SPDT Switch Using PIN Diode NSDP301MX2W

AND90249/D

Overview

This application note explains about SPDT（Single−Pole Double−Throw） switch using PIN diode. NSDP301MX2W is low series resistance PIN diode. It is suitable for RF switch.

For information about the performance, please refer to the datasheet of this product.

Since the evaluation board is adjusted to achieve optimal performance in Sub GHz, the product can provide 0.39 dB Insertion loss at 500 MHz.

A standard material FR4 is used for the printed circuit board (PCB). Please note that the losses of the PCB and the SMA connector are not excluded.

Theory

The equivalent circuit of PIN diode at forward bias is shown in Figure 1. Rs is the series resistance and Ls is the series inductance. On the other hand, under reverse bias, equivalent circuit is shown in Figure 1b. Rp is parallel resistance and Cj is the junction capacitance.

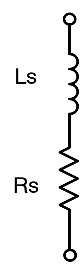

Figure1a. Equivalent Circuit at Forward Bias

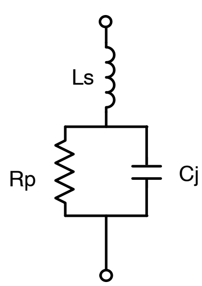

Figure1b. Equivalent Circuit at Reverse Bias

When using a PIN Diode in an RF application, it applies a forward bias to transfer the RF signal. At that time, it is important to select a device with a small Rs to reduce the signal loss.

When blocking the RF signal, apply a reverse bias to the diode. To reduce signal leakage, it is important to select a device with a high impedance given by Rp and Cj.

RF Switch Circuit

There are two ways to use the PIN Diode as a switch. One is a series type switch (Figure 2) and the other is a shunt type switch. In the series type switch, when no bias is applied, the PIN Diode is in the off state and no signal is transmitted. When bias is applied, the PIN diode is turned on and the signal is transmitted from the input to the output. (See AND90067 for series type SPST (Single Pole Single Throw) switches.)

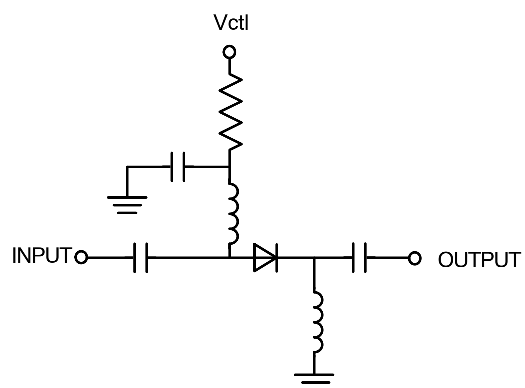

Figure 2. Series Type Switch Circuit

The SPDT switch shown in this application note is a circuit that combines this series type. The RF signal input from the IN terminal is split into two and output to OUTPUT1 and OUTPUT2. The diode NSDP301MX2W is connected in series to each path. A control terminal is connected to each diode. By applying Vctl from the control terminal to the diode in the path through which the signal should be transmitted, the diode turns ON and the signal is transmitted. The diode on the non−biased side is turned off and the signal is not transmitted.

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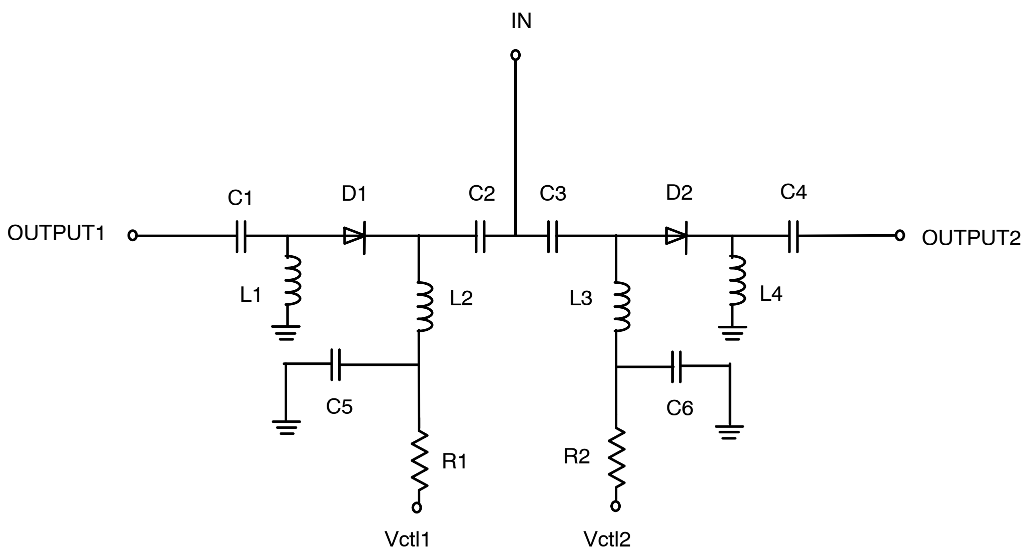

