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Configuring the PE42850 as an SP3T or SP5T

Introduction

PE42850 is designed to be a high power (~30 Watts) SP5T switch. A popular use of this switch is in land mobile radio (LMR) applications, where the number of bands required can vary depending on the region of operation. In order to support these multiple use cases, unused switch ports can be either properly terminated or left open with no discernible effect on switch performance.

Alternatively, it is possible to optimize its TX insertion loss performance in a lower throw SP3T configuration by making some circuit modifications around the RF pins. This should be accompanied by the use of corresponding control logic options already designed into the part. Besides s-parameters, all other performance specifications will remain the same as per the datasheet, i.e. P_{MAX}, compression, linearity, switching time, etc. will be unchanged.

This application note details the circuit options recommended for SP3T and SP5T operation and has simulated and measured data to back them up.

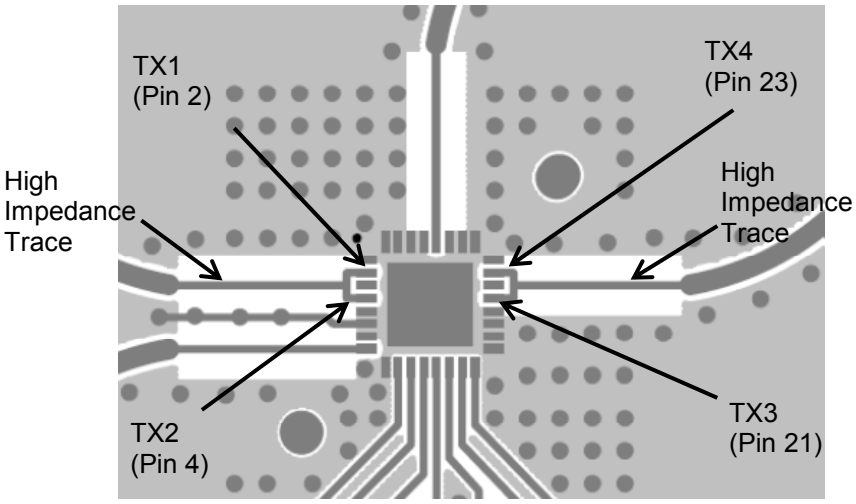
Summary

- Configure PE42850 as an SP3T
- Compare SP3T simulated performances with DUT only (no matching) vs transmission line matching vs lumped inductor matching
- Show measured performance with inductor match for SP3T
- Show simulated and measured performance with similar methodology for SP5T configuration

Configure PE42850 as an SP3T

To configure PE42850 as an SP3T, it is recommended to tie TX1 (Pin 2) to TX2 (Pin 4) and TX3 (Pin 21) to TX4 (Pin 23) as shown in *Figure 1*.

Figure 1. Layout



Similar to the SP5T configuration, narrow high-Z (~100Ω) traces are used near each port to improve impedance matching for PE42850 as an SP3T. A trace length of 250 mil is optimum for matching each port.

Alternatively, if space is a constraint, a 3.6 nH inductor can be used instead of the narrow trace at each port to provide the required match.

The truth table is obtained from the datasheet.

Table 1. Truth Table

Path	V3	V2	V1
ANT – RX Attenuated	L	L	L
ANT – TX1	L	L	H
ANT – TX2	L	H	L
ANT – TX1 and TX2[1]	L	H	H
ANT – RX	H	L	L
ANT – TX3	H	L	H
ANT – TX4	H	H	L
ANT – TX3 and TX4[1]	H	H	H

Note: In a 2TX–1RX SP3T configuration, TX1 and TX2 are tied and TX3 and TX4 are tied respectively.

PE42850 Performance as an SP3T

Simulation results for the SP3T case:

Figures 2–4 show circuits used to simulate SP3T performance in ADS. The first circuit (*Figure 2*) only includes the SP3T s-parameter (vector de-embedded DUT-only) file. The 2nd circuit (*Figure 3*) includes the SP3T s-parameter file and an ADS Microstrip Transmission line (TL), modeled after Peregrine's PE42850 evaluation board's thin trace, with a length of 250 mil. The 3rd circuit (*Figure 4*) includes the SP3T s-parameter file and a 3.6 nH lumped inductor model from Coilcraft. *Figure 5* shows the simulated TX insertion losses of the aforementioned three cases. The matching is observed to significantly reduce the insertion loss, especially at higher frequencies. There is also a significant improvement in the return loss, as shown in *Figure 6*.

Comparable performance improvement is obtained by using either the inductor or TL match.

