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PE42522 and PE42523: High Frequency Performance Improvement Through Narrowband Matching

Introduction

The PE42522 and PE42523 high frequency SPDT products are capable of being used up to 26.5 GHz with the recommended landing pattern. However, the performance can be improved with an external matching network. At frequencies above 21 GHz a significant portion of the insertion loss is the result of the power being reflected due to impedance mismatches at the RF ports. By providing an external matching network, improvement can be made in the return loss, and thereby, improve the insertion loss at these frequencies. There are several factors that can be traded off when designing the external matching network and these will be highlighted in this application note.

Summary

- Means to optimize high frequency performance
- Path to achieve 3 dB insertion loss @ 24 GHz
- Demonstrate multiple matching networks
- Comparative performance benchmarks

## Narrowband Impedance Matching
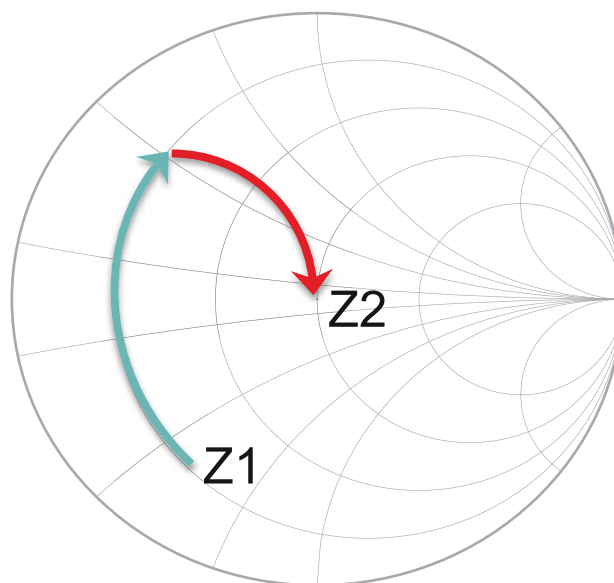
Defining a Narrowband Matching Network

Measured data for the PE42522 and PE42523 is available on Peregrine Semiconductor's web site at www.psemi.com. Data for these SPDTs is in the form of a 3-port S3P data file. To facilitate getting a design simulation defined and running, two data files have been posted, one for each of the two switch states. Each data file contains all of the unique S-parameter data needed to accurately determine the behavior of the resulting matching network. Starting with these data files, create a simple test bench. To verify that the test bench is running correctly, copy the matching network from the datasheet and verify that the simulated results are the same for both the insertion loss and return loss.

There are many different systems that these SPDT components could be placed in and the external matching network is highly dependent on the specifics of the PCB layout, substrate, etc. Making a matching network that is carefully tuned to an application can make a significant difference in performance. By way of an example, a matching network for the 24 GHz ISM band, shown in *Figure 1*, is defined to optimize the 24.0–24.25 GHz performance.

