Introduction of QPZD model

The QPZD model is a compact model based on channel zone division. Initially designed for modeling MODFETs and MESFETs in the 1980, this model has undergone further development for GaN HFETs modeling by R. J. Trew's group at North Carolina State University. In pursuit of practical applications in circuit design, Yuehang Xu's team at the University of Electronic Science and Technology of China (UESTC) introduced a simplified method utilizing the zone division theory, known as the Quasi-physical Zone Division (QPZD) Model. The core concept involves calculating the boundary potential at both drain and source terminals using velocity electric field relations based on the lateral electric field distribution in the access regions. The gradual channel approximation is employed to derive the carrier transport model in the intrinsic region. The development review of the model is depicted in Figure 1.

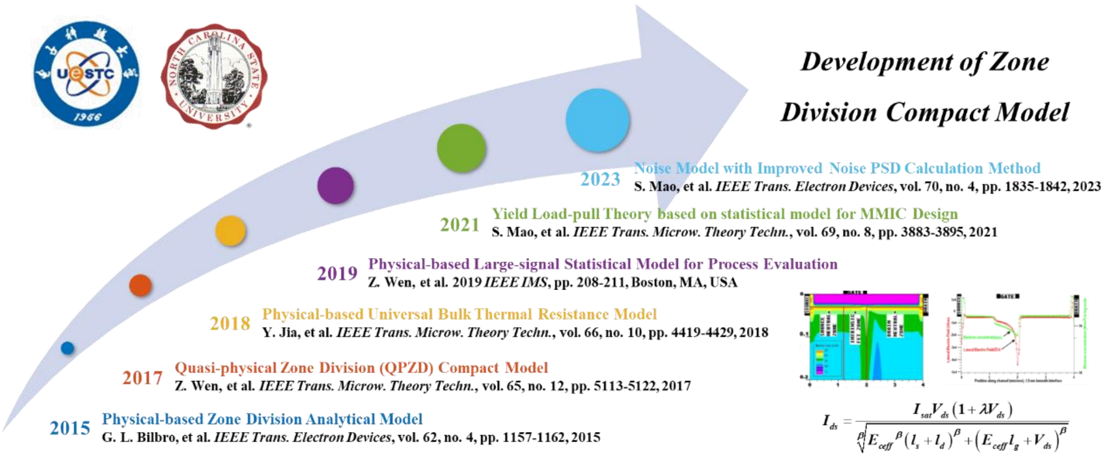

FIGURE 1 The development history of the QPZD compact model.

As illustrated in Figure 1, the QPZD model originated from analytical modeling using zone division methods in 2015. While the model has perfect physical interpretability, its implicit expressions present challenges in implementation within SPICE-like tools. To enhance its characterizing capability and accommodate thermal (including self-heating and ambient temperature effects) and trapping effects modeling, the original QPZD model was proposed in 2017. Subsequent efforts focused on real-device effects characterization, including thermal resistance modeling in 2018 and dynamic trapping modeling in 2019. Addressing process characteristics evaluation, process fluctuation effects were integrated into the QPZD model in 2019, contributing to circuit-level fluctuation prediction and yield optimization design. Moreover, for expanded modeling capabilities, noise characterization was incorporated into the QPZD model in 2023, facilitating the co-design of RF transceiver front-ends. Beyond GaN HEMTs modeling, various enhancements have been introduced to broaden the QPZD model's capabilities, including applications in GaAs PHEMTs, Diamond FETs, and the realization of large-gate-periphery GaN HEMTs. Leveraging the comprehensive capabilities of the QPZD model, it has found successful applications in practical designs, as showcased in Figure 2. Several GaN MMICs with outstanding performance have been designed, such as the X-band 20 W PA with a 50 % bandwidth, a 2-6 GHz broadband transceiver with an output power exceeding 39 dBm, and a Ka-band 15 W PA designed with over a 13 % yield improvement.

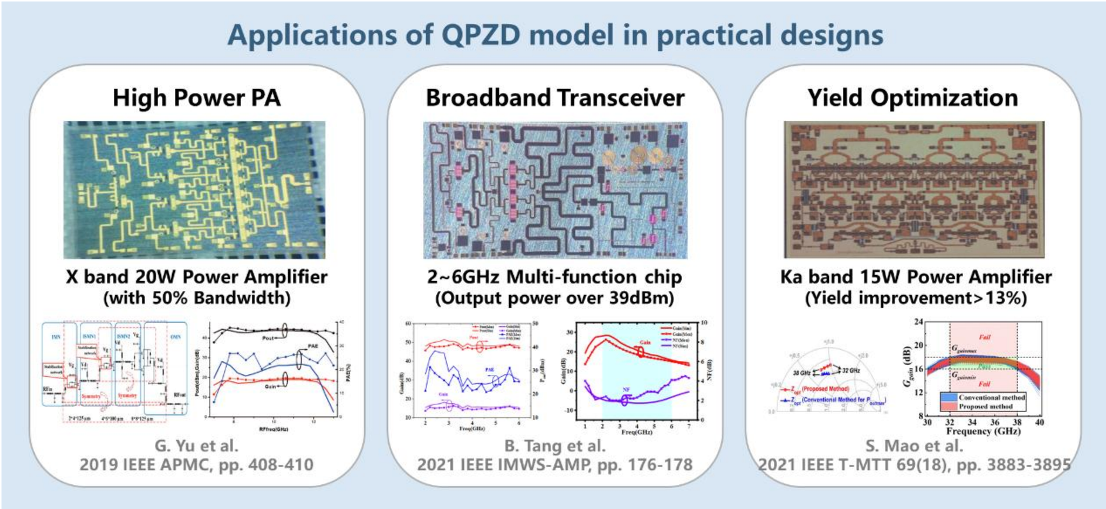

FIGURE 2 Application of the QPZD model in practical designs