# SLOTTED HEART-SHAPED 4.77DB MICROSTRIP COUPLER

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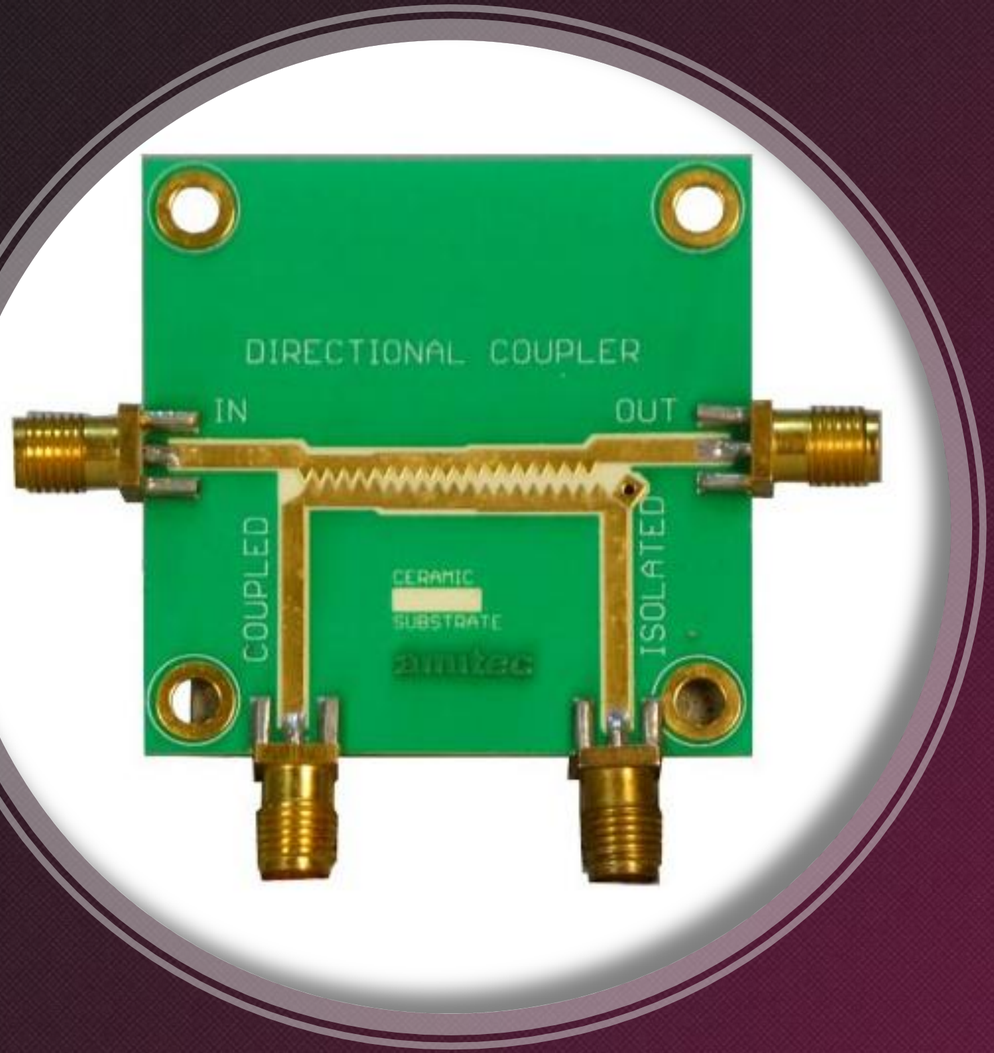
# Background

# BACKGROUND




## MICROSTRIP DIRECTIONAL COUPLER

Widely used in microwave applications, because of their manufacturability, repeatability, low cost, etc. The design procedure depends on the knowledge of the physical geometry of the directional coupler. [1]

Also, a directional coupler is capable of adding or separating microwave signals, and is desired to possess strong coupling and high directivity properties to strengthen the signal, and to reduce noise. [2]

Pictured: Microstrip Directional Coupler by amitec. [3]

[1] T. Jayanthy and S. Maheswari, "Design and simulation of Microstrip directional coupler," 2008 *International Conference on Recent Advances in Microwave Theory and Applications*, Jaipur, 2008, pp. 782-783, doi: 10.1109/AMTA.2008.4763085.

[2] B. Yaduvanshi and D. Bhatia, "Stub-Based Design of Coupled Line Directional Couplers," *2016 International Conference on Micro-Electronics and Telecommunication Engineering (ICMETE)*, Ghaziabad, 2016, pp. 13-17, doi: 10.1109/ICMETE.2016.22.

