Peregrine Semiconductor

Digital Step Attenuators for Microwave Applications

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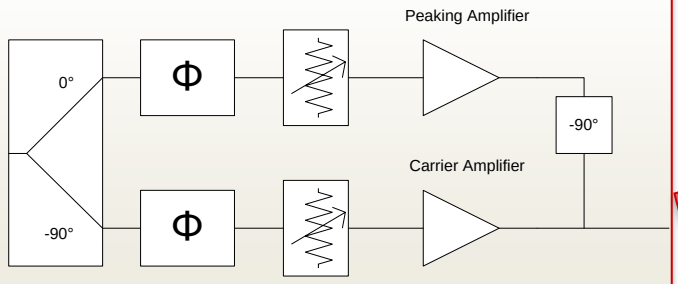
Topics

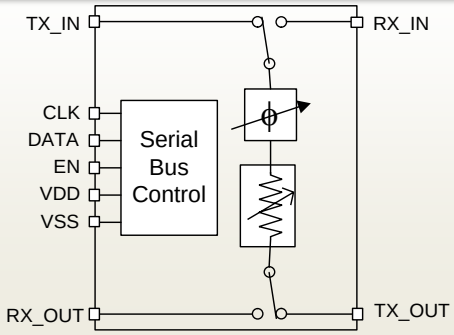
- Space Applications for Digital Step Attenuators (DSA)
- Commercial DSA performance state of the art
- Limitations of Existing DSAs
- What causes these limitations?
- How can we improve performance?
- Conclusions

Space Applications for Microwave DSAs

Doherty Controller for Transponder

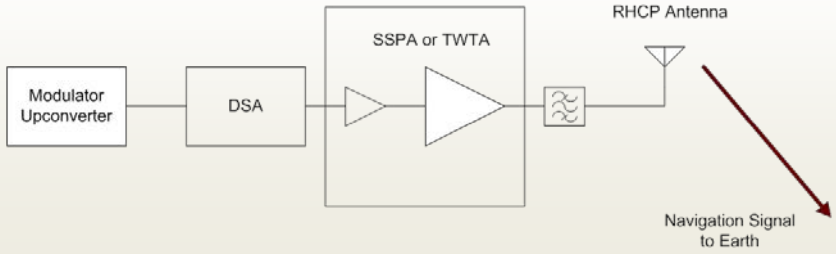


Core Chip for Phased Array/BFN



DSA

Galileo Navigation Satellite

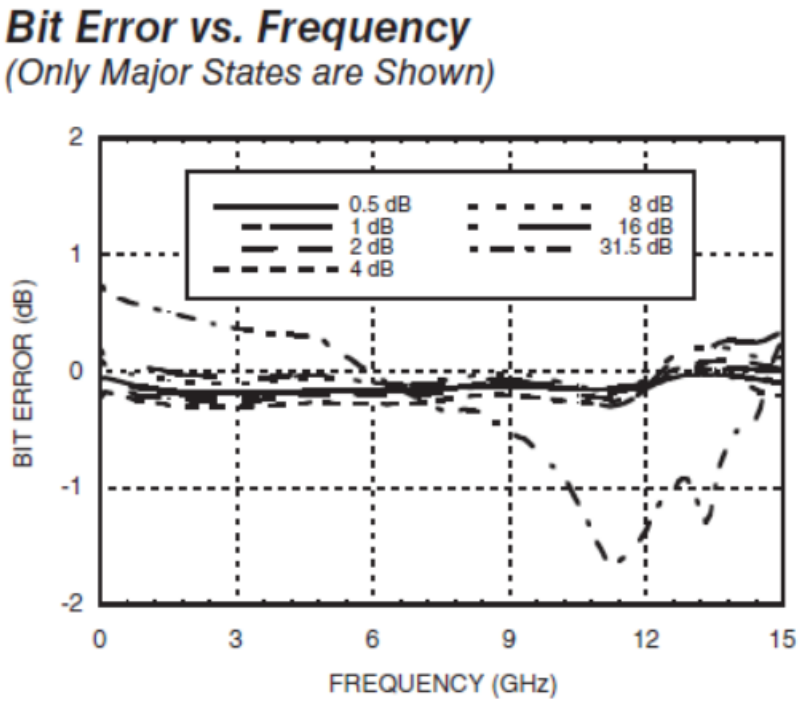


Commercial 6 GHz –How good are they?