Figure 2. DUT Only

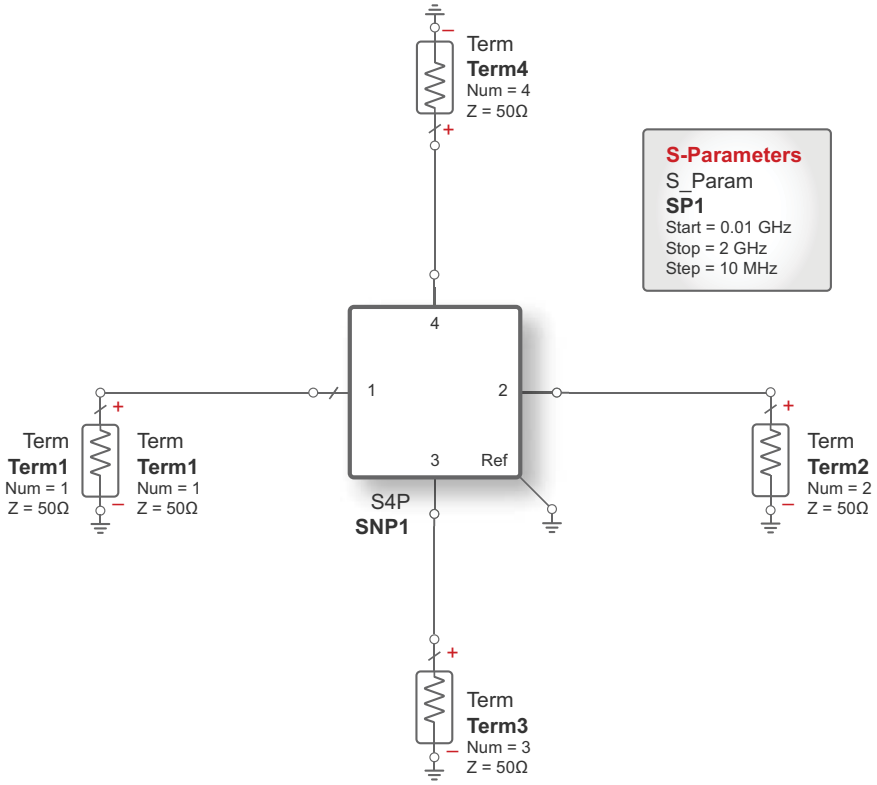


Figure 3. DUT + TL Matching

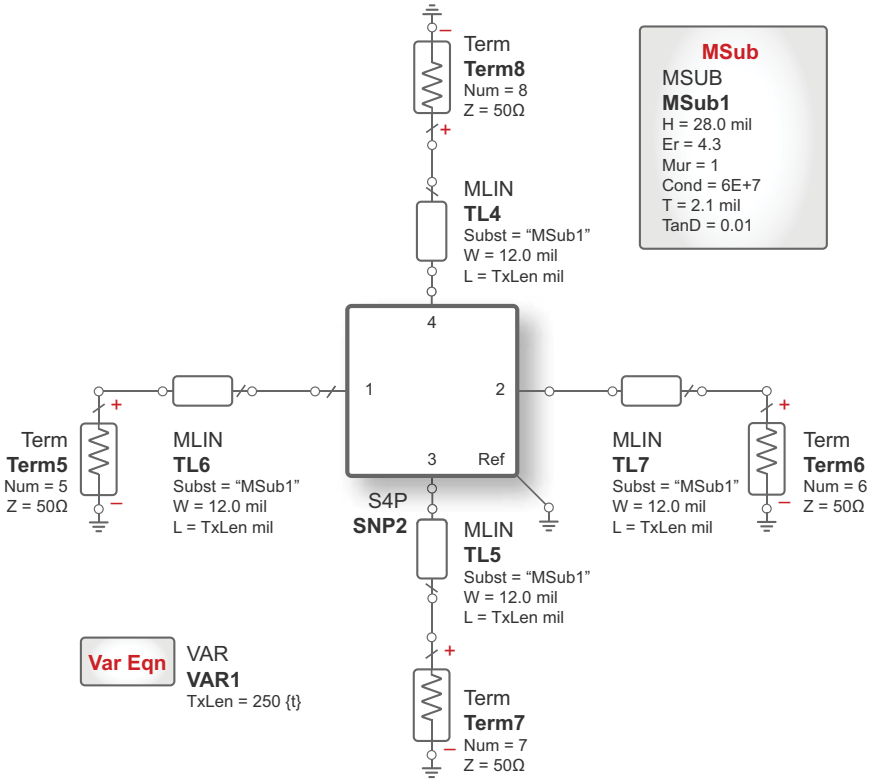


Figure 4. DUT + Lumped Inductance Matching

