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A Cascaded Salty Water Attenuator

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Introduction

- The heat dissipation path of **traditional resistance attenuator** is limited in many aspects, and the **cost** of these resistive attenuation materials is relatively **high**.
- In order to dissipate the heat quickly, at the same time, maintain a high attenuation, **liquids** can be introduced in attenuator designs.
- **A salty water attenuator** based on Π-type resistance attenuation network is proposed.

Attenuator Design

1. Attenuator Design

The configuration of proposed attenuator is shown in Fig. 1.

- Its **overall volume** is 204 mm × 124 mm × 52.8 mm (length × width × height).
- It consists of **three liquid loads**, **parallel transmission line**, **gradient transmission line** and **transparent container**.
- The **liquid loading** is made of salty water with a **conductivity** of 3.53 S/m.
- The **container** is printed by transparent resin with **relative permittivity** of 3 and **loss tangent** of 0.01.

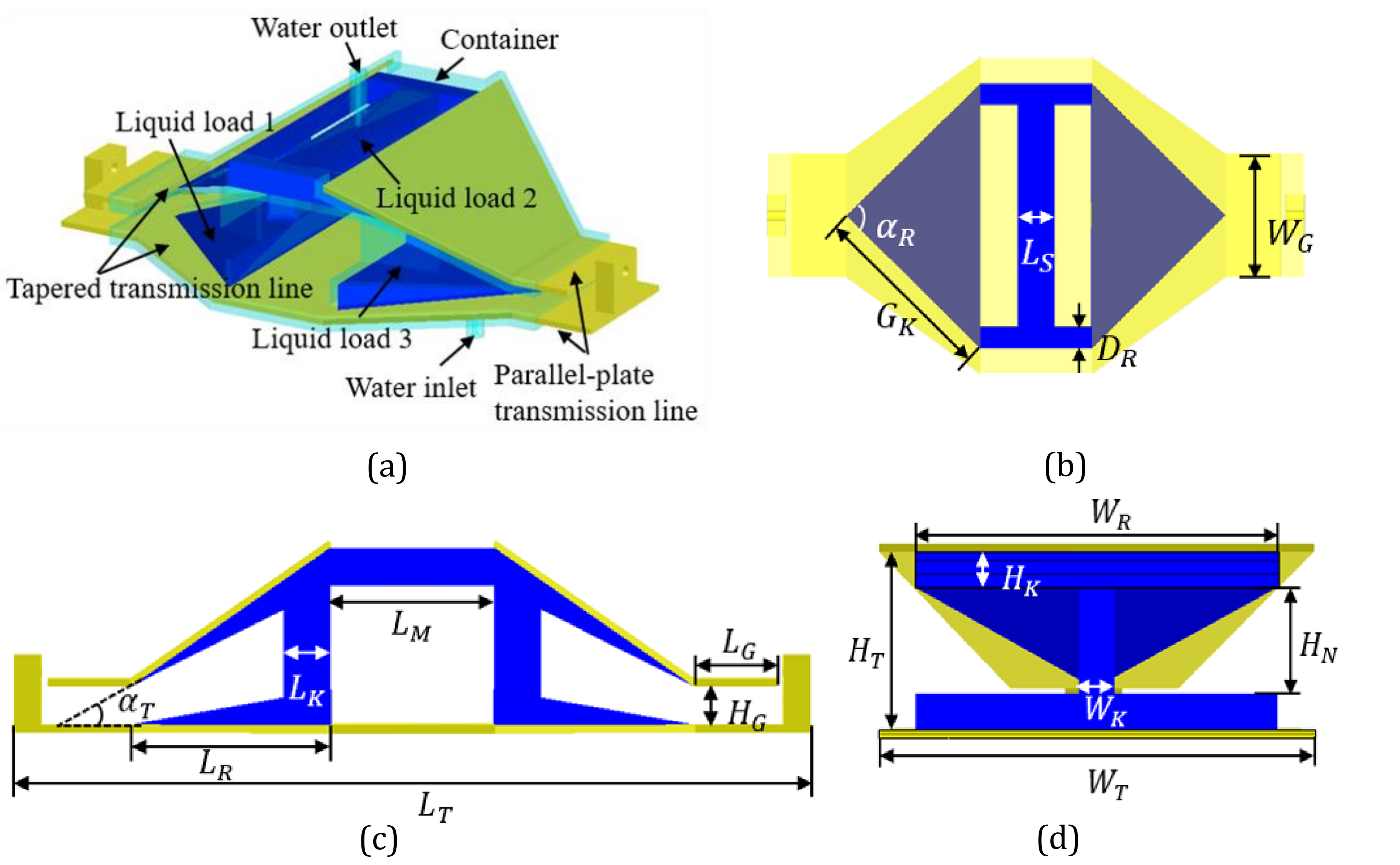

Fig. 1. Geometry of the 10 dB attenuator. (a) Perspective view. (b) Top view. (c) Front view. (d) Left view.

The simulation results of liquid attenuator are shown in Fig. 2.

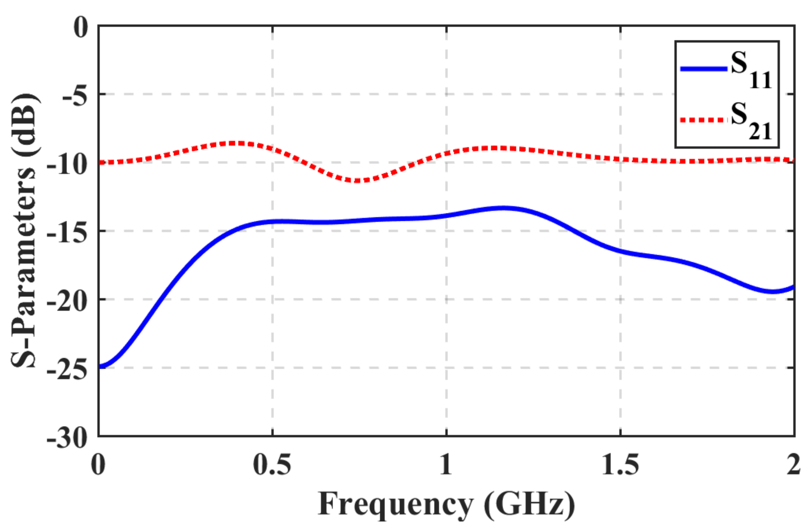

Fig. 2 shows that the S_{11} is less than -10 dB from **DC to 2 GHz**, which indicates the transmission line and the Π-type resistance attenuation network **match well**, and the attenuation value of the attenuator is **10 ± 0.9 dB**.

Fig. 2. Simulated results of liquid attenuator.

2. Cascaded Attenuator Design

The cascaded Π-type resistance attenuation network is shown in Fig. 3.

