PEREGRINE SEMICONDUCTOR

AN15: Application Note

Impedance Matching the PE4210/20/30 RF Switches for 75-Ohm Applications

Features

- Simple Matching Circuits
- Minimum External Parts Required
- Significant Performance Improvement

Introduction

Peregrine solid-state RF switches find many applications, including replacing mechanical switches in cable TV equipment. This Application Note explains how the PE4210/20/30 series of SPDT Switches can operate in 75-ohm systems by including simple impedance matching circuits.

A non-reflective SPST switch design is also presented that uses two PE4230s. Together they provide very high signal isolation for use in CATV distribution equipment.

Performance in 75-Ohm System Impedance

The PE4210/20/30 RF switches have been designed as 50-ohm components, and require no additional matching for optimum performance in 50-ohm systems. Figure 1 shows typical measured performance of the PE4230 switch mounted in a standard 50-ohm Peregrine 101/0037 RF Switch evaluation board. The return loss exceeds 20 dB through 1.5 GHz, and insertion loss of the board/switch combination is quite low.

In a 75-ohm system, however, the PE4230 presents a mismatch that prevents the same performance from being realized. Figure 2 shows the computed performance of a single PE4230 switch placed in a similar evaluation board with 75-ohm transmission lines. Note the return loss is now only 10 dB at 1.5 GHz, and the insertion loss has also degraded due to the increased mismatch loss. While this performance is acceptable in some applications, adding a few inexpensive external components can increase the return loss to better than 20 dB.

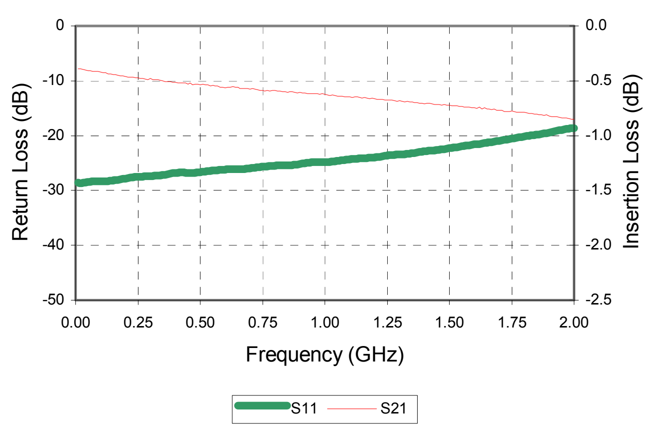

Figure 1. PE4230 Switch Evaluation Board [50-Ohm System]

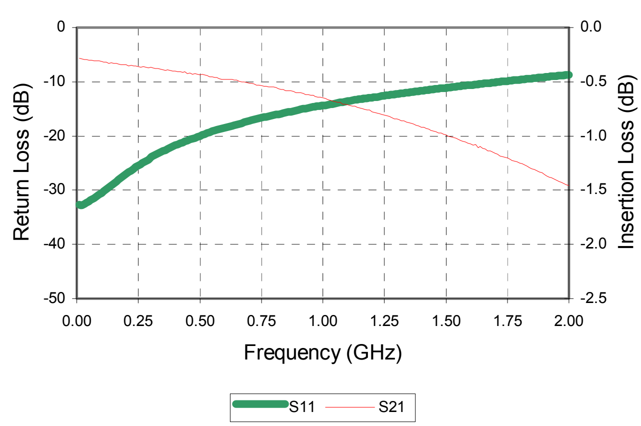

Figure 2. PE4230 Switch [75-Ohm System]

Implementing 75-Ohm Impedance Matching Circuits

A lumped shunt capacitor at the RF terminals is a simplistic model of the PE4230 in a 75-ohm system. Over a reasonable bandwidth, a low pass structure can absorb this shunt C nicely. The simplest such circuit is shown in Figure 3, where a single PE4230 and two series inductors creates a three-element LPF:

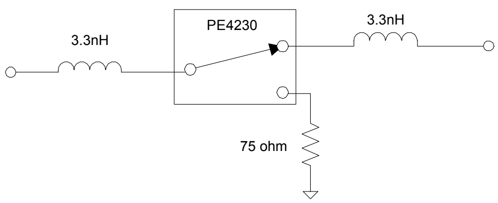

Figure 3. PE4230 75-Ohm Impedance Match

As we see from Figure 4 below, this approach yields good performance to beyond 1 GHz. A simple three-element matching circuit is limited in terms of the bandwidth it can match, and additional elements could potentially provide more bandwidth, but for a typical CATV application this bandwidth is more than satisfactory.