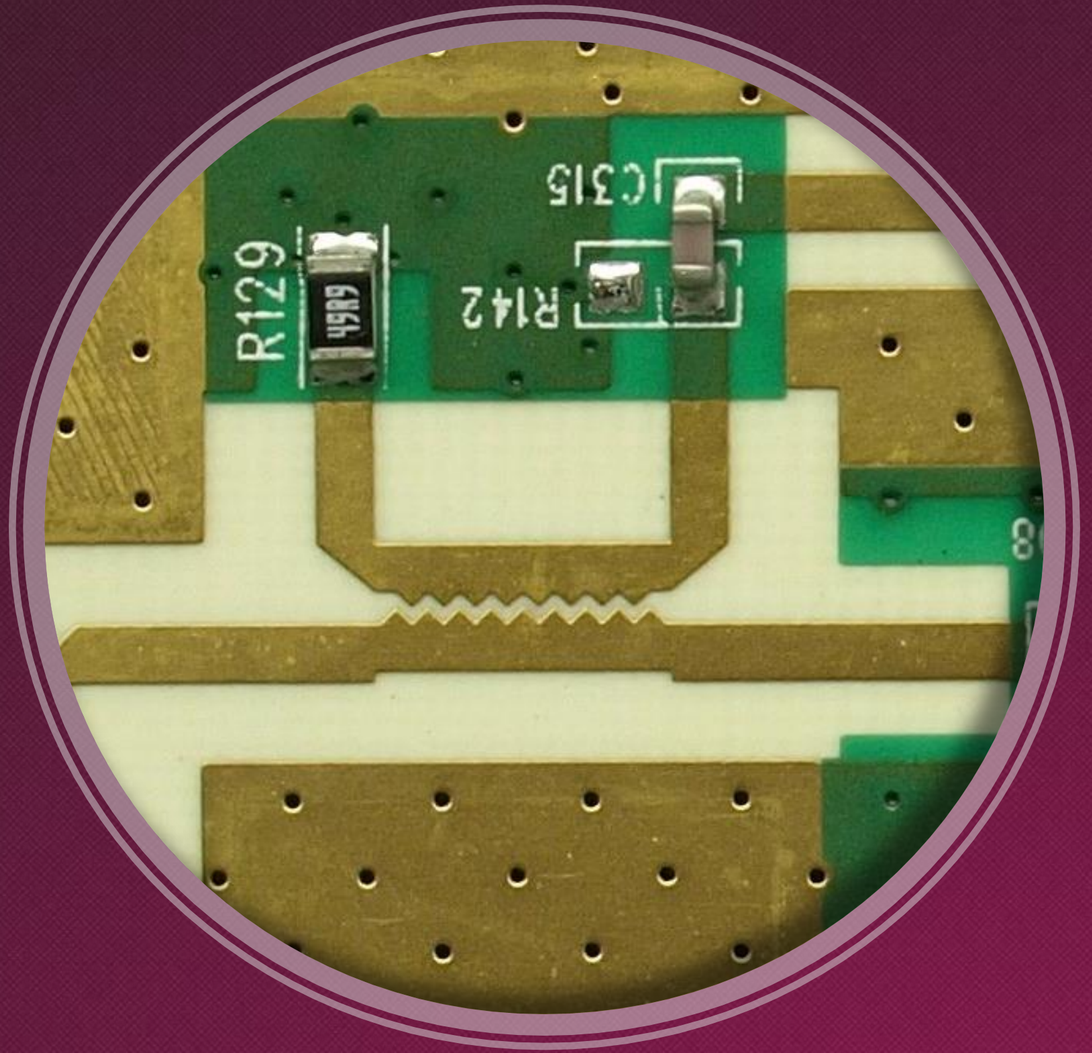
[3] amitec, "Microstrip Directional Coupler," 12 July 2018. [Online]. Available:. *https://amitec.co/microstrip-directional-coupler*. [Accessed 10 September 2020].