Attenuation error	0 dB – 15.75 dB Attenuation settings	50 MHz – 2.2 GHz			+ (0.15 + 1.5% of attenuation setting) - (0.1 + 1% of attenuation setting)	dB dB
		>2.2 GHz – 4 GHz			+ (0.15 + 3% of attenuation setting) - (0.1 + 1% of attenuation setting)	dB dB
		>4 GHz – 6 GHz			+ (0.2 + 6% of attenuation setting) - (0.15 + 1% of attenuation setting)	dB dB
	16 dB – 31.75 dB Attenuation settings	50 MHz – 2.2 GHz			+ (0.15 + 1.5% attenuation Setting) - (0.1 + 1.5% of attenuation setting)	dB dB
		>2.2 GHz – 4 GHz			+ (0.15 + 4% attenuation Setting) - (0.1 + 0.75% of attenuation setting)	dB dB
		>4 GHz – 6 GHz			+ (0.25 + 7.5% of attenuation setting) - (0.2 + 0% of attenuation setting)	dB dB

- PE43705
- Typically performance quoted at <2.2GHz
- Plastic QFN Package

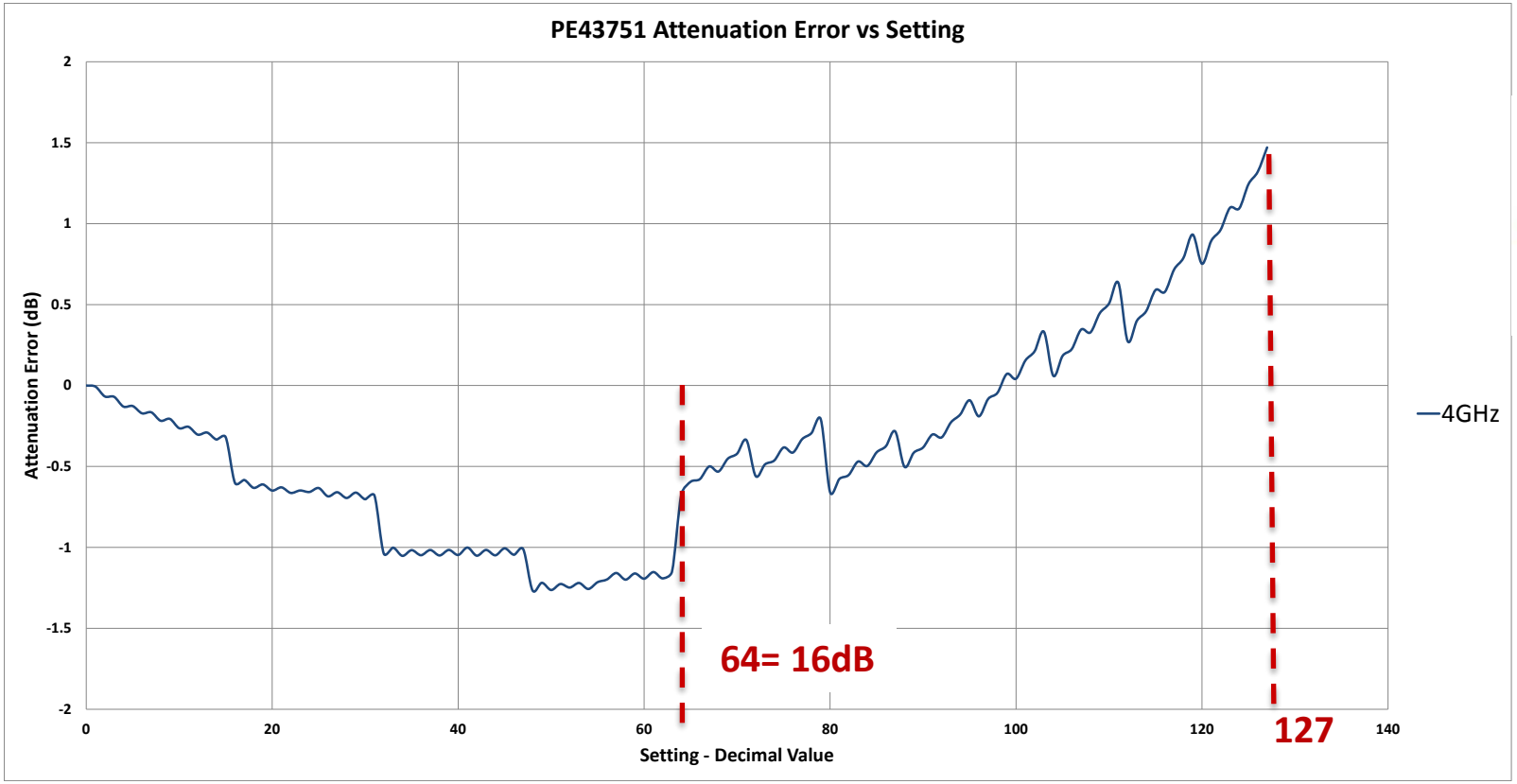
Commercial 13 GHz – How good are they?