Figure 3. Series Type SPDT Switch Circuit

BILL OF MATERIALS

Item	Symbol	Value	Manufacturer	Size
PIN Diode	D1, D2	NSDP301MX2W	**onsemi**	X2DFN2W
Capacitor	C1, C4	120 pF	Various	1005
	C2, C3	47 pF	Various	1005
	C5, C6	0.1 μF	Various	1005
Resistor	R1, R2	220 Ω	Various	1005
Inductor	L1, L2, L3, L4	270 nH	Various	1005
Material	–	FR4	–	25 x 18 mm

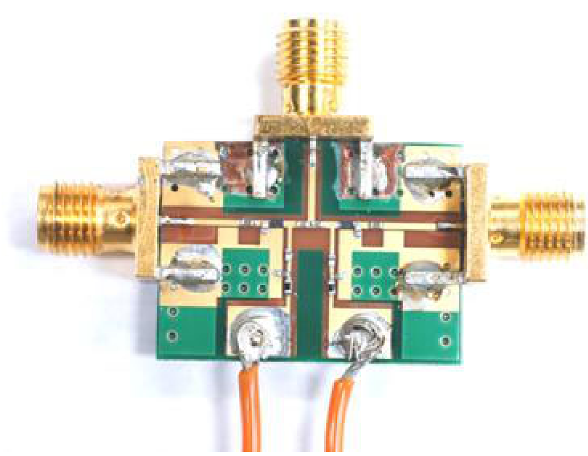

Figure 4. Evaluation Board

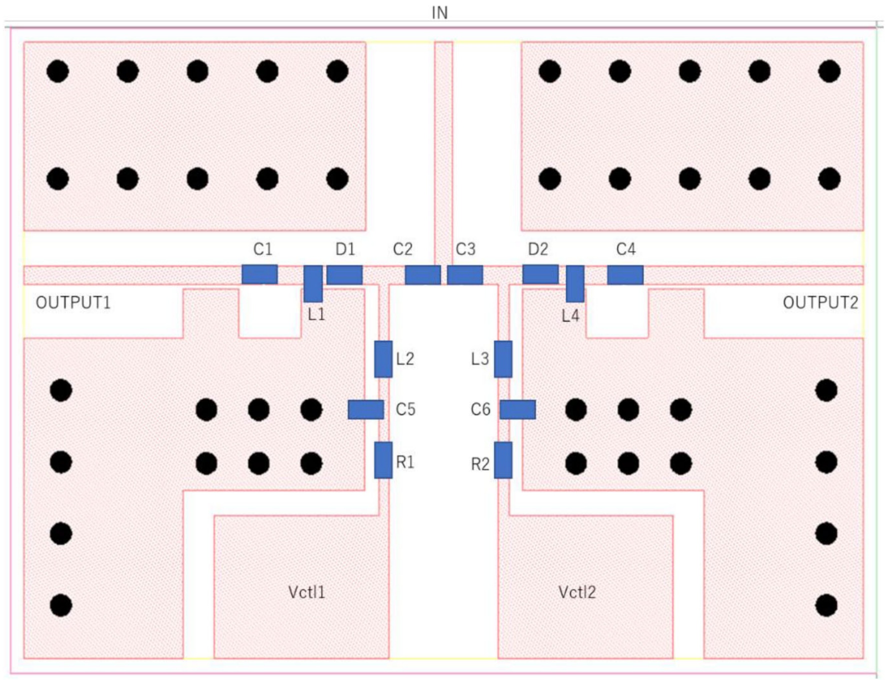

Figure 5. Evaluation Board Layout

SUMMARY OF DATA

DC Characteristics

Port	Parameter	Symbol	Condition	Vctl = 1 V	Vctl = 2 V	Vctl = 3 V	Unit
Vctl1	Control Current1	Ictl1	Vctl2 = 0V	0.98	5.14	9.48	mA
Vctl2	Control Current2	Ictl2	Vctl1 = 0V	0.98	5.14	9.48	mA

RF Characteristics

IN – OUTPUT1

(T_A = 25°C, Input Power = −5 dBm, Zo = 50 Ω, Include Board Loss)