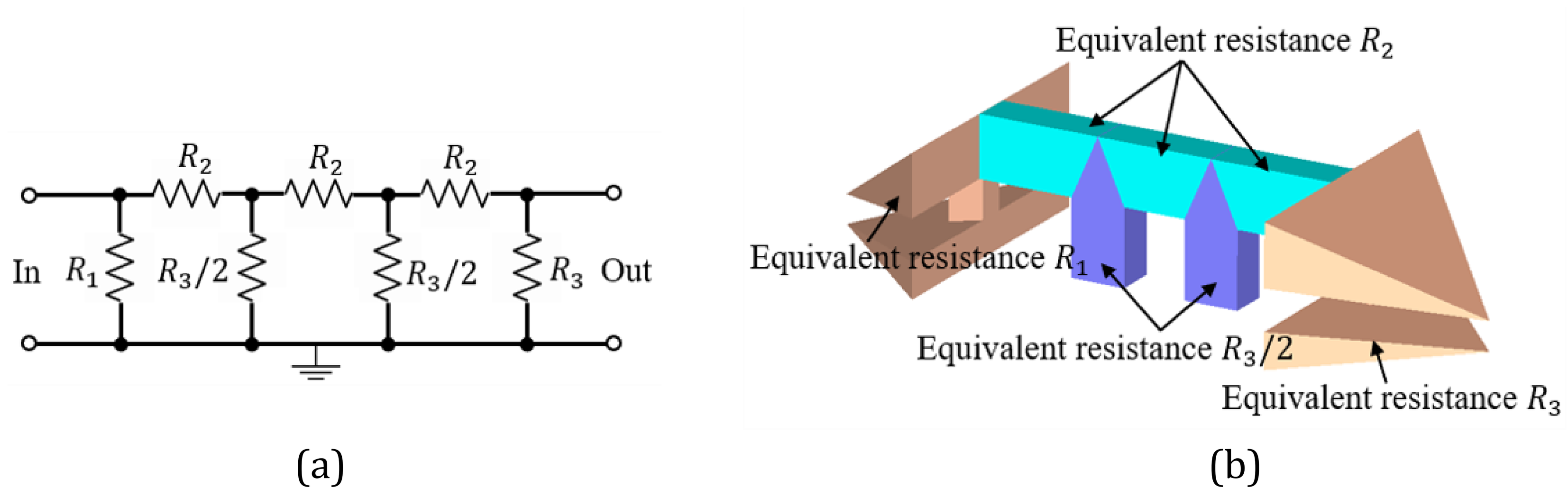

Fig. 3. Cascaded Π-type resistance attenuation network. (a) Circuit structure. (b) Equivalent model of liquid loads.

The configuration of the cascaded attenuator is shown in Fig. 4.

- Its **dimensions** are is 273 mm × 125 mm × 52.8 mm (length × width × height).
- It is composed of **seven liquid loadings**, parallel transmission line, gradient transmission line and transparent container.

