Estimate of Harmonic Loadpull Impedances for RF High Power Devices Using 3D FEM Simulation

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Next generation cellular telecommunication systems demand high DC-to-RF conversion efficiency. As the primary consumer of DC power in the transceiver system, RF power amplifiers (PAs) need to be carefully designed to achieve high efficiency to satisfy both DC power budget and heat dissipation requirements. In recent years, practitioners and researchers have put considerable effort into developing highly efficient RF PAs using optimized semiconductor technology, including Gallium Nitride (GaN) and silicon-based laterally diffused metal oxide semiconductor (LDMOS). With such efforts, it has been realized that the current semiconductor technology generation of high power active devices shows significant performance dependence on harmonic terminations in cellular frequency bands. Consequently, harmonic termination methods, such as Class F and inverse Class F, are becoming very popular to increase the DC-to-RF efficiency of high power RF PAs for cellular telecommunications applications.

Although the performance dependence of RF active devices can be easily characterized using loadpull techniques by manipulating the source and load reflection coefficients at the fundamental carrier frequencies, knowledge of reflection coefficients at harmonic frequencies during such characterization is uncertain due to the bandwidth limitations of the TRL (Thru, Reflect, Line) calibration of the impedance transformer of the loadpull fixture. Consequently, the harmonic reflection coefficient information of the loadpull characterization system is unknown.

In this presentation, a method to estimate harmonic terminations of passive loadpull characterization systems will be shown. This method uses a hybrid approach of 3D full wave simulation and the traditional high power loadpull setup. A finite element method (FEM) solver is applied to simulate the loadpull fixture, connectors, and current clamp wire loop, as shown in Fig. 1. Cascaded with loadpull tuner measurement results, the FEM simulation results can then be fed back into a circuit simulator to validate large signal compact models of RF PA devices, evaluate harmonic termination sensitivity for RF PA designs, and help design highly efficient RF PA devices.

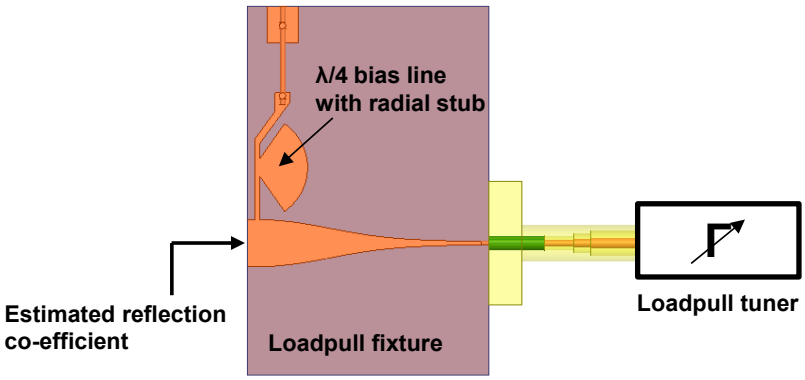

Figure 1. Method to estimate reflection coefficient of loadpull fixture cascaded with loadpull tuner measurements.