Parameter	Symbol	Condition	150 MHz	500 MHz	900 MHz	Unit
ON State						
Insertion Loss	IL	Vctl1 = 1 V, Vctl2 = 0 V	−0.58	−0.56	−0.88	dB
		Vctl1 = 2 V, Vctl2 = 0 V	−0.42	−0.42	−0.73	dB
		Vctl1 = 3 V, Vctl2 = 0 V	−0.40	−0.39	−0.71	dB
Isolation	ISO	Vctl1 = 0 V, Vctl2 = 1 V	−31.5	−23.7	−23.7	dB
		Vctl1 = 0 V, Vctl2 = 2 V	−31.5	−23.7	−23.7	dB
		Vctl1 = 0 V, Vctl2 = 3 V	−31.5	−23.7	−23.6	dB
OFF State						
Insertion Loss	IL	Vctl1 = 0 V, Vctl2 = 0 V	−30.84	−22.96	−20.69	dB

RF Characteristics

IN – OUTPUT2

(T$_A$ = 25°C, Input Power = −5 dBm, Zo = 50 Ω, Include Board Loss)

Parameter	Symbol	Condition	150 MHz	500 MHz	900 MHz	Unit
ON State						
Insertion Loss	IL	Vctl1 = 0 V, Vctl2 = 1 V	−0.58	−0.56	−0.88	dB
		Vctl1 = 0 V, Vctl2 = 2 V	−0.43	−0.41	−0.73	dB
		Vctl1 = 0 V, Vctl2 = 3 V	−0.40	−0.39	−0.71	dB
Isolation	ISO	Vctl1 = 1 V, Vctl2 = 0 V	−31.0	−23.4	−23.3	dB
		Vctl1 = 2 V, Vctl2 = 0 V	−31.0	−23.4	−23.3	dB
		Vctl1 = 3 V, Vctl2 = 0 V	−31.0	−23.4	−23.3	dB
OFF State						
Insertion Loss	IL	Vctl1 = 0 V, Vctl2 = 0 V	−30.33	−22.63	−20.34	dB