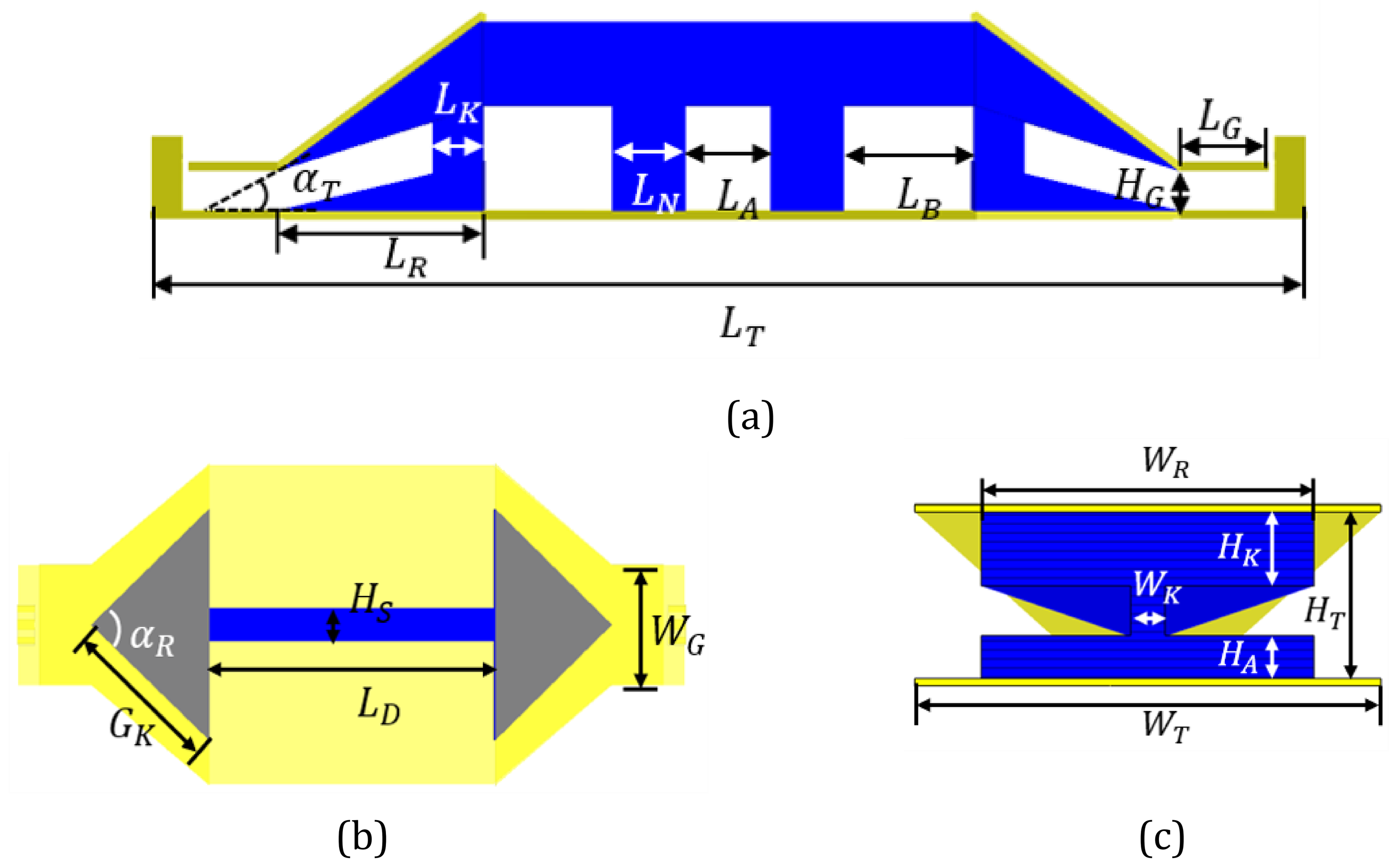

Fig. 4. Geometry of the cascaded attenuator. (a) Front view. (b) Top view. (c) Left view.

The simulated results are shown in Fig. 5.

- With the increase of the parameter H_K, the $\mathbf{S_{11}}$ within 1.3 GHz **decreases**.
- For the performance of attenuation, when the parameter H_K is **17 mm**, and the flatness fluctuation is not more than **4 dB**.
- The H_K is set to **23 mm**, the attenuation fluctuates within **30±2.3** dB.
- When the parameter H_K is equal to **20 mm**, the attenuation only changes within **30±1.4 dB**, and the attenuation value is relatively flat.
- The optimal performance will be realized when H_K = 20 mm.