# Introduction

# INTRODUCTION

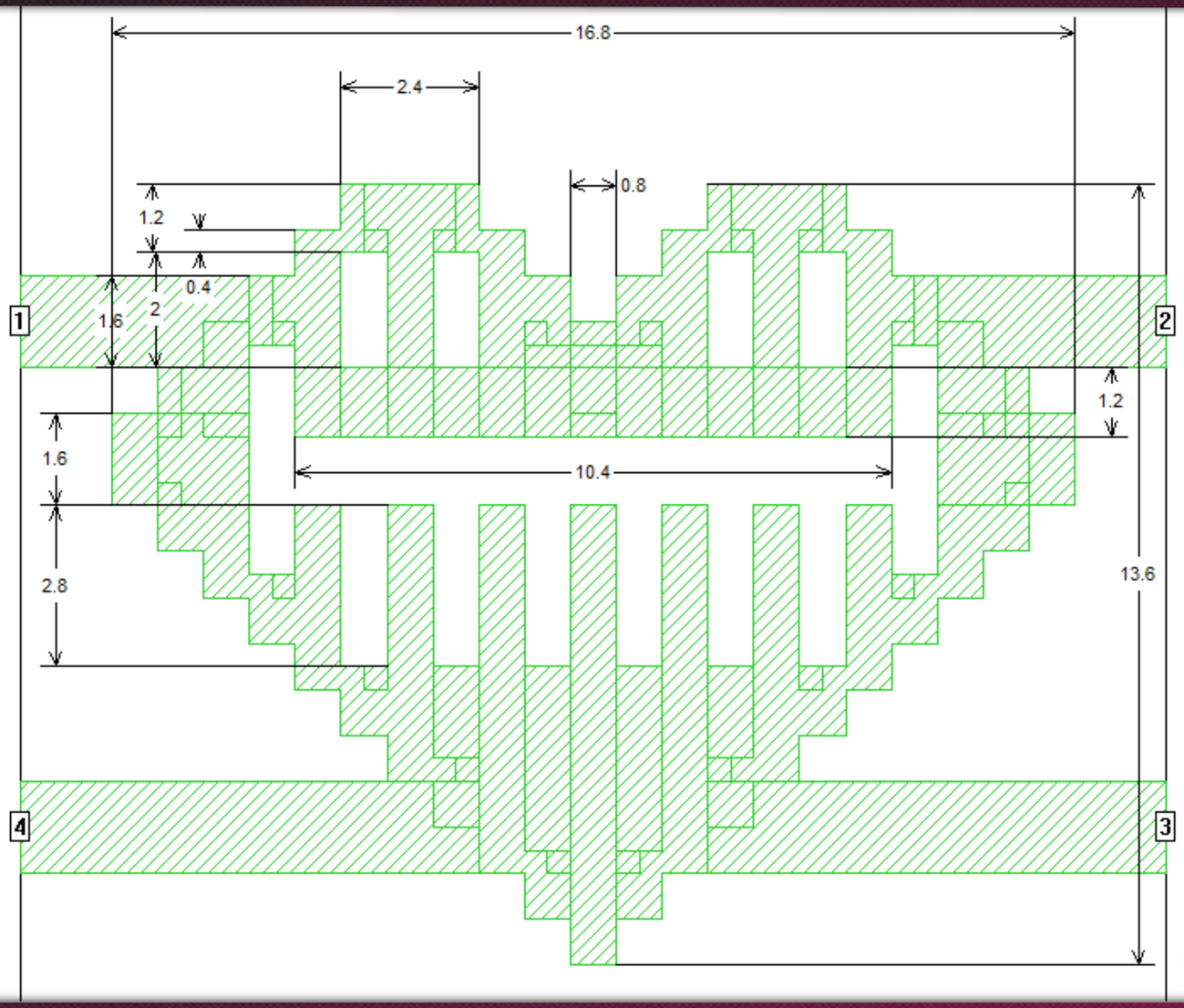
Microstrip couplers are very important elements in many microwave circuits, such as balanced amplifiers and data modulators.
Among those, the most popular ones are starting with 3dB, 4.77dB, 6.02dB, 10dB, 20dB [4], and 30dB.
There are different types of structures in the industry for different applications [5], such as a 3-way power divider, which can be achieved when a 4.8dB coupler and 3dB hybrid are cascaded.

Pictured: Microstrip Sawtooth Directional Coupler. [6]