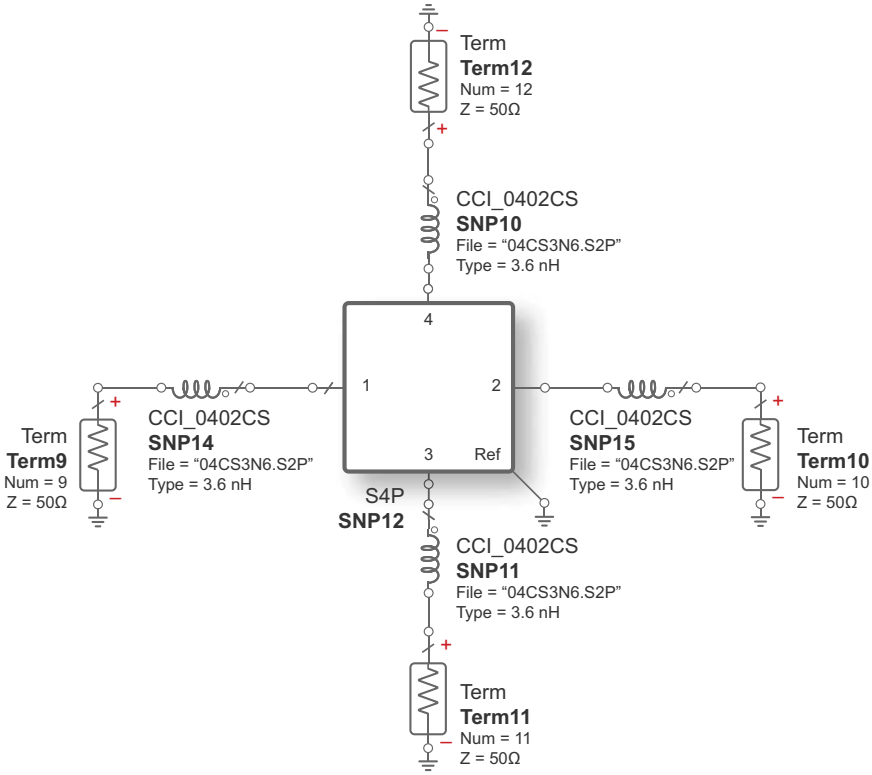


Figure 5. Insertion Loss

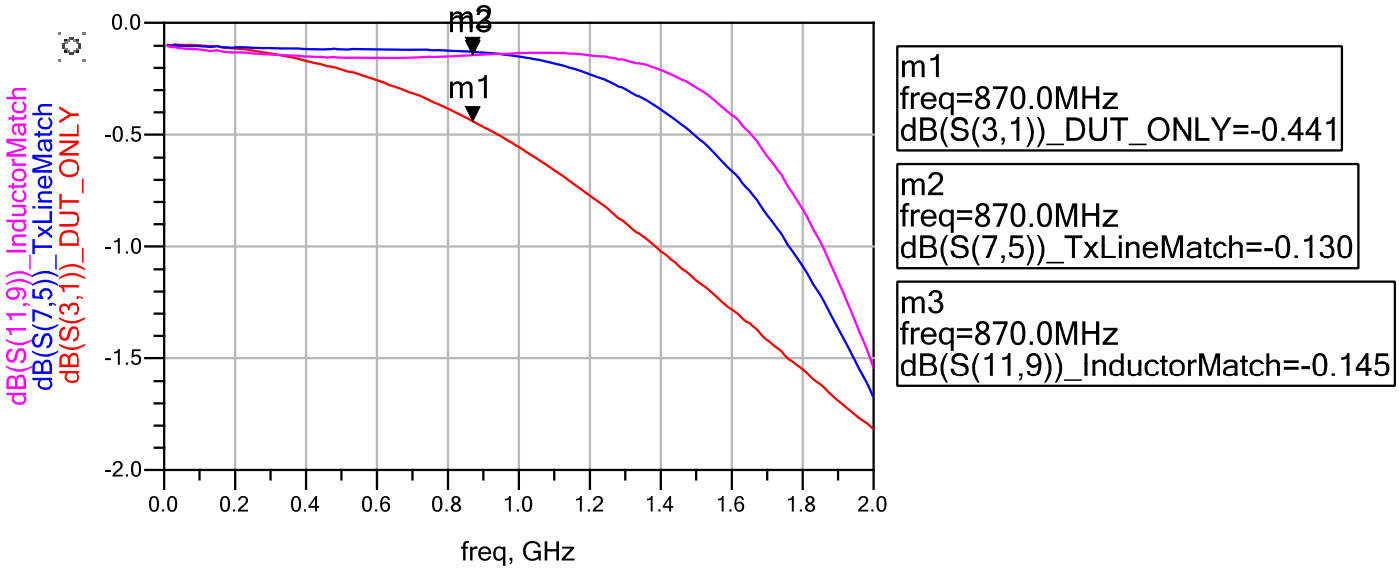
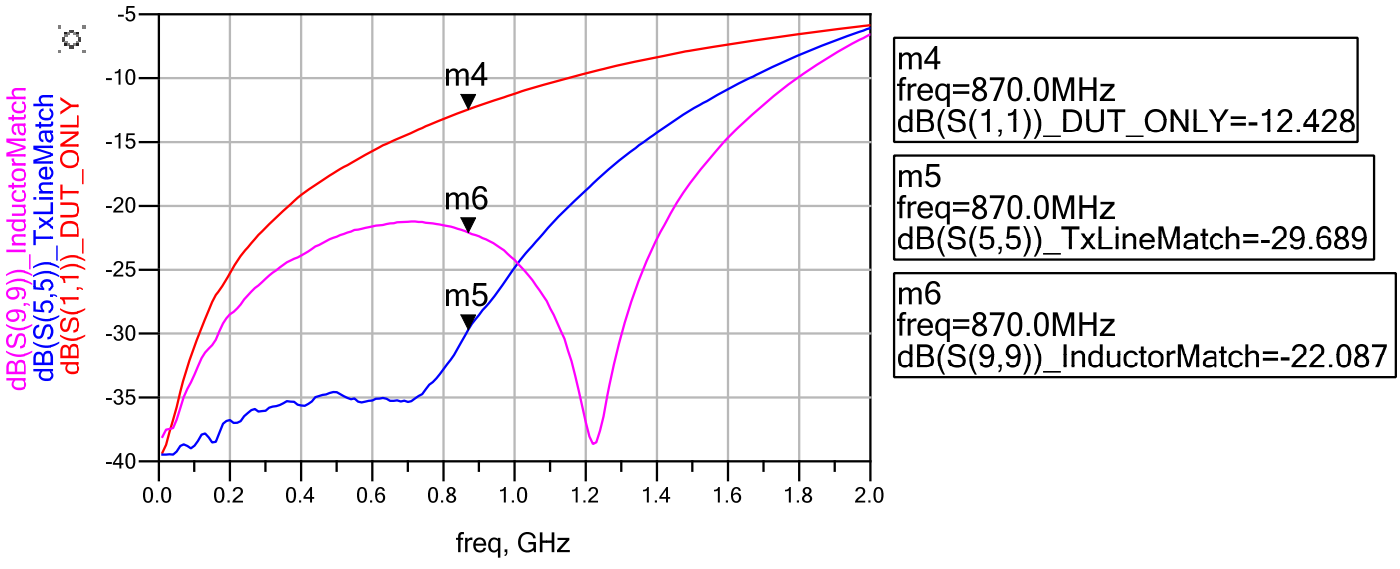