Attenuation Accuracy: (Referenced to Insertion Loss)			
	0.5 - 16.5 dB States	DC - 13.0 GHz	± 0.4 + 4% of Atten. Setting Max	dB
	17 - 31.5 dB States	DC - 13.0 GHz	± 0.5 + 5% of Atten. Setting Max	dB

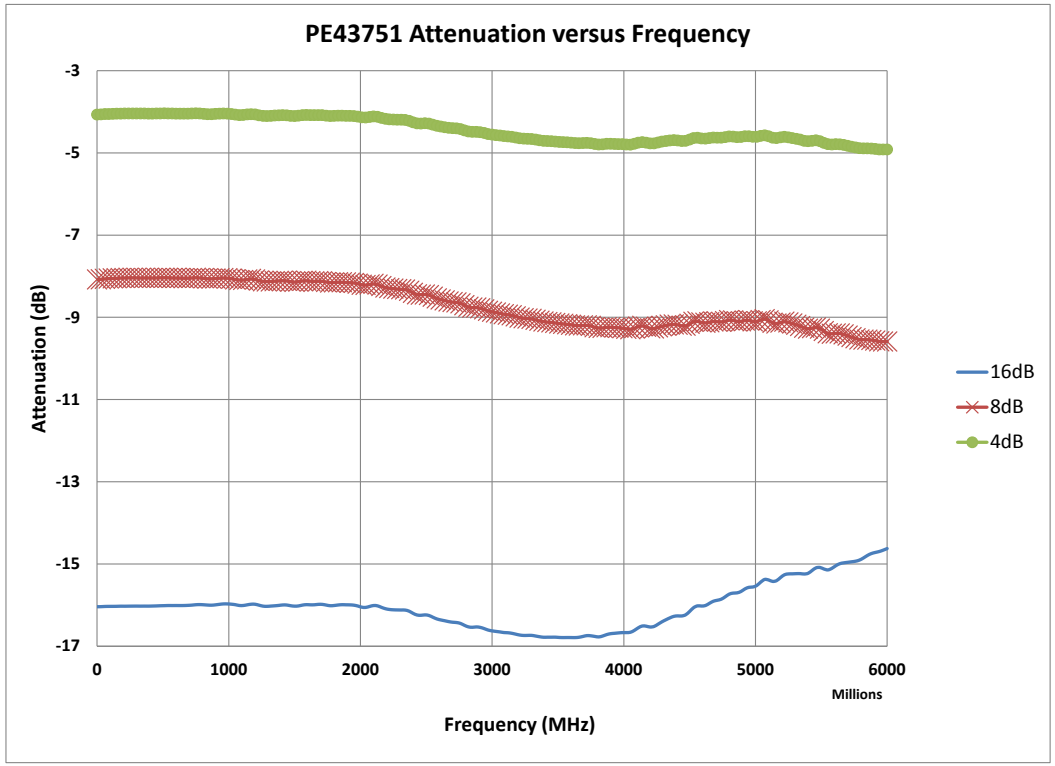
- HMC424LH5
- Ceramic Lead-less package

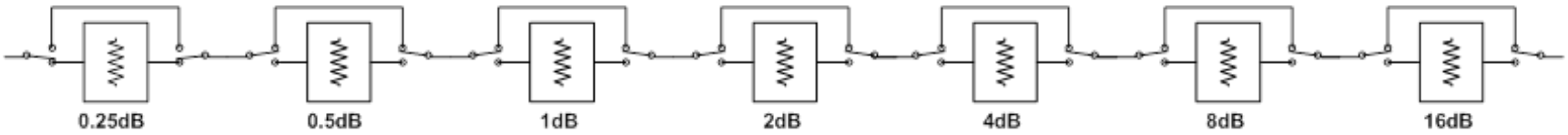
ESA Space Qualified DSA - Limitations



- **PE43751**
  - 31.75dB Attenuation
  - 0.25dB steps
  - 30kHz – 6GHz
  - Ceramic, hermetic package