Figure 1. 24 GHz ISM Frequency Band

Source: http://www.ntia.doc.gov/page/2011/united-states-frequency-allocation-chart
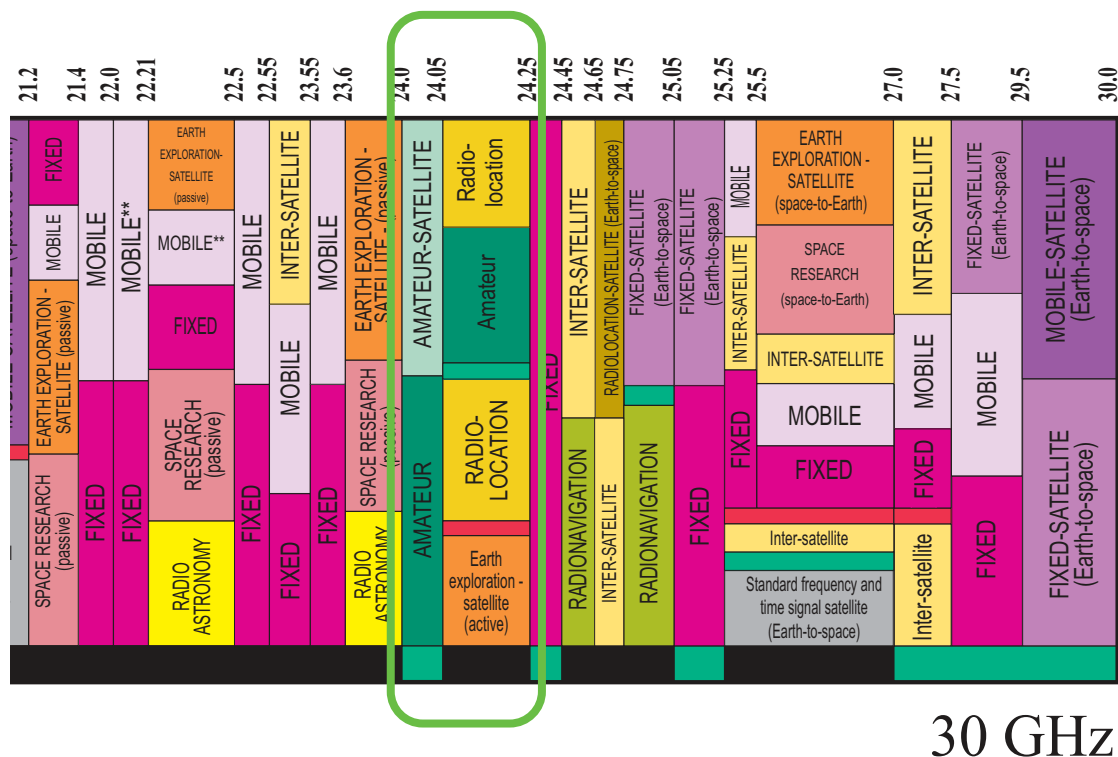
Test Bench, Schematic and Labeling

The test bench shown in *Figure 2* is set up so that two different S-parameter files will be loaded. One file is for RF1 active and the other file is for RF2 active. The port convention is that Port 1 is for the RF common port, RFC. Port 2 is for RF1 and Port 3 is for RF2. This means that S11 is the return loss for RFC, S22 is the return loss for RF1 and S33 is for RF2. If RF1 (S22) is active then RF2 (S33) is the terminated port and RFC and RF1 are the active ports and define the insertion loss (S21).