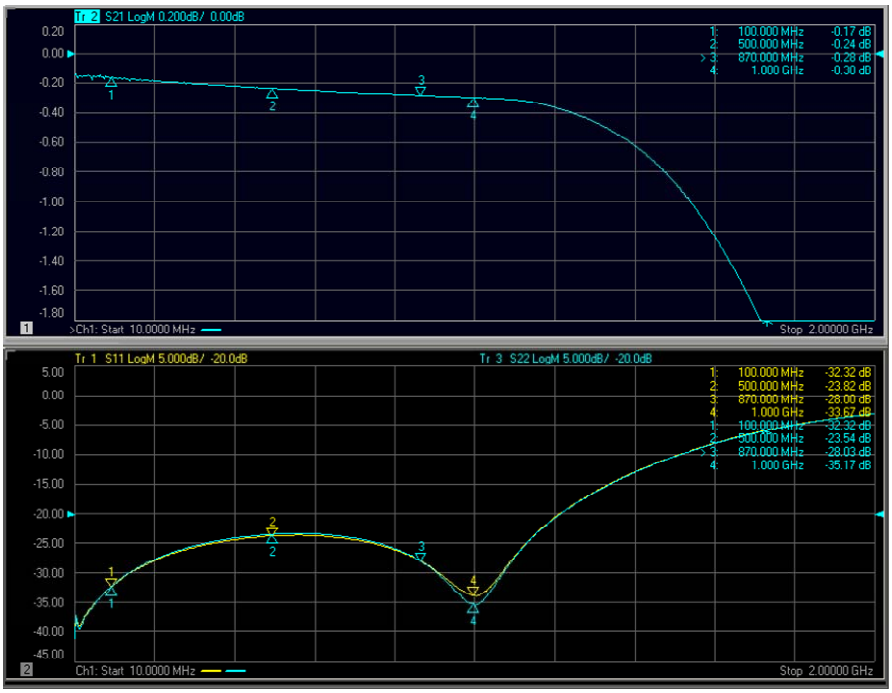
Figure 6. Return Loss



Measured SP3T Performance with Inductor Match

Figure 7 shows the measured results for the SP3T with L = 3.6 nH when ANT to TX1 and TX2 is ON. The inductor is in an 0402 package. At 870 MHz, insertion loss = 0.28 dB and return loss is around 28 dB. Although the measured insertion loss with the discrete inductor match is higher than the simulated result, it still results in a significant improvement over the SP5T case (see “Simulation and Measurement for SP5T Configuration”).