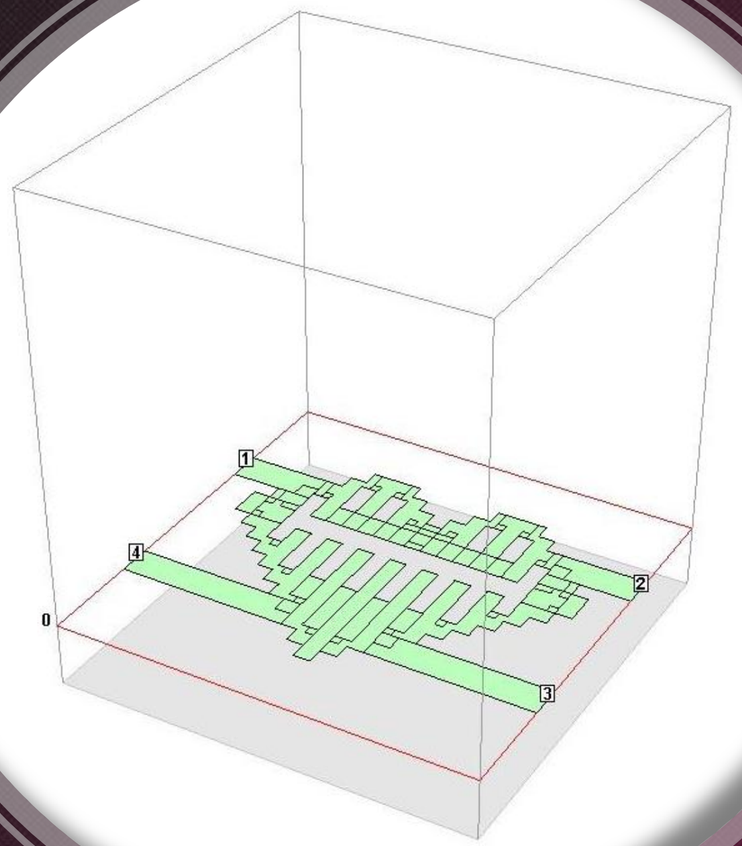

[4] T.P. Budka, and R.A. Flynt, “Alignment tolerant stripline directional couplers“, IEEE MTT-S Digest, 1997.
[5] S.T. Imeci, K.S. Bayram, A.Z. Zeytinoglu, “20-dB hybrid stripline coupler“, ACES Conference Finland, April 2010.
[6] Binarysequence, "Power dividers and directional couplers," 21 June 2016. [Online]. Available: *https://en.wikipedia.org/wiki/Power_dividers_and_directional_couplers*. [Accessed 10 September 2020].

# Design PROCEDURE




Top view and the dimensions of the Slotted Heart-shaped Microstrip coupler (in millimeters)

# Design PROCEDURE




## THE COUPLER DATA

The circuit with 0.3mm thick **copper** metal is made on top of a dielectric **RO4350B**, with the thickness of 3mm, and the dielectric constant $\varepsilon_r$ of 3.36.

The dielectric above the circuit is **air**, whose thickness is more than three times the thickness of the dielectric below (which is 20mm).

Simulations were made using the **Sonnet Software**.

The total circuit box size is 20mm by 20mm by 23mm.

Pictured: A 3d view of the coupler.

# Parametric STUDY

| Stubs' length (mm) | Amplitude balance (dB) |
|---|---|
| 2.5 | 0.621 |
| 2.6 | 0.512 |
| 2.7 | 0.496 |
| 2.8 (original) | 0.472 |
| 2.9 | 0.448 |
| 3.0 | 0.380 |
| 3.1 | 0.669 |

| Slots' length (mm) | Amplitude balance (dB) |
|---|---|
| 2.5 | 0.461 |
| 2.6 | 0.468 |
| 2.7 | 0.472 |
| 2.8 (original) | 0.472 |
| 2.9 | 0.480 |
| 3.0 | 0.484 |
| 3.1 | 0.488 |

Parametric study was done by increasing and decreasing all stubs/slots simultaneously, each time by 0.1mm up to 0.3mm.

# Parametric STUDY

| Stubs' length (mm) | Amplitude balance (dB) |
|---|---|
| 2.5 | 0.621 |
| 2.6 | 0.512 |
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| 2.8 (original) | 0.472 |
| 2.9 | 0.448 |
| 3.0 | 0.380 |
| 3.1 | 0.669 |

## CHANGING STUBS‘ LENGTH

- 1st two increases -> amplitude balance **decreases**.
- 3rd increase -> amplitude balance significantly **increases**. (+1.972dB)
- By each stub‘s increase, highest reflection **increases** a bit. (+0.064dB total)
- Decreasing the stubs‘ length three times by 0.1mm, each time the amplitude balance has risen, +0.3mm yield +0.149dB in amplitude balance.
- The highest reflection for each stubs‘ decrease got lower. (-0.031dB in total)
- Original stub length -> most reliable results, but a slight change won‘t affect the coupling.