PE43751 - Individual Attenuator Limitations

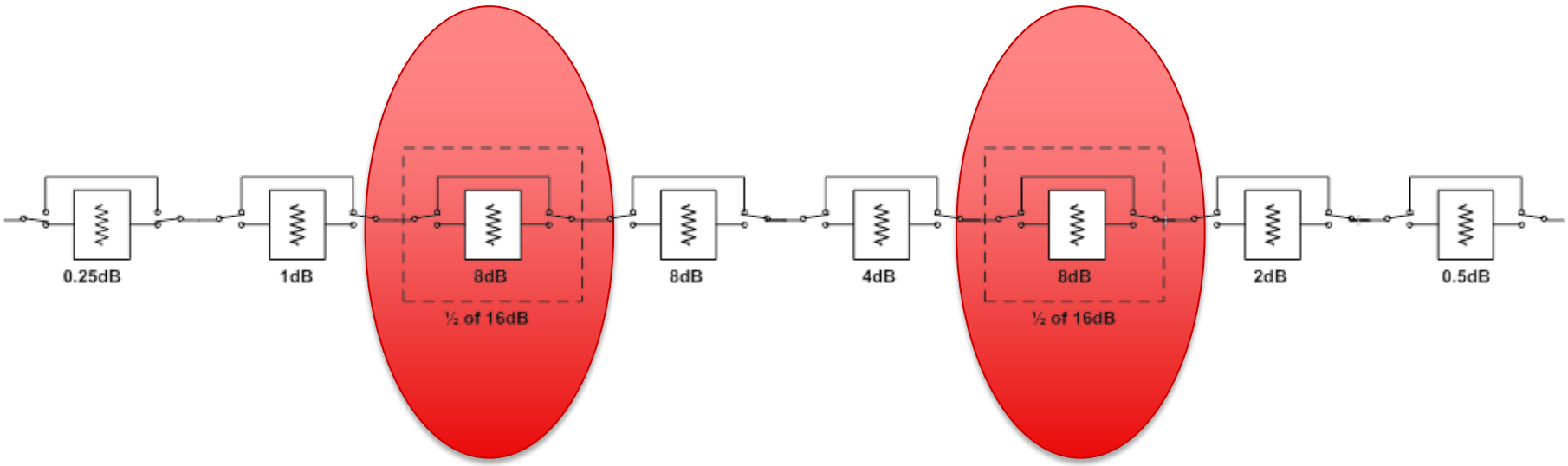




- 4dB and 8dB exhibit similar behaviour – WHAT CAUSES THIS?
- 16dB exhibits different frequency response – WHY?

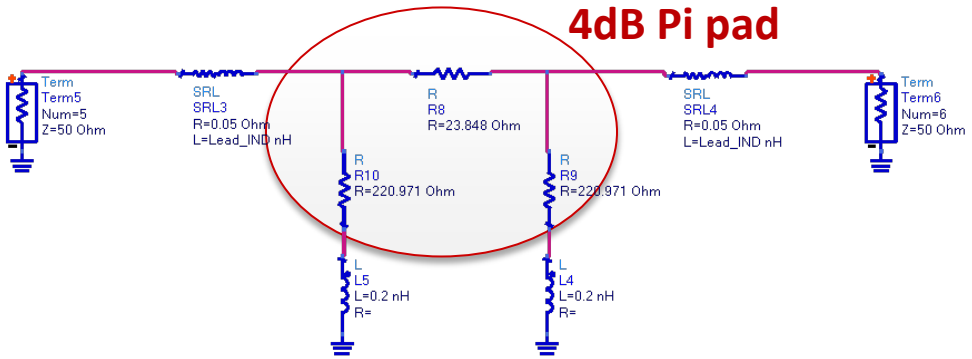
Improving Isolation – 16dB attenuator

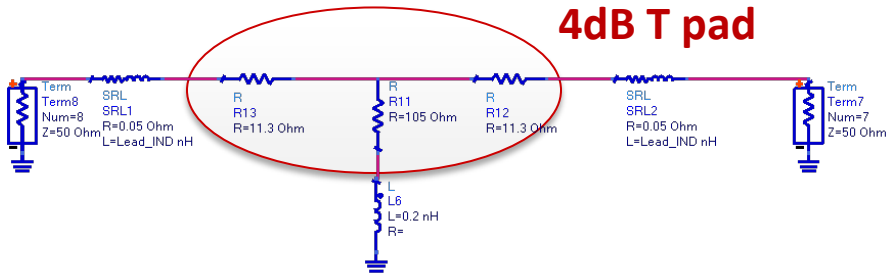
Splitting Larger Attenuators into 2 Smaller Attenuators