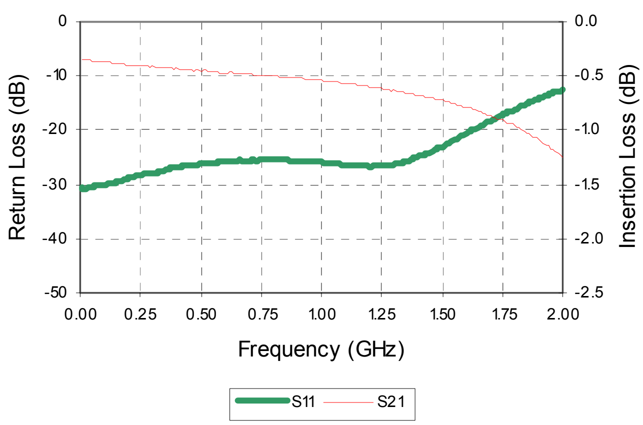

Figure 4. PE4230 Switch Matched to 75 Ohms [75-Ohm System]

A 75-Ohm High-Isolation CATV Switch

One very effective application of the PE4230 is as a 75-ohm CATV subscriber switch. In this application the SPDT function is not necessary (a SPST switch is sufficient), but the input port should be non-reflective and present a well-matched impedance when the switch is commanded OFF. Two series-connected PE4230s both increase isolation and provide terminated input and output ports when in the OFF state.

For a two-switch cascade the 75-ohm mismatch is more severe than that seen with a single switch. Figure 5 shows the computed performance of two PE4230 switches in a 75-ohm impedance board connected with a short length (12 ps) of 75-ohm transmission line. In this configuration the VSWR of the switches combine, resulting in a worst-case return loss of about 9 dB. The mismatch loss is also magnified, reaching 0.5 dB at 1 GHz. This additional loss due to VSWR effects increases the insertion loss more than 50% over the loss of a well-matched system. Eliminating this additional loss through proper impedance matching is both simple and desirable.

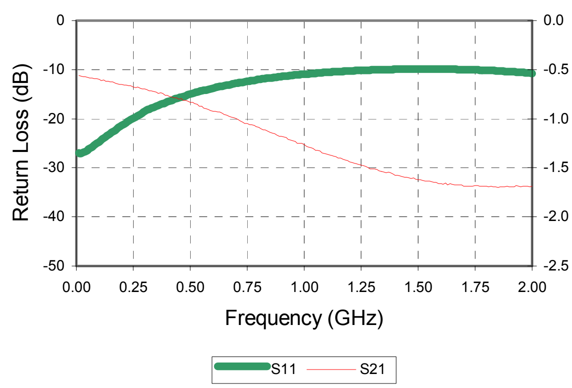

Figure 5. Two Cascaded PE4230 Switches [75-Ohm System]

As was shown in the previous example with a single PE4230, the 50-ohm switch mismatches can be absorbed into a simple low-pass structure. Figure 6 shows the schematic of one possible circuit.

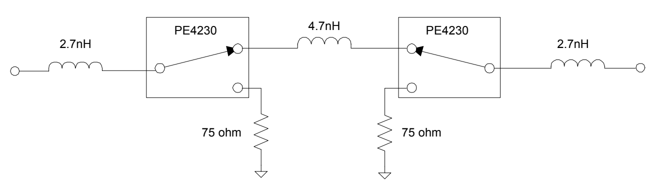

Figure 6. 75-ohm Impedance Matching of Two PE4230 Switches

In this example the three inductors combine with the switches to synthesize a five-section LPF. This circuit provides a very good match in a 75-ohm system, as seen from the computed performance shown in Figure 7. One interesting effect of the five-section LPF structure is the increased bandwidth attained by the more complex network; a minimum 20 dB return loss extends to frequencies beyond 2 GHz.