# Parametric STUDY

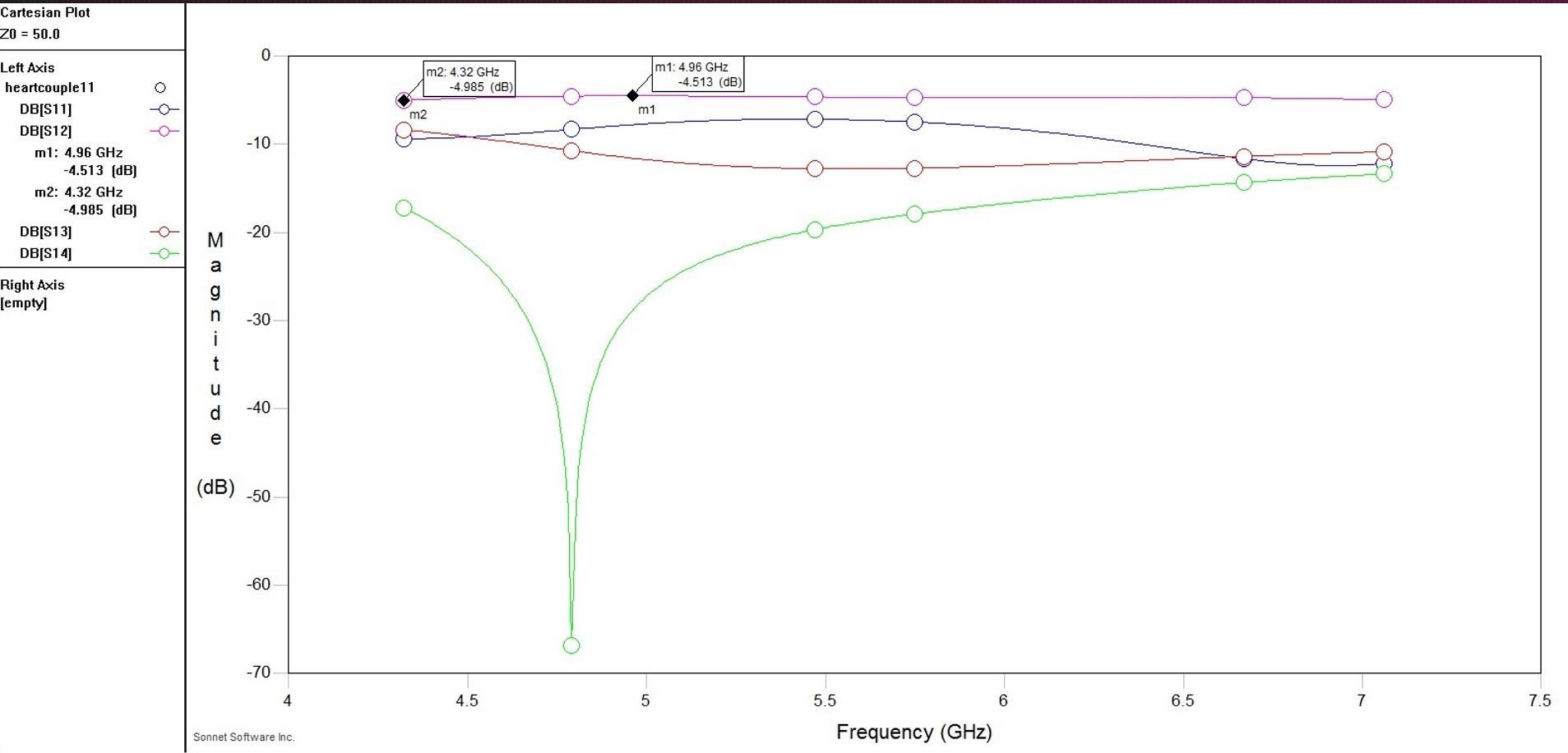
## CHANGING SLOTS‘ LENGTH

- For increasing slots‘ length three times by 0.1mm, the amplitude balance **increases** insignificantly (+0.016dB), while the highest reflection change is negligible. (+0.006dB)
- For decreasing slots‘ length three times by 0.1mm, the amplitude balance inconsiderately **decreases** (-0.011dB), while the highest reflection change is hardly noticeable. (-0.016dB)
- Therefore, the change in slots‘ length doesn‘t consequently alter the coupling process.