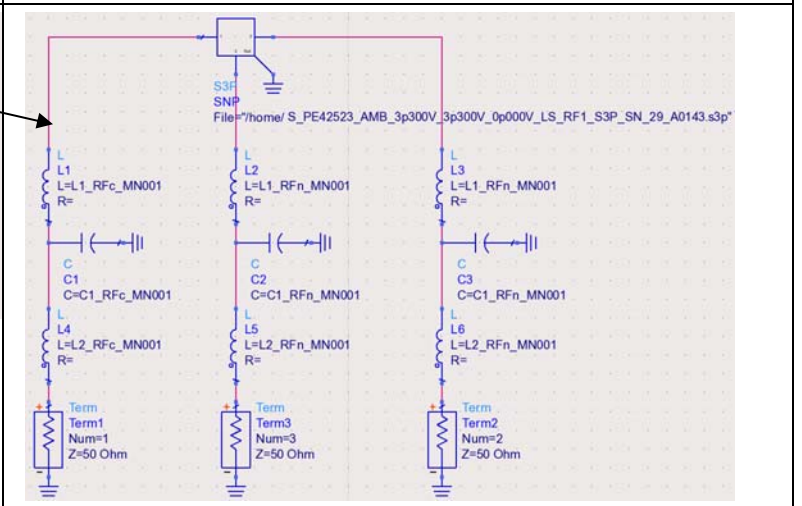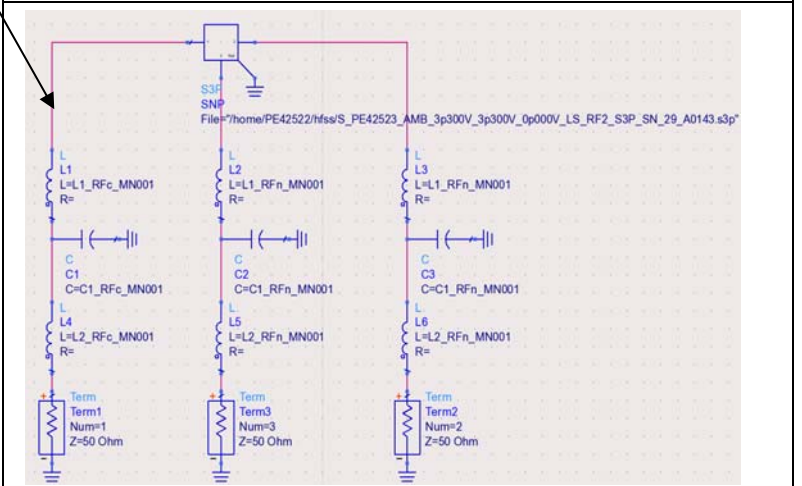| **Figure 2.** Top ADS Test Bench	**Figure 3.** Descended into "Dembedded_SPDT_measured_RF1_s3p_523"
	Figure 4. Descended into "Dembedded_SPDT_measured_RF2_s3p_523"
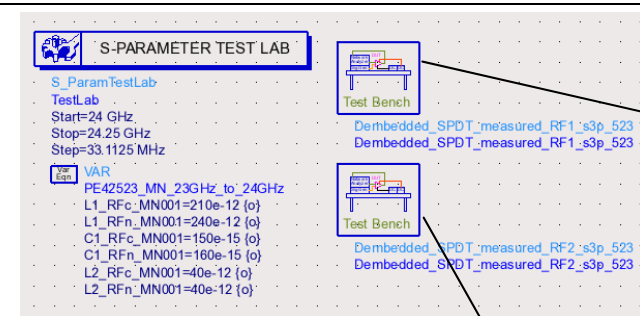
Port Matching Results

The use of an optimized narrowband match for the PE42522 and PE42523 SPDTs can result in improved high frequency performance. Improvements can be realized for 24 GHz ISM band applications using the following defined matching networks.

Figure 5–Figure 7 depict the performance for the PE42523 using baseline broadband matching networks. *Figure 8–Figure 10* present the results for narrowband matching networks. In both sets of figures, the first figure shows the S-parameters across the entire frequency range of interest, the second plot shows the schematic for each matching configuration, and the third plot shows the Smith chart representation of the port impedances for each case. In the graphs an instance name "Dembedded_SPDT_measured_RF1_s3p_523" followed by a .S(1,1) indicates that this is the return loss for the RFC when RF1 is active.

Table 1. Performance Comparison: No Port Matching vs. Baseline Match vs. Narrowband Match Response at 24 GHz

Parameter	No Match @ 24 GHz	Baseline Match @ 24 GHz	24 GHz Narrowband Match	Unit
Insertion loss	−6.6	−3.21	−3.02	dB
Return loss (RFC)	−8	−13	−24	dB
Return loss (active port)	−9	−18	−15.8	dB