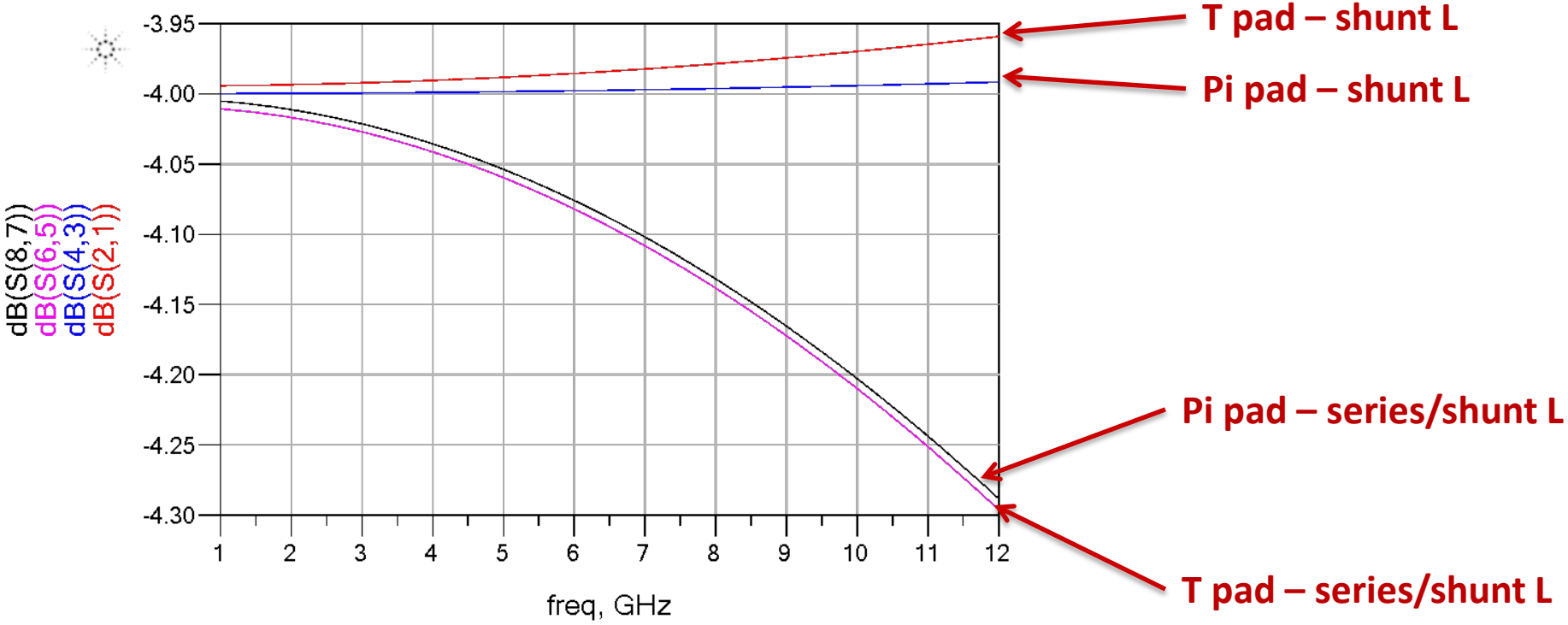


8dB + 8dB = 16dB