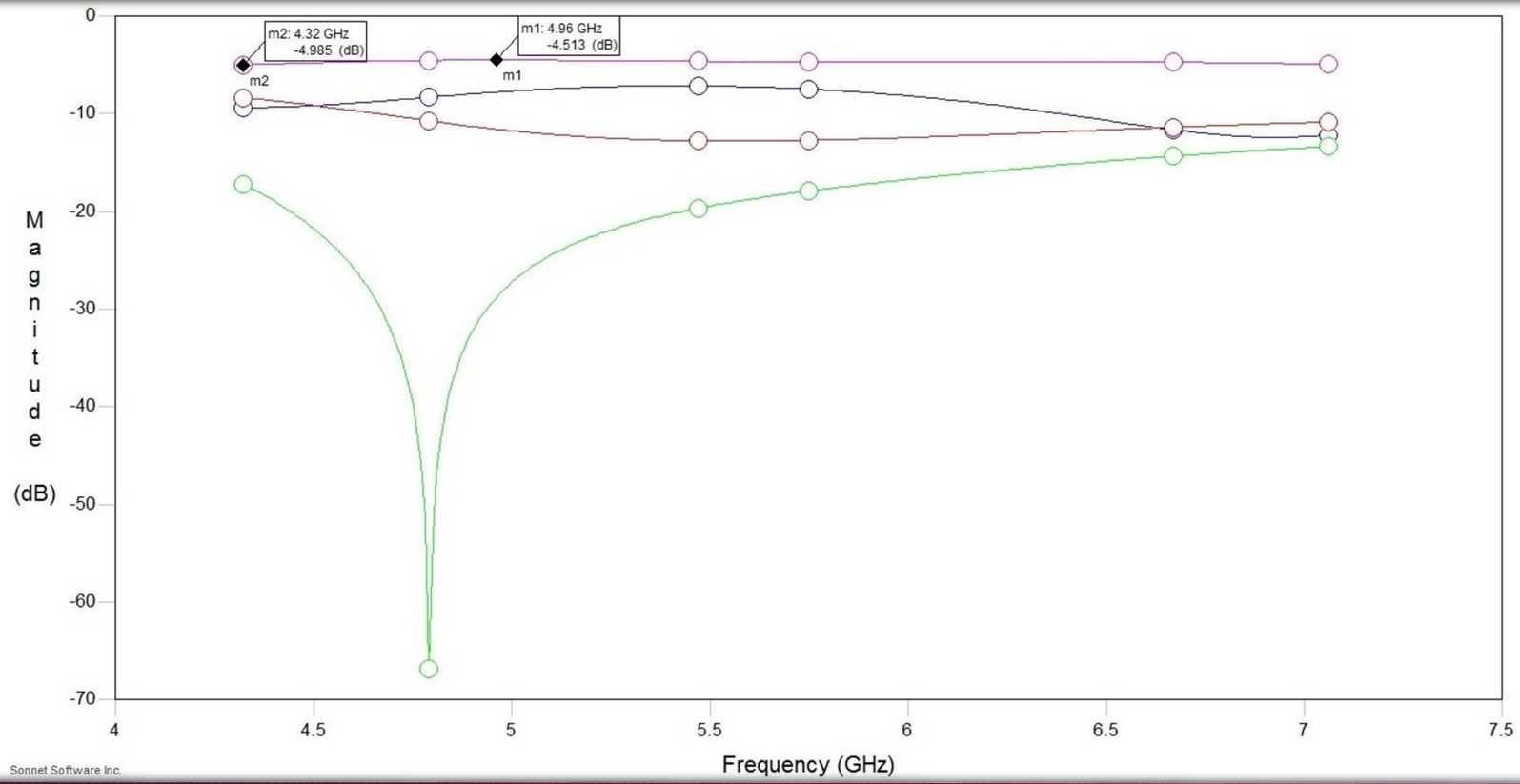
| Slots' length (mm) | Amplitude balance (dB) |
|---|---|
| 2.5 | 0.461 |
| 2.6 | 0.468 |
| 2.7 | 0.472 |
| 2.8 (original) | 0.472 |
| 2.9 | 0.480 |
| 3.0 | 0.484 |
| 3.1 | 0.488 |