Figure 5. Performance Response of Baseline Match
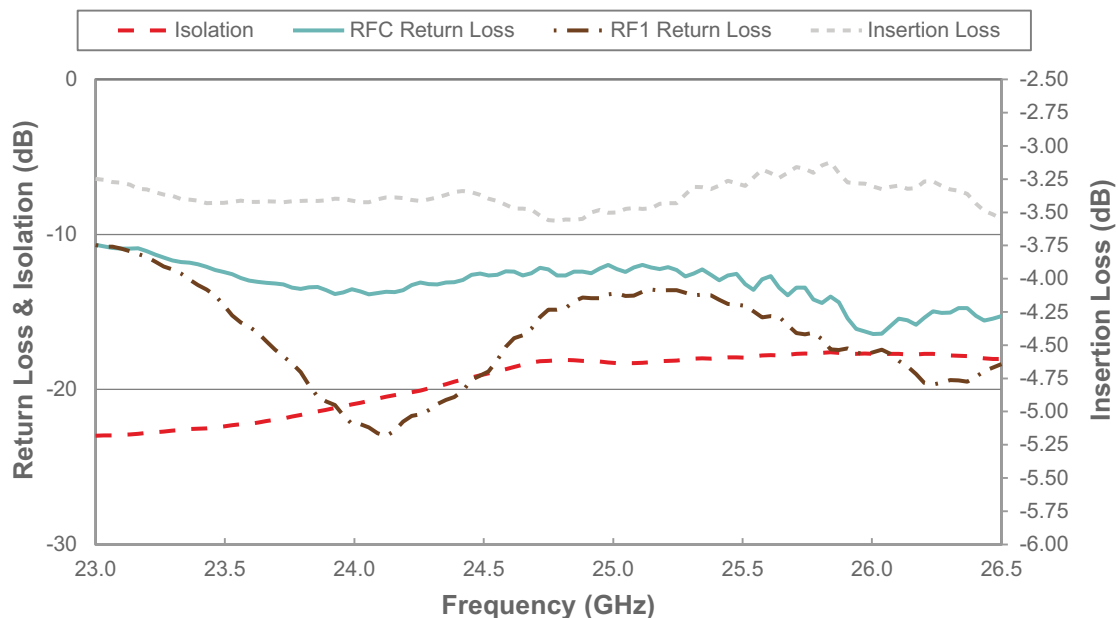
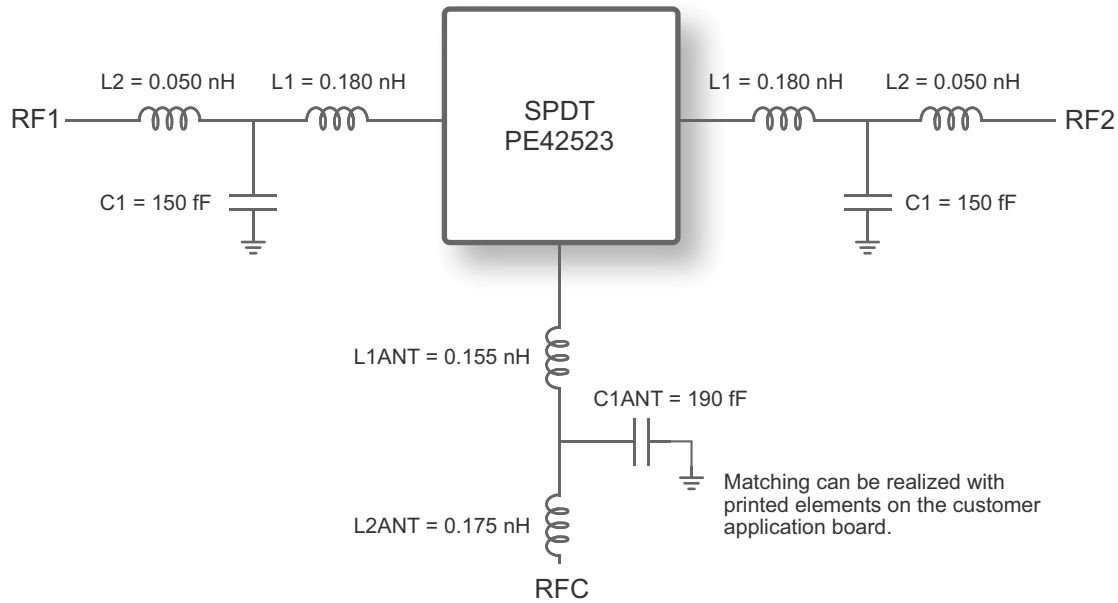**Figure 6. Schematic Diagram of Baseline Match**

RF1 — L2 = 0.050 nH — L1 = 0.180 nH

C1 = 150 fF

SPDT
PE42523

L1 = 0.180 nH — L2 = 0.050 nH — RF2

C1 = 150 fF

L1ANT = 0.155 nH

C1ANT = 190 fF

Matching can be realized with printed elements on the customer application board.