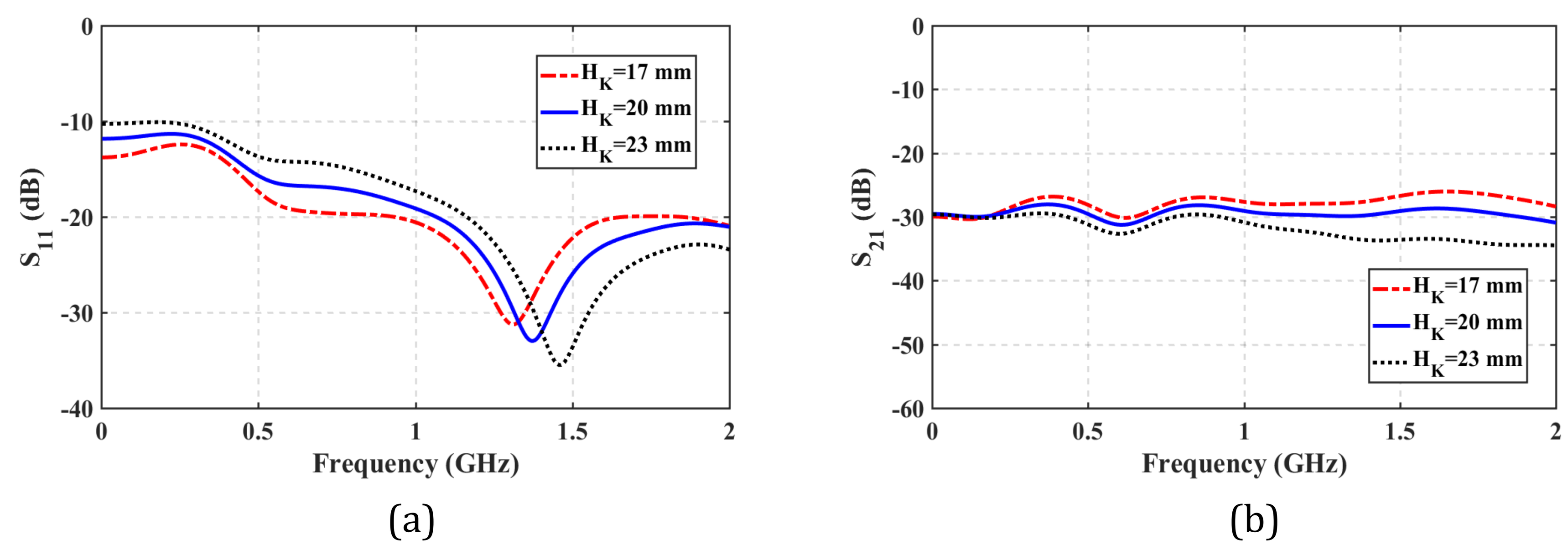

Fig. 5. Simulated results of different H_K values. (a) S_{11}. (b) S_{21}.

Fig. 6 shows the prototype of the cascaded attenuator. The simulated and measured S_{11} and S_{21} are presented in Fig. 7.

- It is noted that when the S_{11} is less than -10 dB, the simulated and measured bandwidth is from **DC to 2 GHz**.
- The overall agreement is good, but the S_{11} is quite different within 0.5 GHz.
- In the working frequency band, the **simulated** attenuation fluctuates within **30±1.4 dB**, while the **measured** value changes within **30±3.2 dB**.

Fig. 6. Prototype of the proposed cascaded attenuator.

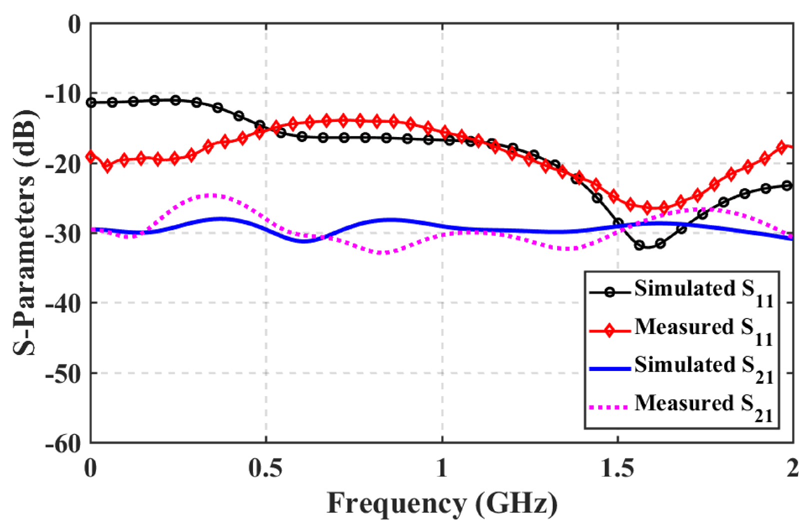

Fig. 7. Simulated and measured S_{11} and S_{21} of the cascaded attenuator.

There are several reasons for discrepancies between simulation and measurement:
1): fabrication error;
2): material differences between measurements and simulations.

Conclusions

In this paper, a salty water attenuator based on Π-type network is proposed.

- It utilizes the **cascade method** and effectively combines **the fluidity of liquid load** to achieve **a compact size**, **a large attenuation** and **a better heat dissipation**.
- The measured results show the attenuation can reach **30 dB** from 0 - 2 GHz, the attenuation flatness is less than ± 3.2 dB, and the S_{11} is better than -10 dB.
- This work demonstrates the unique advantages and shows great potentials of liquid components.