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**Title:** Gallium Nitride Device Modeling for Broadband Power Amplifiers

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Adoption of microwave technology plays a vital role in the areas of high RF power and high frequency in communication transmitter applications as well as microwave radar. To serve a large geographical area, there is a need for driving antenna with high power. It arises the demand of high power amplifiers which can deliver large RF output power. Besides high output power, optimized linearity and power added efficiency (PAE) is desirable to serve a vast area and ensure high quality services for next generation communication systems. It is imperative to note that a high terminal voltage is essential to extract large output power from a transistor device. In this context, device (transistor) based on the material possessing wide band gap can be utilized to achieve high terminal voltages. AlGaN/GaN based HEMT technology is emerging as the most suitable candidate in the designing of front-end high RF power amplifiers owing to its unique inherent traits such as high breakdown voltage, wide band gap, high saturation velocity, higher operating frequency and temperature. Owing to wide band gap property, GaN based HEMT possess inherent high breakdown voltage and is therefore able to operate at higher bias voltage and high RF power level. Higher operating frequency is achieved due to high electron saturation velocity. In addition, GaN based device operates at higher temperature as well which is attributed to lower thermal resistance of GaN and excellent thermal properties of the employed SiC substrate. To develop efficient, less time consuming and inexpensive design flow for RFPA's, identification of optimal equivalent circuit configuration on computer-aided design (CAD) tools is a prerequisite prior to fabrication. This necessitates development of an accurate transistor model that can work well in a real-time environment.

This dissertation presents empirical (table-based method and parameter extraction) as well as machine learning (ML) techniques based small-signal modeling strategy oriented to the computer-aided design for power amplifiers. It is imperative to note that an accurate small-signal model of GaN HEMT lays foundation for the accurate large-signal model. The modeling strategy is formulated to address the crucial effects observed in the advanced GaN based HEMTs transistors, such as complex parasitic effects and frequency dispersion, charge-trapping and self-heating effects which hinders the power level. Moreover, the formulation gives a clear physical interpretation of the model parameters, therefore providing a meaningful insight of the device physics.

The main contributions of this research work include:

1. Parameter Extraction Method for extracting extrinsic and intrinsic parameters, and complete development of small-signal model for GaN High Electron Mobility Transistor (HEMT) using empirical (table based method) modeling technique.
2. An accurate, fast, and reliable small-signal behavioral modeling of GaN HEMT using Artificial Neural Network.
3. Development of Generic and Efficient Globalized and Kernel Mapping-Based Small-Signal Behavioral Modeling for GaN HEMT and deployment of the proposed model into CAD environment for determination of optimal bias point, stability test and determination of gain in the designing of Power Amplifiers.
4. Hybrid Modeling Approach (empirical and machine learning) to model the GaN HEMT device. It includes the development of intrinsic section using Support Vector Regression utilizing the values of extracted parameters obtained from empirical modeling and eventually deployment of the proposed model into CAD tool for the simulation and validation of accuracy GaN HEMT.