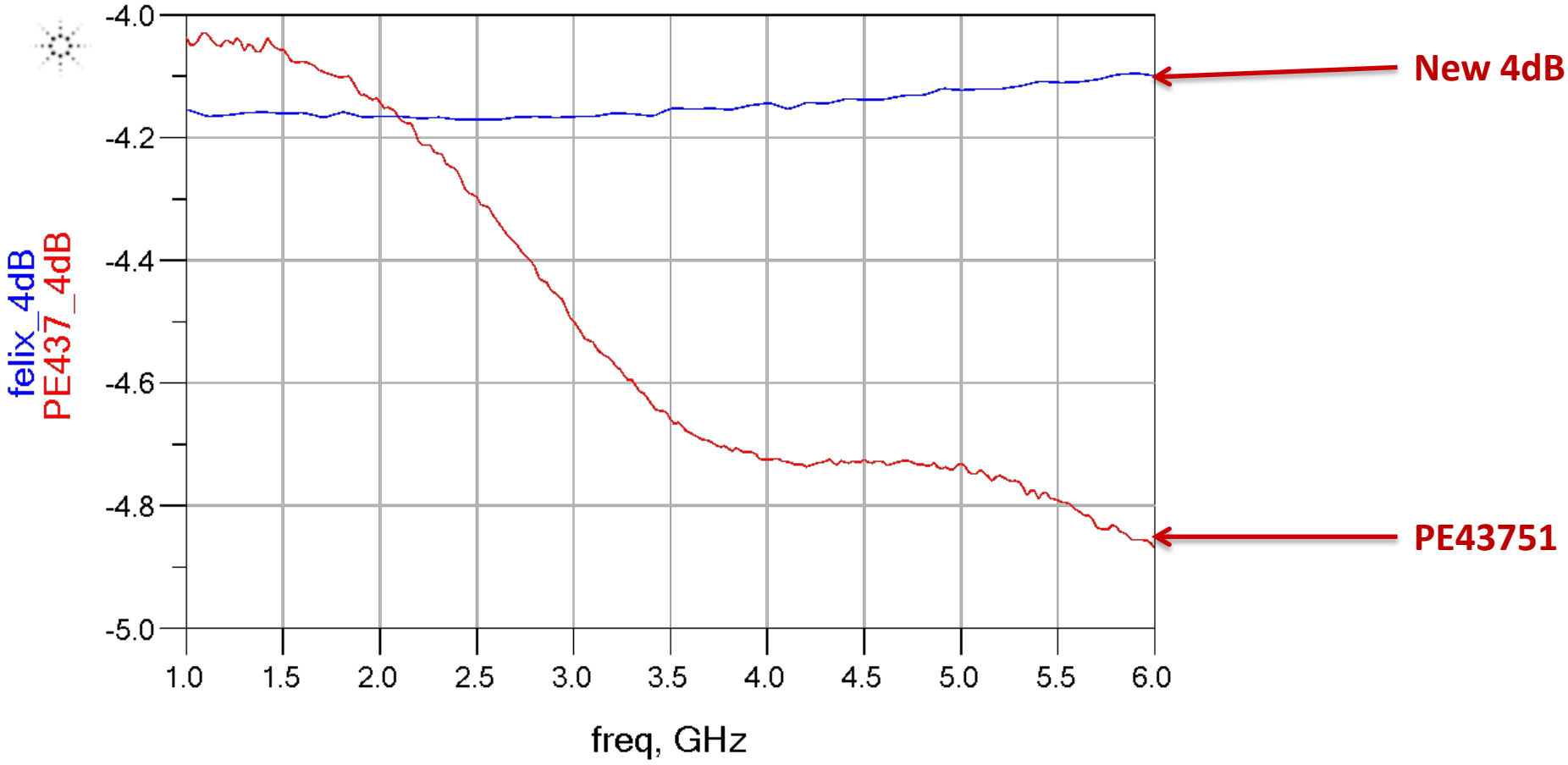
What Causes Frequency Slope – Example 4dB