L2ANT = 0.175 nH

RFC

Figure 7. Smith Chart Representation of the Baseline Match Port Impedances

—— 23-26.5 GHz Match   —— No External Match
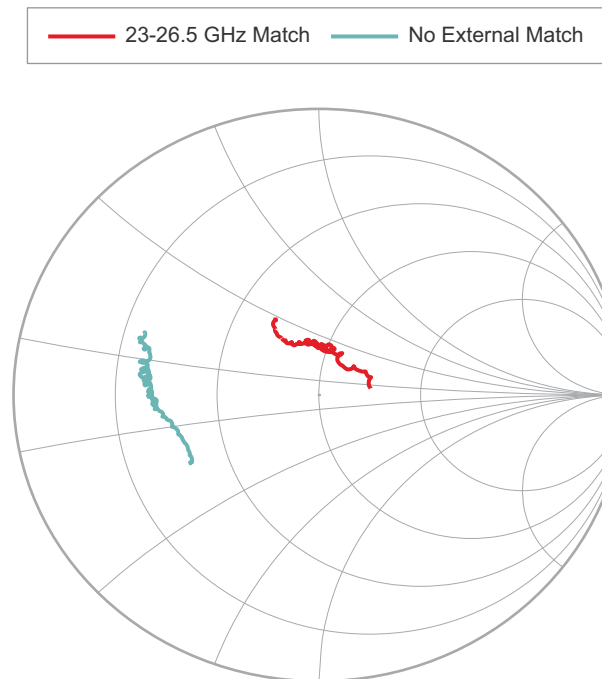
Figure 8. Performance Response of Narrowband Match
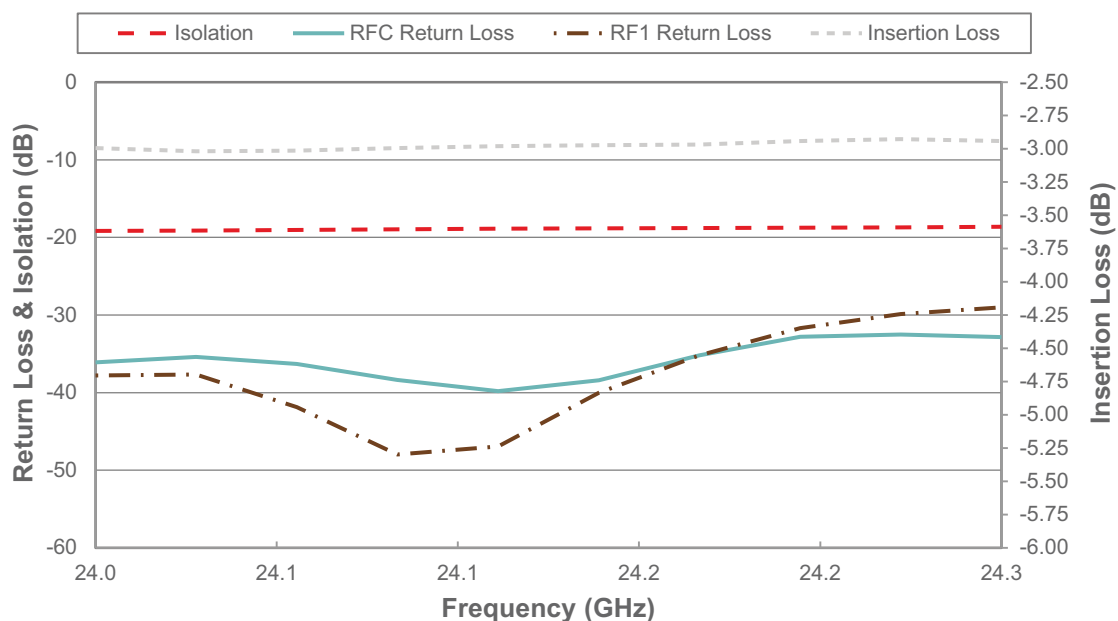
Figure 9. Schematic Diagram of Narrowband Match