Figure 7. Measured IL and RL (TX Port)



Simulation and Measurement for SP5T Configuration

Simulation results for SP5T case:

Figures 8–10 show circuits used to simulate SP5T performance in ADS. The methodology used here is very similar to the SP3T case. The value of the matching inductor however is reduced to 2.4 nH (and alternatively the TL length is 200 mil, exactly as in the PE42850 EVB). *Figure 11* shows the TX insertion loss of the three cases. Again, the matching is observed to significantly reduce insertion loss, especially at higher frequencies. This is accompanied by a significant improvement in the return loss, as shown in *Figure 12*.

As before, comparable performance is obtained by using either the inductor or TL match.

Figure 8. DUT Only

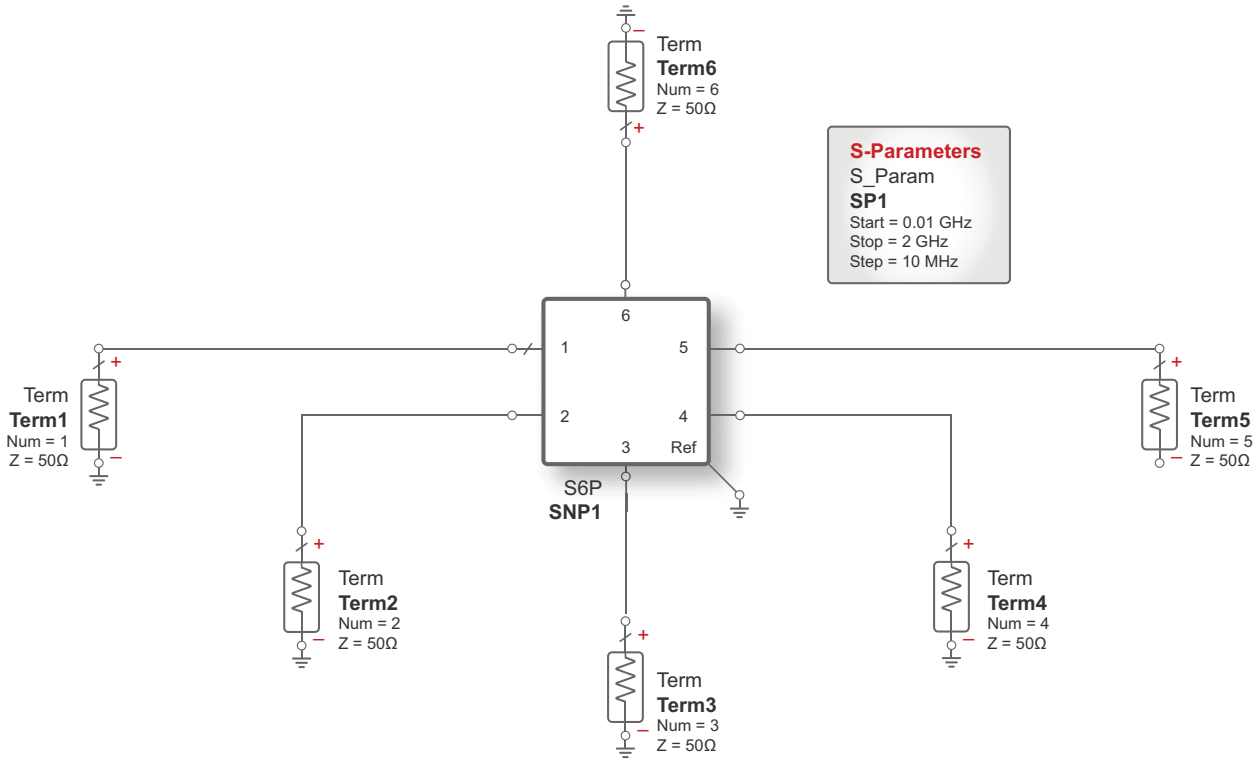


Figure 9. DUT + TL Match

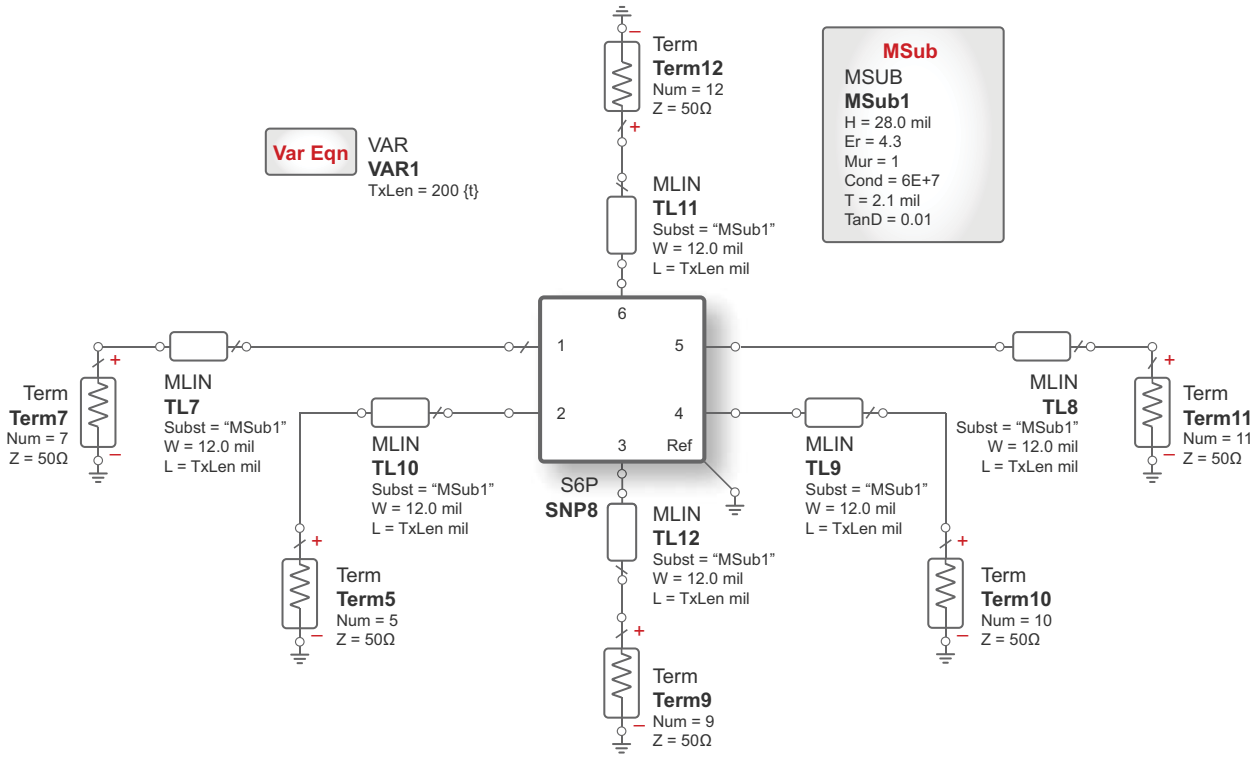


Figure 10. DUT + Lumped Inductance Match