# Results

# Bandwidth limits: 4.32GHz – 7.06GHz (2.74GHz Bandwidth)



# RESULTS

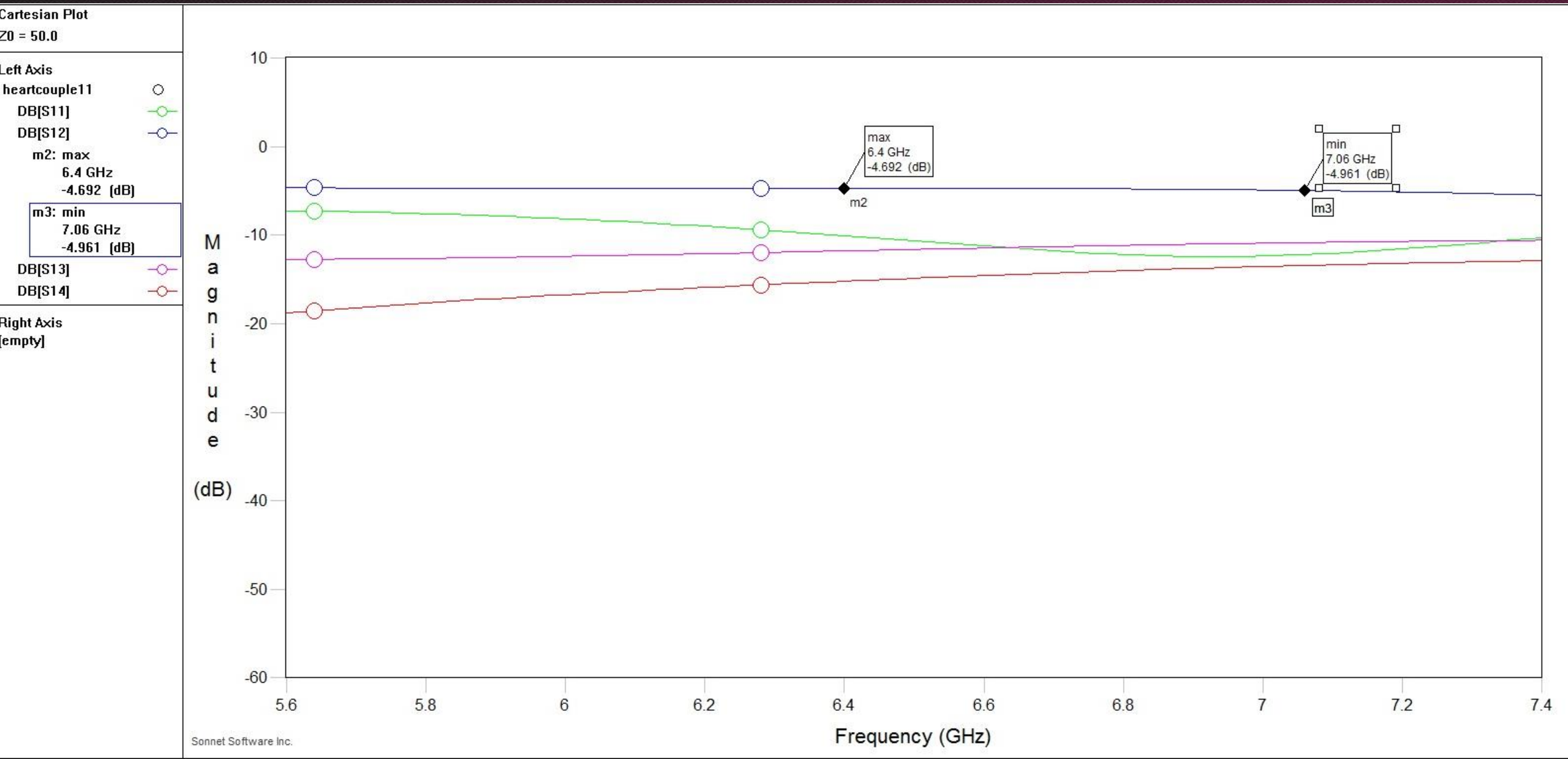



## 4.32GHz – 7.06GHz ANALYSIS (2.74GHz BANDWIDTH)

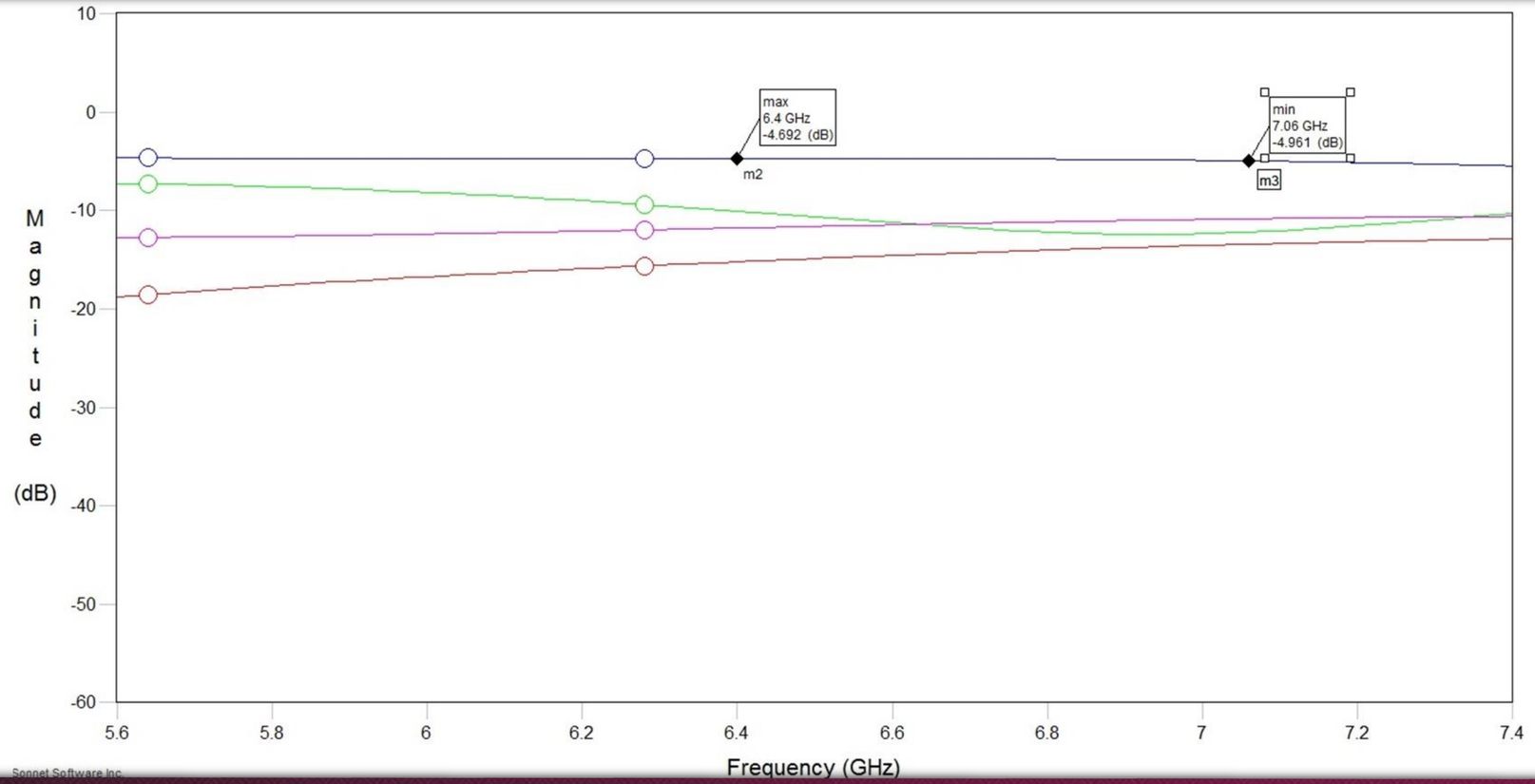
The $S_{12}$ (coupling) has an amplitude balance of 0.472dB, with the highest amplitude of -4.513dB, and the lowest of -4.985dB.

