SPDT Shunt PIN Diode Switch

Design of various microwave circuits using semiconductor devices can be carried out utilizing WIPL-D Microwave. Many types of diodes, such as PIN and Schottky diodes, or transistors operating in a linear regime, can be simulated by inserting into a schematic a suitable equivalent circuit usually provided by a manufacturer. Alternatively, a semiconductor device can be represented in a schematic as an S parameter data block which has originated from a manufacturer, or from the appropriate measurements carried out in a laboratory. Other schematic elements from the libraries available, including ideal, microstrip, coplanar or coaxial elements, can be subsequently added to the schematic to complete the design of complex microwave circuits such as switches, detectors, amplifiers, oscillators etc.

Example

The following example illustrates the introduction of PIN diode into WIPL-D Microwave schematic through the design of single pole double throw (SPDT) switch utilizing two PIN diodes. The diodes are represented in a form of an equivalent circuit. Due to the operating principle of the switch, both ON and OFF equivalent circuits are used in the same circuit.

Schematic of the switch is shown in Fig. 1. The requirement for such a switch is to route a signal applied to an input port (port 1) to one of the other two output ports (port 2) while the remaining output port (port 3) should remain isolated. The switching function is provided by connecting the isolated output port to a ground through a low impedance of a PIN diode when it is biased in ON state. To provide direct signal path, the PIN diode at the other output port should be biased in OFF state providing high shunt impedance which doesn't significantly influence the loss of the direct transmission path. To reverse the direct transmission path from port 2 to port 3, the bias of the diodes should be switched. Quarter wavelength transformers are introduced to connect both PIN diodes to the input port in order to prevent a short circuited diode to load the input port.

The same switch can be utilized in the case when an application scenario requires the directions of the signals in the switch to be altered providing the alternative connection of one of the two input signals (at ports 2 and 3) to the output port (1).

The transmission S parameters for the direct and isolated transmission paths are shown in Fig. 2. Within the frequency band of interest (±10%) the isolation is in the range of approximately 12-14 dB.

Such isolation values are illustrative to explain the principle of switch operation, which is particularly good example to demonstrate the introduction of semiconductor devices in circuit simulation, but are perhaps not sufficient for practical applications. The first step to obtain more practical values in the range 20-25 dB would be to replace quarter wavelength transmission line segments with more complex networks.

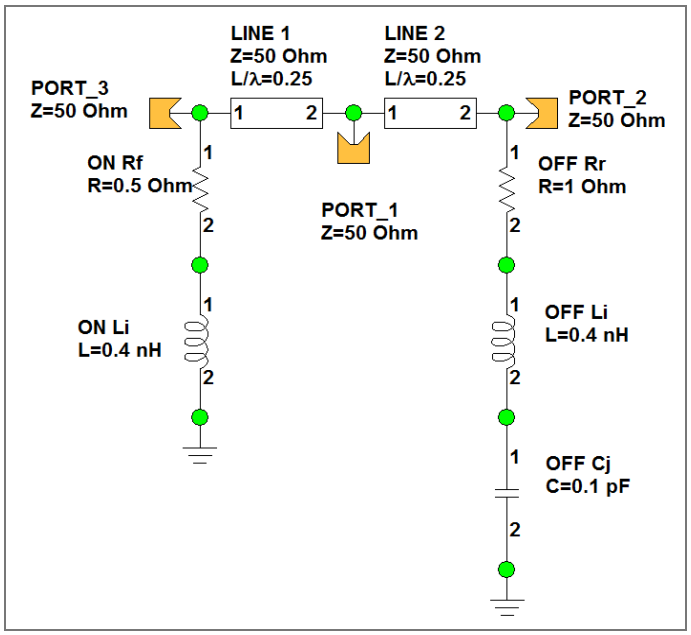

Figure 1. Schematics of SPDT PIN diode switch.

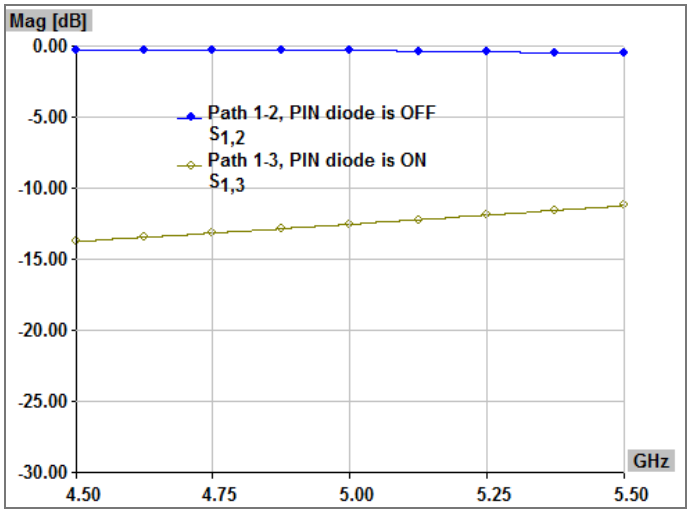

Figure 2. Transmission S parameters corresponding to direct and isolated signal path of SPDT switch in Fig. 1.

Conclusion

An illustrative example of a SPDT PIN diode switch simulation using WIPL-D Microwave has been presented. An example demostrates that besides main strengths in EM related problems, the WIPL-D suite provides a complete environment for design of complex microwave circuits including those utilizing semiconductor devices.