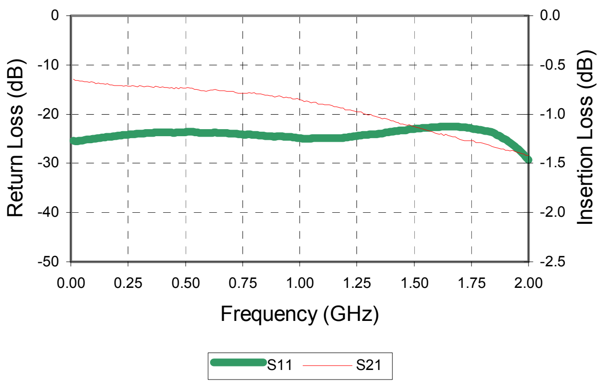

Figure 7. Two PE4230 Switches Matched to 75 Ohms

Peregrine CATV SPST Applications Board

The circuit of Figure 6 has been designed into a ready-to-test Application Board. The layout and parts list are shown in Appendix A. Contact a Peregrine Sales Office for more information (see page 6 for a list of Sales Office locations).

PE4230 S-Parameters

S-Parameters for the PE4230 in the ON state can be found in Appendix B. Note: This data is referenced to a 50-ohm system impedance.

Conclusions

The performance of the PE4230 switch in a 75-ohm system can be improved substantially by incorporating a few external matching elements. The resulting circuit is simple, low-cost, and easy to implement.

Appendix A.