The $S_{11}$ (reflection) is not under -10dB throughout the entire bandwidth.

# Close-up on coupling: good amplitude balance between 6.4GHz and 7.06GHz



# RESULTS



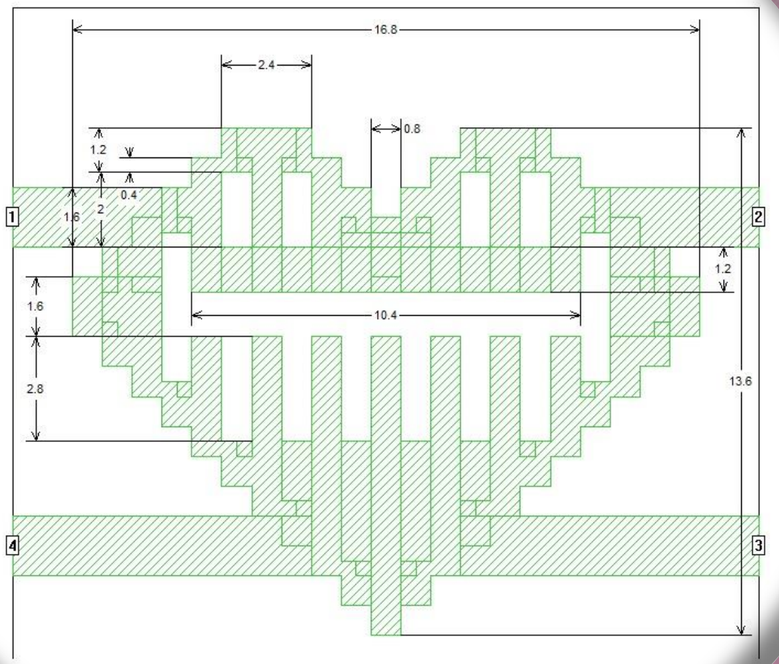

## CLOSE-UP ON COUPLING (6.4GHZ – 7.06GHZ)

If we take the bandwidth limits from 6.4GHz to 7.06GHz, which is 0.66GHz bandwidth, both $S_{11}$ and $S_{12}$ are good and stable in that region – $S_{11}$ is always under -10dB, and $S_{12}$ has a lower amplitude balance of 0.269dB. (The highest amplitude is -4.69dB, and the lowest is -4.96dB)

# Conclusion

# CONCLUSION

- The Slotted Heart-shaped 4.77dB Microstrip Coupler was designed and simulated.
- With its compact size of 2cm by 2cm by 3mm, it offers good coupling on a broad bandwidth of 2.74GHz (from 4.32GHz to 7.06GHz), with a stable amplitude balance of 0.472dB.
- The results acquired by simulations also show reflection between -7.130dB and -14.404dB, which is considered acceptable.
- With everything being considered, our coupler met the acceptable requirements and parameters according to the simulation results of the Sonnet Software.



# REFERENCES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# THANK YOU!

Any Questions?

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