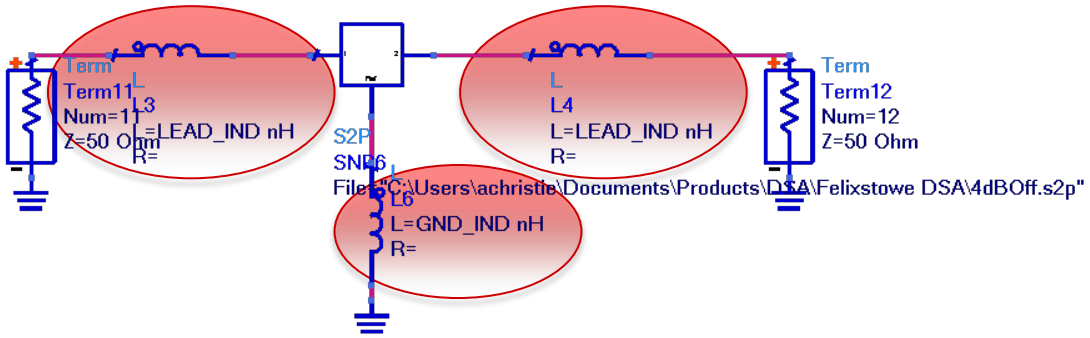


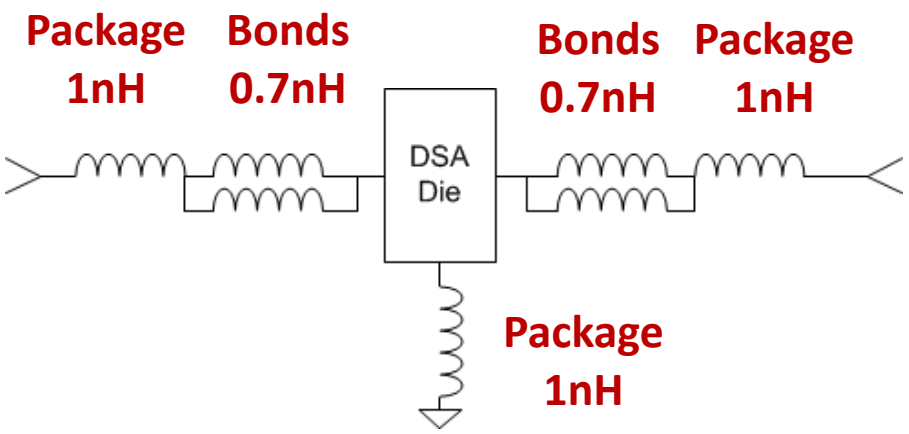
Improved 4dB Attenuator

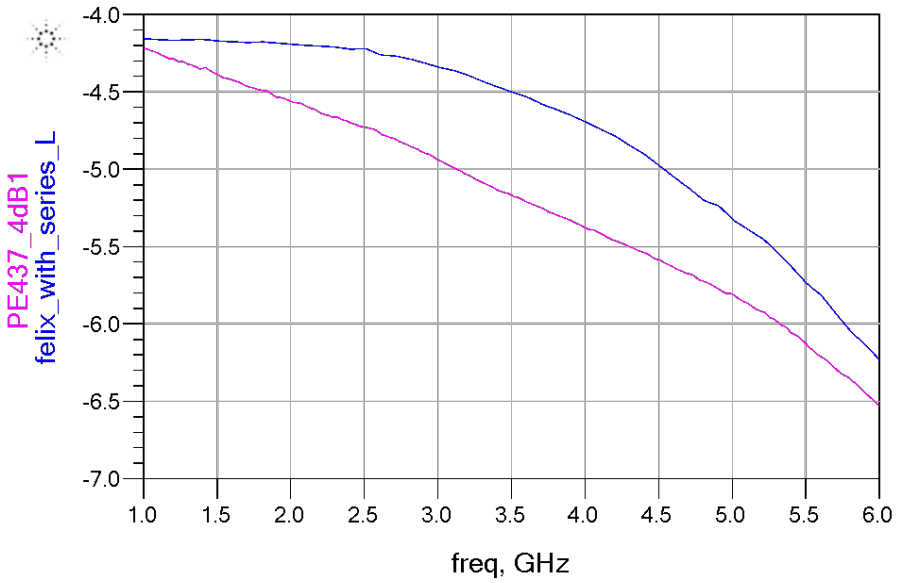


- 4dB attenuator on carrier with ground bonds. Die probed (G-S-G)

Effect of CQFP Lead Inductance on New 4dB

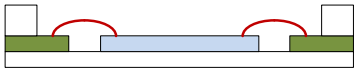




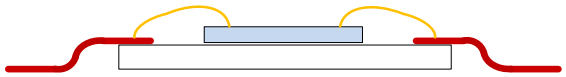


- LEAD_IND=1.7nH
- GND_IND=1nH

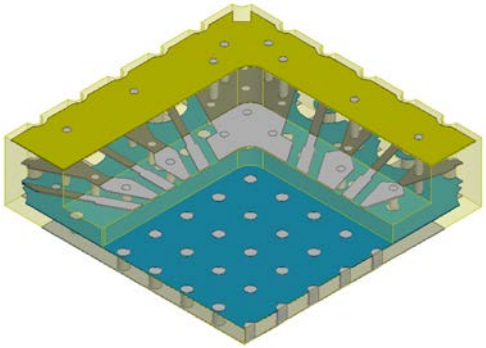
Benefits of Improved package on 4dB Attenuator