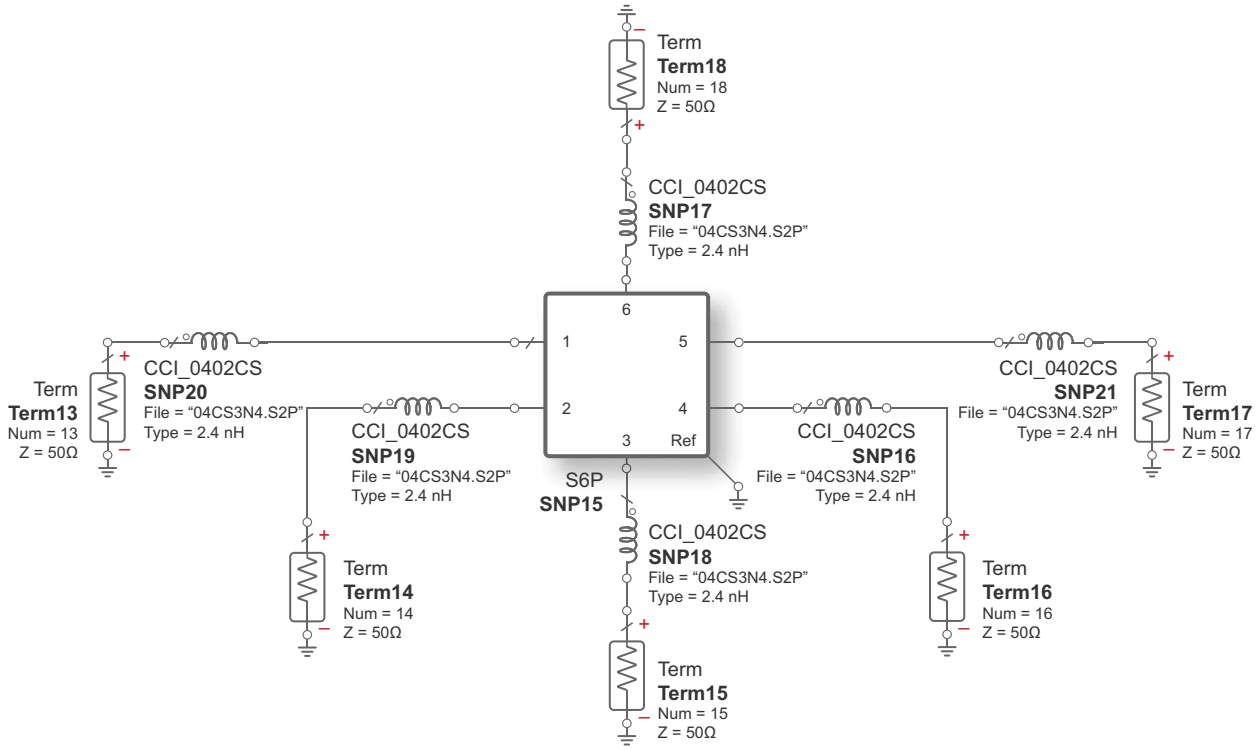


Figure 11. Insertion Loss

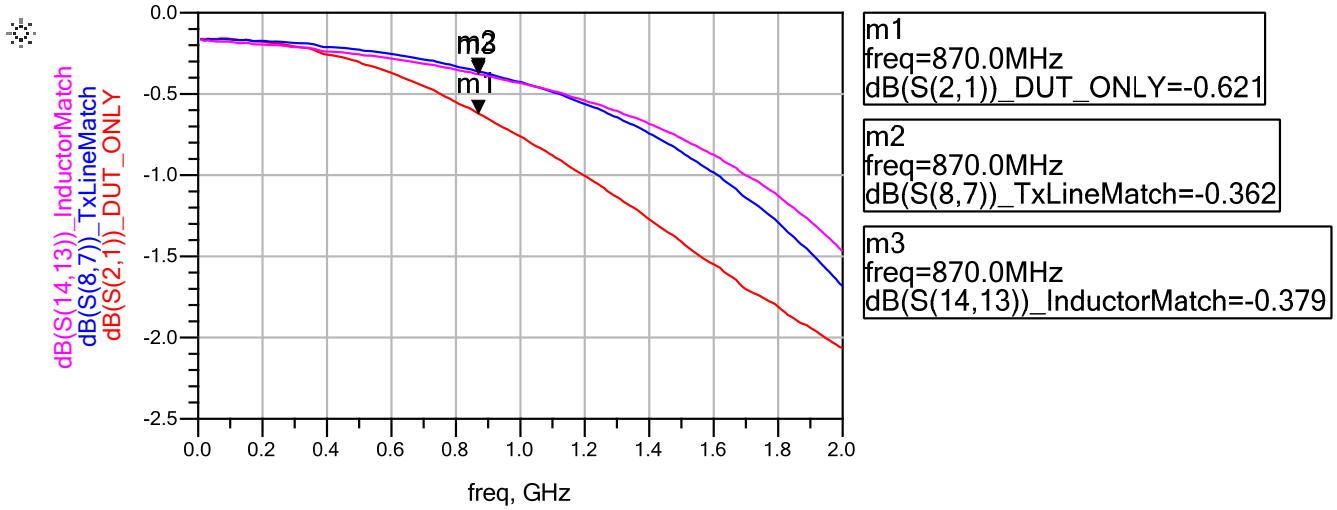


Figure 12. Return Loss

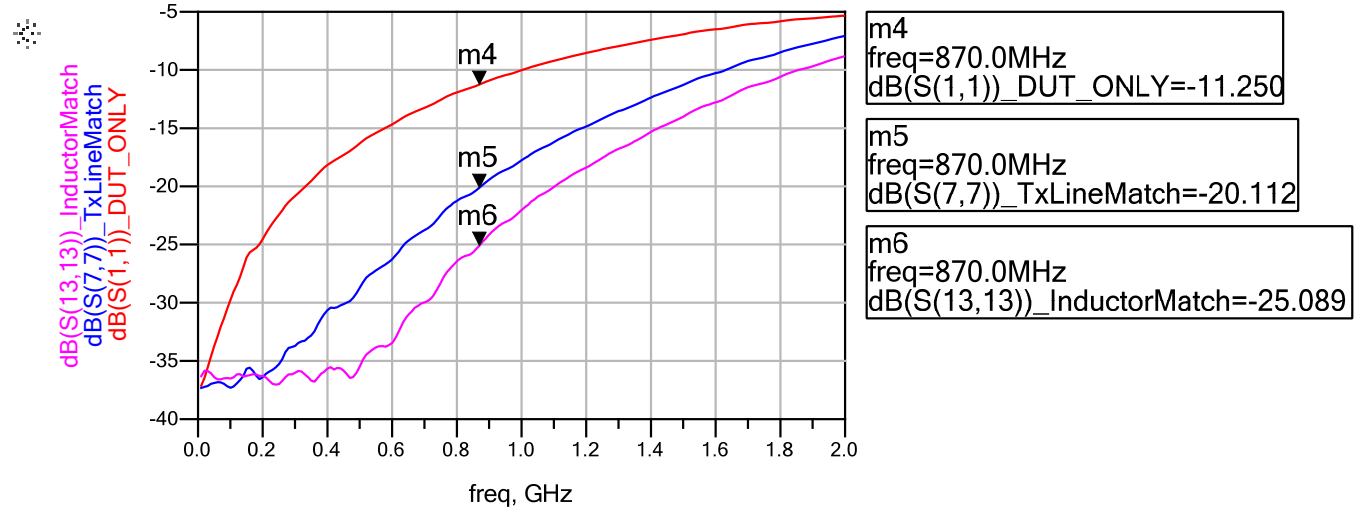


Figure 13 shows the measured results for SP5T with L = 2.4 nH at ANT and TX2. The inductor is in an 0402 package. At 870 MHz, insertion loss = 0.38 dB and return loss is around 20 dB. The measured insertion loss with a discrete inductor match is quite close to the simulated data.

