



**Title:** Considerations on the Impedance Transformation Characteristics of  $\lambda/4$  Transmission Lines and Their  $\pi$ -Type Equivalent Circuit

**Abstract:** Quarter-wave transmission lines are widely used in RF circuits such as Wilkinson couplers, power dividers, RF switches, and impedance transformers in Doherty power amplifiers. When implemented in integrated circuits, quarter-wave transmission lines often occupy a relatively large area compared with other circuit elements. Therefore, they are frequently replaced by lumped-element  $\pi$ -type equivalent circuits, such as LCL networks.

Although these equivalent circuits can reproduce the characteristics of a quarter-wave transmission line at the design center frequency, their frequency responses differ outside that frequency. Understanding these differences is important for achieving predictable circuit performance and avoiding unintended design tradeoffs.

This presentation investigates not only single-stage  $\pi$ -type equivalent circuits but also multi-stage implementations, and clarifies their similarities and differences with respect to quarter-wave transmission lines. The results provide practical design insights and help circuit designers better understand the limitations and applicability of transmission-line approximations in integrated RF circuits.