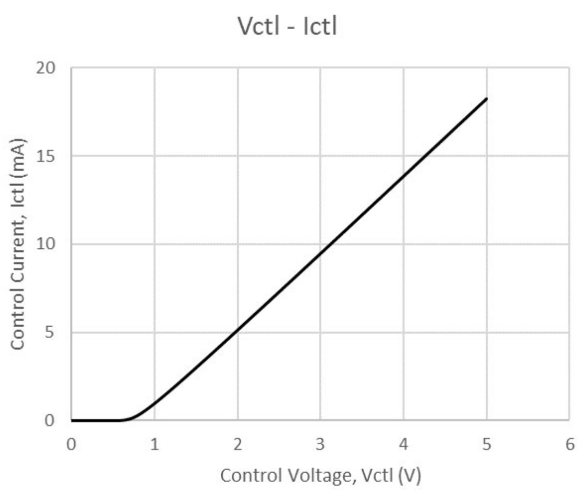

Figure 6. DC Characteristics Graph

IN – OUTPUT1

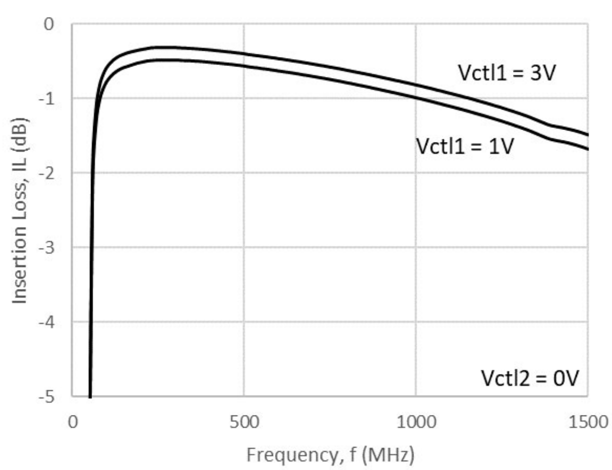

Figure 7. Insertion Loss, IN – OUTPUT1

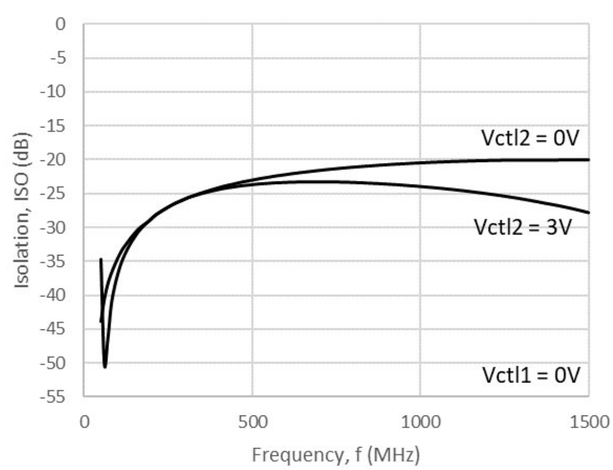

Figure 8. Isolation, IN – OUTPUT1

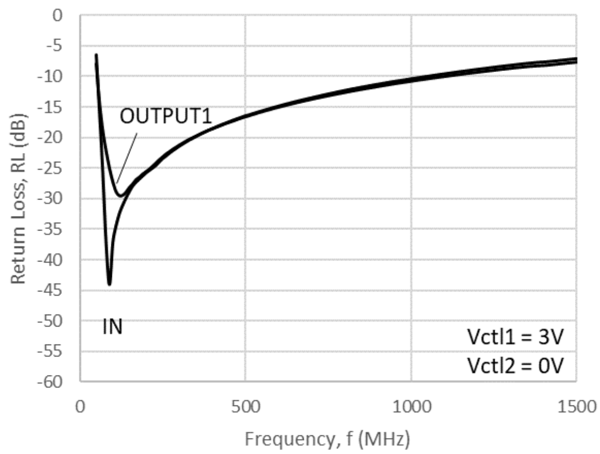

Figure 9. Return Loss, IN − OUTPUT1

IN − OUTPUT2

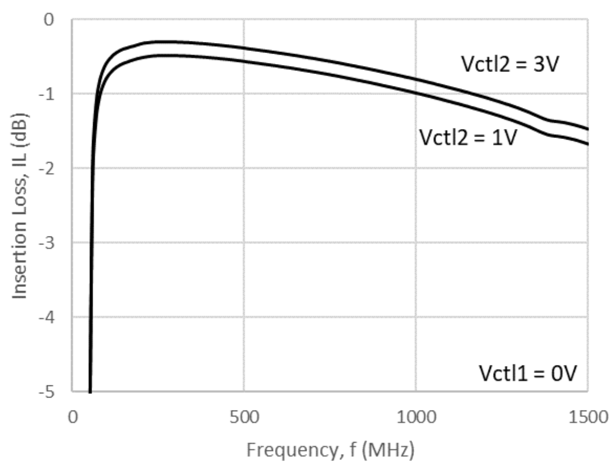

Figure 10. Insertion Loss, IN − OUTPUT2

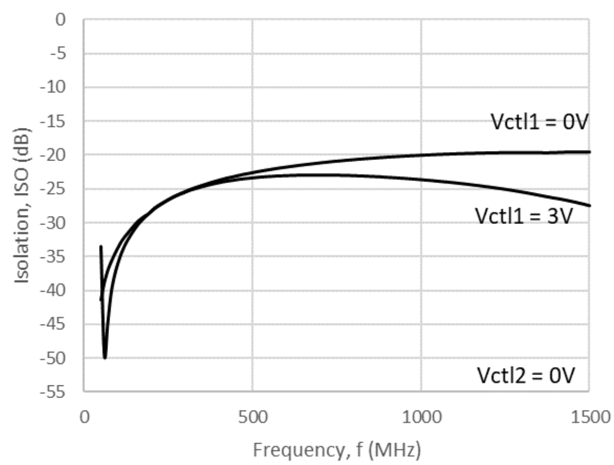

Figure 11. Isolation, IN − OUTPUT2

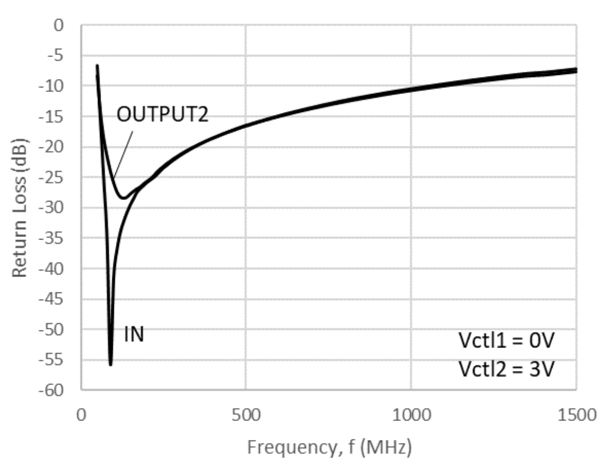

Figure 12. Return Loss, IN − OUTPUT2