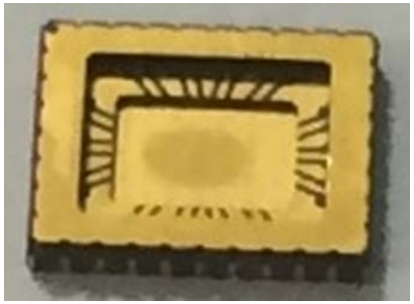
Die Shelf

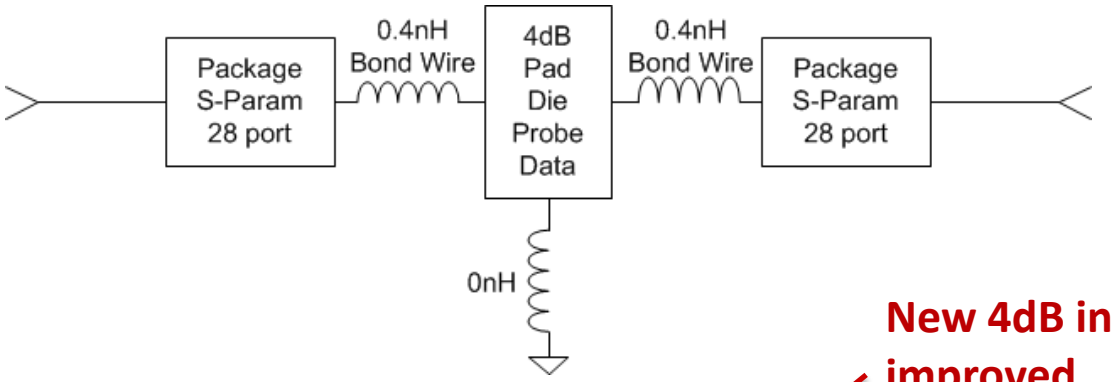


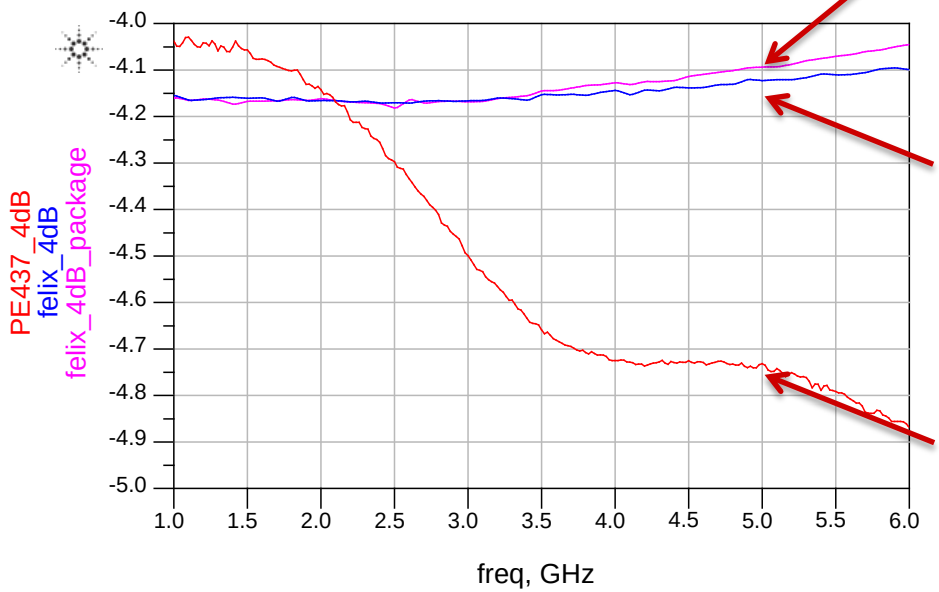
+ CPW Transition



= Microwave Package







New 4dB in improved package

New 4dB die probe

PE43751 4dB Atten.

Conclusions

- Partitioning is critical for Microwave DSAs
  - Use several Smaller attenuators instead of one large attenuator
  - Separating larger attenuators with smaller value attenuators
- Package selection and series inductance reduction is key
  - Important to minimize series and ground inductance
    - Series inductance has largest impact
  - True microwave packaging techniques can assist
    - CPW structures
- This is before we even design a single switch or attenuator!

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Thank You

NASDAQ: PSMI

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