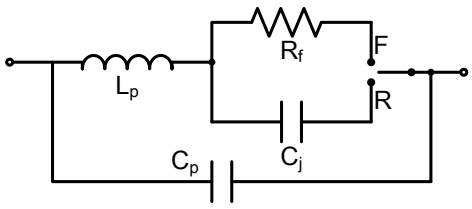
2025 RF Circuit Design HW-5 2025/05/1

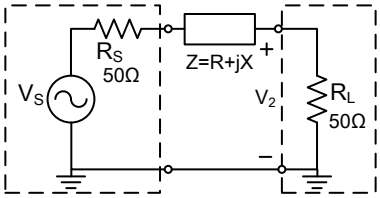
1. Because of a finite impedance of switching devices in the low-impedance state and a definite non-infinite impedance in the high impedance state, the switching circuits are not perfect. The performance of a practical switch can be expressed by specifying its insertion and isolation. Isolation is defined as the ratio of the power delivered to the load for an ideal switch in the **ON** state to the actual power delivered to the load when the switch is in the **OFF** state. There are two types of pin diode used. One has low on resistance with large off parasitic capacitance, and the other has larger "on" resistance but smaller parasitic capacitance. The equivalent circuit and the relevant parameters are listed in the table. Operating frequency is at 3.18GHz. Please answer the following questions by software simulator.



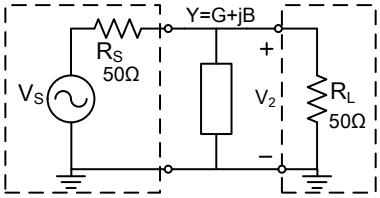
RF Model of PIN diode

Parameters	**Case 1**	**Case 2**
Cj (off)	1pF	0.1pF
Rf (on)	0.4Ω	1Ω
Lp	0.3nH	0.3nH
Cp	0.08pF	0.18pF

(a) Calculate and compare the insertion loss and isolation with Series configuration



(b) Calculate and compare the insertion loss and isolation with Shunt configuration

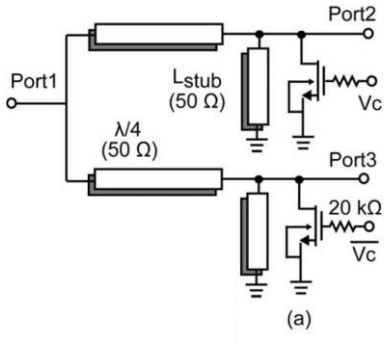


(c) Calculate and compare both IL and isolation with Inductive compensation in shunt configuration

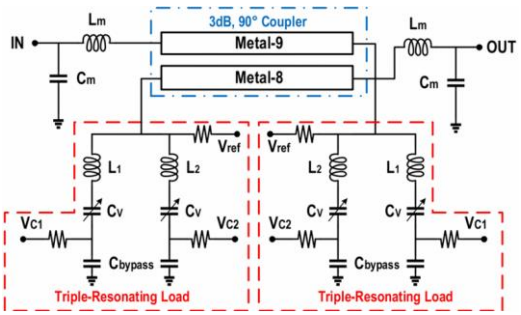
(d) Find the IL and Isolation with Series-Shunt Configuration and compare to those in (a) and (b)

(e) Study and verify the results from the paper "Mehmet Uzunkol, and Gabriel M. **Rebeiz**, *Fellow, IEEE,* A Low-Loss 50–70 GHz SPDT Switch in 90 nm CMOS,

IEEE JOURNAL OF SOLID-STATE CIRCUITS, VOL. 45, NO. 10, p. 2003, OCTOBER, 2010 by **UCSD.** Assume equivalent circuit model of MOS Roff=2.15kΩ, Coff=0.25pF, Ron=2.53Ω. Find the IL and Isolation from 8-12.0GHz without and with inductive compensation at 10GHz.



2. A reflection-type phase shifter (RTPS) can be converted into two-port network either by using a circulator or by a 90º hybrid. The hybrid is preferred due to integration in MIC and high power handling with two phase switching devices. Study and verify the results from the paper "5G Millimeter-Wave Phased-Array Transceiver: System Considerations and Circuit Implementations" To achieve full **360°** phase-shift range at **28GHz**, triple-resonating load technique is proposed. A Ka-band RTPS using triple-resonating load technique in 65-nm CMOS technology is presented (see Fig. 7). By adding an extra resonating inductor, the phase-shift range of a triple-resonating load can exceed 360° even with a limited varactor tuning range, while a flat insertion loss is achieved by optimizing the characteristic impedance of the 3-dB quadrature coupler. Please use the microwave software to verify the results. Values of Inductors and varactors L_1, L_2, $C_{v,max}$, and C_{vmin} are designated by yourself.



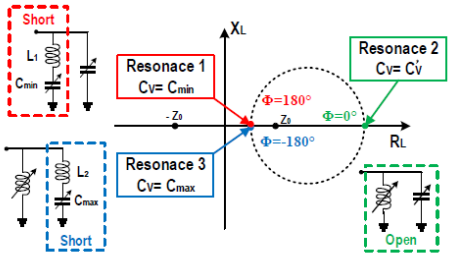


Fig. 8. The triple-resonating load technique.