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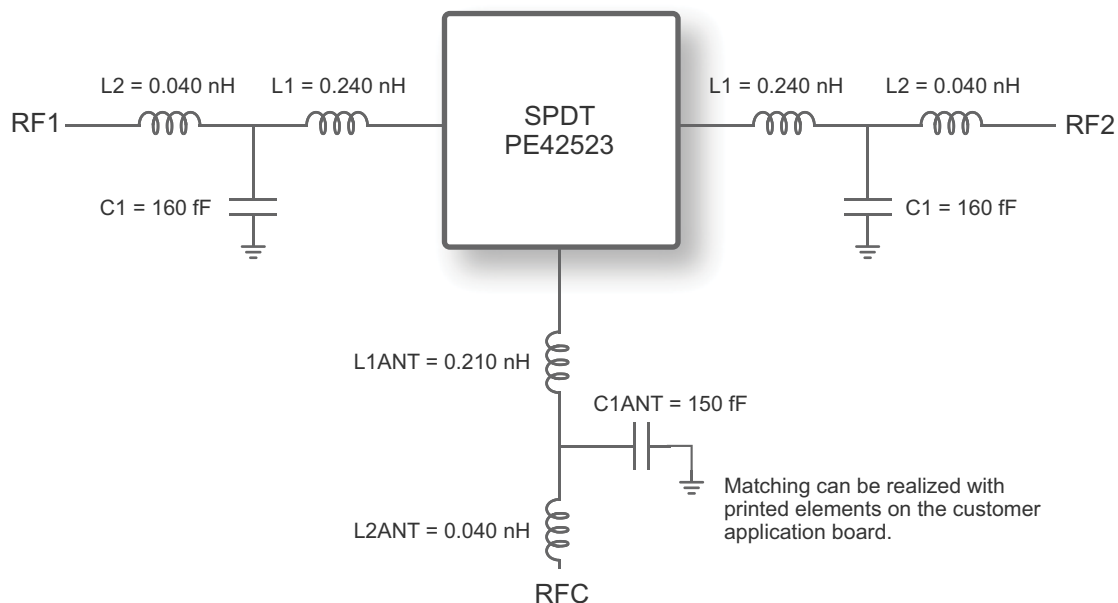
Figure 10. Smith Chart Representation of the Narrowband Match Port Impedances
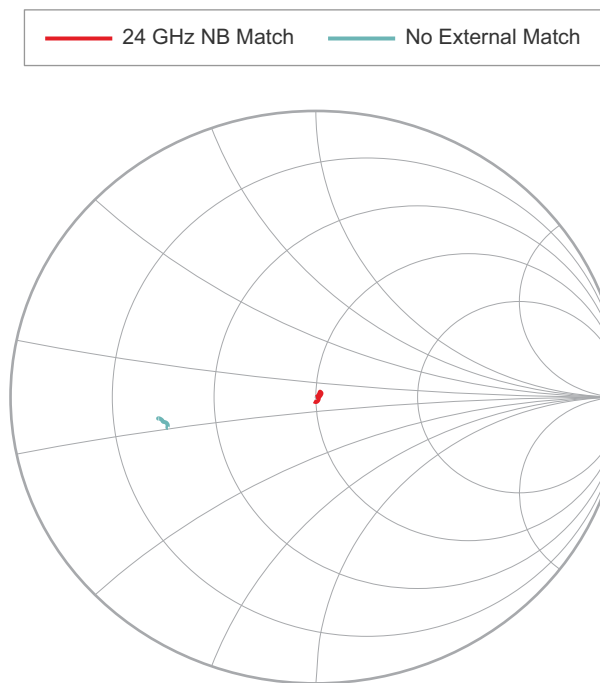
Conclusion

The means and method for improving high frequency performance has been discussed. The parasitics associated with these products, especially above 21 GHz cause a significant degradation in return loss which causes the insertion loss to increase. Much of the reflective loss can be recovered with the use of narrow band matching networks. Two different bandwidths have been addressed in this application note, and the same concept and matching techniques can be applied to the specific frequency and system integration details of the end use application.

For applications support, please visit www.psemi.com

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