported by Caddemi et al.[15] Dependence of GaN HEMT millimeter wave performance on temperature has also been reported by Darwish et al.[16] One of the primary findings of their investigation has been decrease in drain saturation current with increase in temperature while the pinch of voltage is very weak. High temperature modeling of AlGaN/GaN HEMTs has been investigated by Vitanov et al which considers both DC and small signal measurements.[17] Though efficient the method is computationally intensive which in turn limits its prediction capability. Influence of ambient temperature on DC, small signal and large signal parameters of AlGaN/GaN HEMT on SiC substrate has been reported in Reference 18. From the observations it has been concluded that microwave performance degrades at high ambient temperature. In Reference 19, an artificial neural network