Figure 7. 75-Ohm CATV SPST Switch Application Board

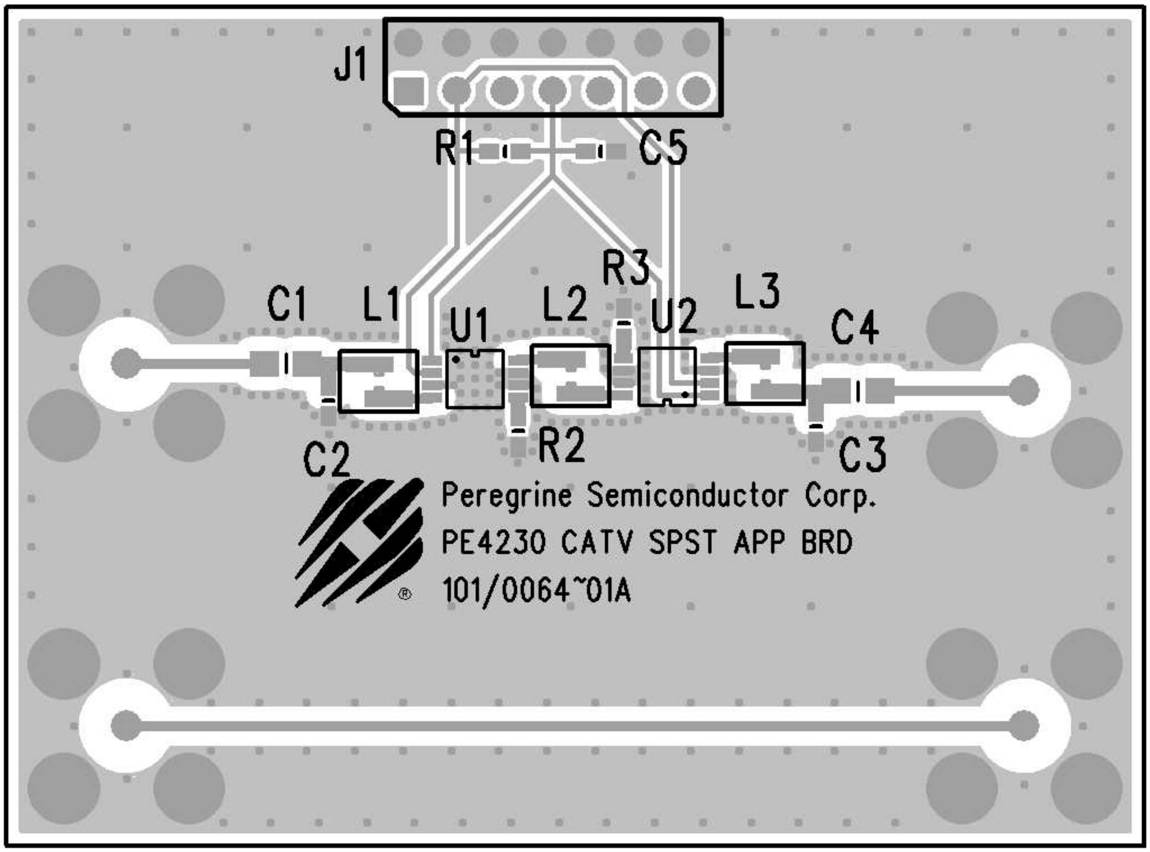

Table 1. Parts List

Item	Quantity	Reference Designator	Description	Part Number	Manufacturer
1	1		PWB	101/0064~01A	Peregrine
2	1	J1	Header, 14 pin	S2011-36-ND	Digi-Key
3	2	J2,J3	75 ohm BNC connector	413558-1	Tyco/AMP
4	2	C1,C4	6800 pF	GRM39X7R682K50V	MuRata
5	2	C2,C3	N/L		
6	2	C5	0.01 uF	0805B103K500P	Novacap
7	1	R1	50k ohm	MCR10JW563	Garrett Elect.
8	2	R2,R3	82 ohm	MCR10JW820	Garrett Elect.
9	2	U1,U2	RF Switch	PE4230	Peregrine
10	2	L1,L3	2.7 nH	LQP11A2N7C00	MuRata
11	1	L2	4.7 nH	LQP11A4N7C00	MuRata

Appendix B.

Table 2. 50-Ohm S-Parameters of the PE4230 in the ON State
(Port 1 = Pin 4, Port 2 = Pin 8)

Freq (GHz)	S11		S21		S12		S22	
	Mag	Ang	Mag	Ang	Mag	Ang	Mag	Ang
0.1	0.039	-0.5	0.956	-2.8	0.955	-2.8	0.039	-0.2
0.2	0.043	-3.5	0.954	-5.4	0.954	-5.4	0.042	-2.1
0.3	0.047	-8.8	0.954	-7.9	0.953	-8.2	0.044	-5.9
0.4	0.051	-13.6	0.953	-10.4	0.953	-10.7	0.043	-10.2
0.5	0.053	-18.6	0.952	-12.8	0.953	-13.1	0.044	-13.7
0.6	0.057	-23.7	0.952	-15.3	0.953	-15.6	0.041	-19.4
0.7	0.058	-29.1	0.952	-17.7	0.953	-18.0	0.039	-23.6
0.8	0.061	-33.7	0.953	-20.1	0.953	-20.5	0.036	-31.9
0.9	0.063	-39.3	0.953	-22.6	0.953	-22.8	0.032	-39.2
1.0	0.064	-44.1	0.953	-25.0	0.953	-25.3	0.028	-52.4
1.1	0.067	-50.5	0.953	-27.5	0.953	-27.8	0.025	-69.2
1.2	0.067	-55.5	0.952	-29.9	0.952	-30.2	0.025	-89.4
1.3	0.069	-62.3	0.953	-32.3	0.952	-32.6	0.028	-110.9
1.4	0.072	-68.5	0.952	-34.8	0.952	-35.1	0.034	-127.7
1.5	0.074	-75.3	0.952	-37.3	0.952	-37.6	0.043	-138.9
1.6	0.078	-82.7	0.951	-39.8	0.952	-40.1	0.054	-147.5
1.7	0.082	-90.1	0.951	-42.3	0.951	-42.6	0.065	-152.8
1.8	0.089	-97.3	0.951	-44.8	0.951	-45.0	0.079	-156.3
1.9	0.096	-104.7	0.950	-47.3	0.950	-47.6	0.093	-159.8
2.0	0.106	-111.5	0.949	-49.8	0.949	-50.2	0.108	-161.2
2.1	0.118	-118.1	0.947	-52.5	0.947	-52.8	0.124	-162.9
2.2	0.130	-124.1	0.945	-55.1	0.946	-55.4	0.141	-163.8
2.3	0.147	-130.4	0.943	-57.7	0.944	-58.0	0.159	-165.1
2.4	0.164	-135.7	0.940	-60.4	0.939	-60.6	0.178	-165.4
2.5	0.183	-141.1	0.937	-63.1	0.937	-63.3	0.198	-166.2
2.6	0.205	-146.2	0.932	-65.8	0.933	-66.0	0.219	-166.6
2.7	0.228	-150.8	0.927	-68.5	0.927	-68.8	0.241	-167.4
2.8	0.253	-155.2	0.922	-71.3	0.923	-71.6	0.266	-168.0
2.9	0.280	-159.9	0.915	-74.1	0.915	-74.4	0.290	-168.9
3.0	0.308	-164.1	0.907	-76.9	0.908	-77.2	0.315	-169.7

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Application Note Identification

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