Figure 13. Measured IL and RL (TX Port)

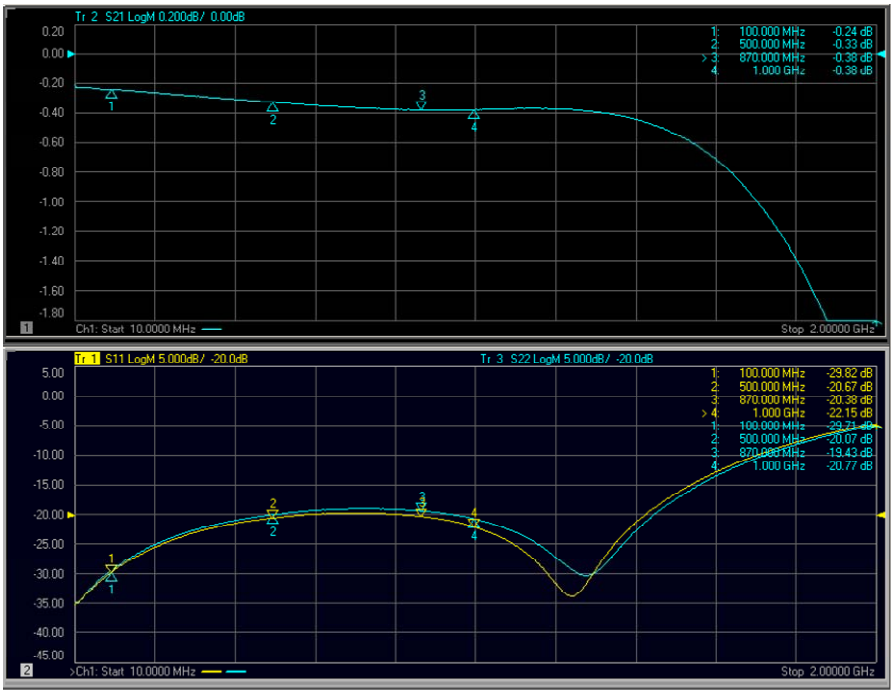
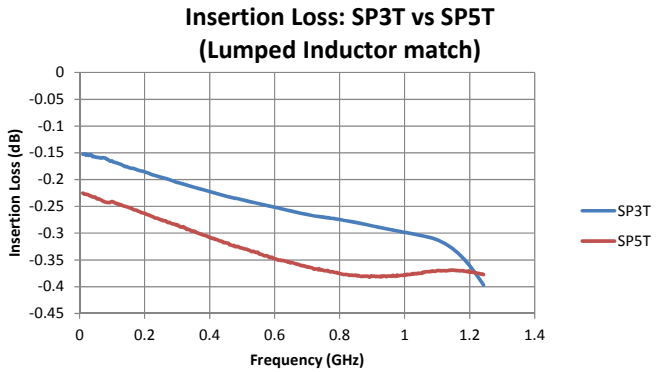
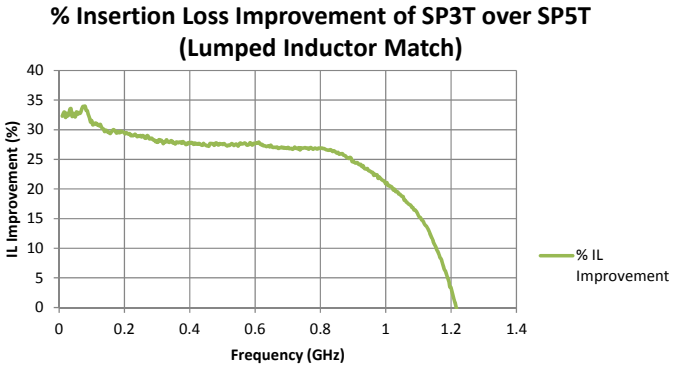


Figure 14 shows an overlay comparison of TX insertion losses obtained in both the SP3T and SP5T setup, and highlights the improvement of the matched SP3T over the matched SP5T. As can be seen, it is possible to obtain better than 25% improvement over the band by using the modified layout and matching of the SP3T configuration. While this measured data is specific to a lumped match, similar improvement is also seen with the distributed match.

Figure 14. Measured IL (SP3T vs. SP5T)





Conclusion

This application note provides information on how to configure PE42850 as an SP3T or SP5T switch. Its performance is optimized by providing inductive matching of a distributed or lumped element type. As an SP3T switch, further TX insertion loss improvement can be realized by some circuit modification around the RF pins, coupled with alternative control logic options already provided in the datasheet. In the modified SP3T configuration, we see a >25% improvement in insertion loss compared to the SP5T configuration.