Design of Wideband Millimeter Wave Power Equalizer

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***Abstract*—A broadband millimeter wave power equalizer using new waveguide resonator structure is presented and experimentally verified for the first time. To improve the accuracy of equalization and impedance matching, rectangle coupling holes integrated with mircostrip to waveguide transition is introduced and the electromagnetic wave absorber placed in the waveguide resonators is adopted. The EM simulation shows that, the input and output return loss is more than 15dB over the range 26.5-40GHz, the value of equalization is about 11dB, and the minimum insert loss is less than 2dB. The equalizer is fabricated to verify the design with compact structure. Measured results show good agreement with simulated results.**

I. INTRODUCTION

Power equalizer is widely used in traveling wave tubes (TWT), it is a passive component used to flatten the output power of traveling wave tubes (TWT). As we know, TWT applied for MMPM is the key element in radar system and electronic countermeasures, however, it has a severe problem is that the curve of power versus frequency appears parabola form, which is high output power at the center frequency and much lower at the start and stop frequency. To get smooth curve of power versus frequency, it need equalization at input port which allow their output power fluctuate little in its working frequency band [1][2].

II. BASIC CONCEPTS OF EQUALIZER

The main indexes of equalizer include reflection coefficient, value of equalization, minimal insertion loss, etc. The value of equalization means the max attenuation minus the min attenuation in the working frequency band.

A simple grounded series loop composed of resistance, inductance, and capacitance is shown in Figure 1(a). Its transfer function is [3]:

$$S_{21}(\omega)=\frac{2(1-\omega^2 LC+j\omega RC)}{2(1-\omega^2 LC+j\omega RC)+j\omega Z_0 C}$$

Its frequency response wave shape is shown in Figure 1(b). Based on series expanded theory, we can get arbitrary equalized curve by correctly choosing resonance frequency and Q value of every branch [5].

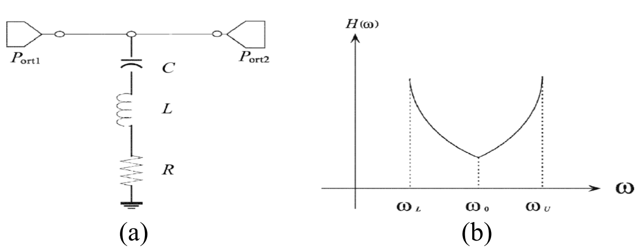

Fig. 1. Model and S21 response of the grounded series resonance loop

III. DESIGN OF MILLIMETER WAVE POWER EQUALIZER

The simple equalized response has been fulfilled use the waveguide with a coupling waveguide branch. The size of the coupling waveguide is designed based on frequency, so the branch will only couple corresponding frequency energy, which will be absorbed by electromagnetic wave absorber [4].

The calculation of the coupling structure is very complicated, so we optimize the hole by using commercial software HFSS. The model of coupling hole in HFSS is shown as follows:

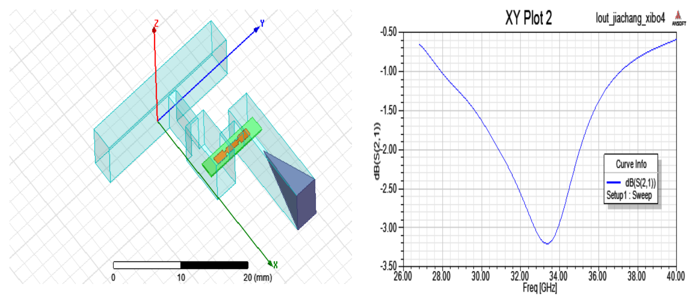

Fig. 2. Waveguide resonate unit integrated with transition structure and its wave trapped characteristic

The traditionally structure is putting the wave absorber into rectangular resonator cavity directly. However, this is very hard to control the reflection coefficient and the attenuation point for we cannot precisely control the position and amount of electromagnetic wave absorber when we are assembling the equalizer. So, we design a new structure to overcome this problem. Here, in fig1 we use two transitions of waveguide to microstrip structure. Use the transitions we can put the electromagnetic wave absorber in another resonator cavity to absorb the corresponding frequency energy completely and we do not need to worry about the position and amount of absorber in the rectangular resonator cavity when we are assembling the equalizer.

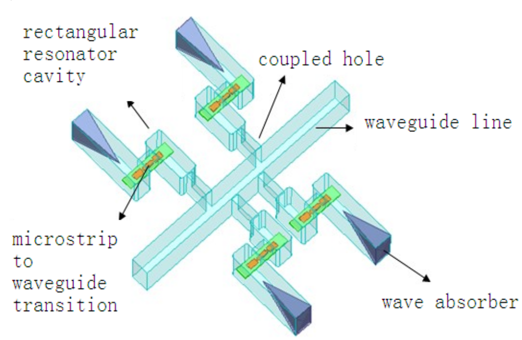

Fig. 3. The whole model of Ka-band wideband power equalizer in HFSS

The millimeter wave power equalizer can be fulfilled by properly cascading several resonant branches. The simulated model of waveguide power equalizer is shown in Fig 3.

The structure is composed of waveguide line, rectangular resonator cavity, coupled hole, transition of microstrip to waveguide and millimeter wave absorber. Coupled hole is located at the wide side of main waveguide line which can couple energy from waveguide line to rectangular resonator cavity. The wave absorber will absorb the corresponding frequency energy in another resonator cavity completely through the transition structure.

The simulation results is shown in fig 4, from the picture we can see, the input and output return loss is more than 15dB over the range 26.5-40GHz, the value of equalization (minimal insertion loss minus maximal insertion loss) is more than 10dB, the minimal insertion loss is less than 2dB at 40GHz, the maximal insertion loss is 12.7dB at 33.6GHz.

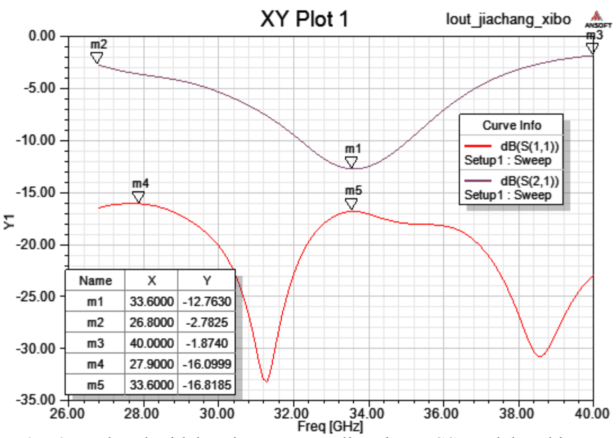

Fig. 4. Ka-band wideband power equalizer in HFSS model and its simulation result(input return loss and insert loss)

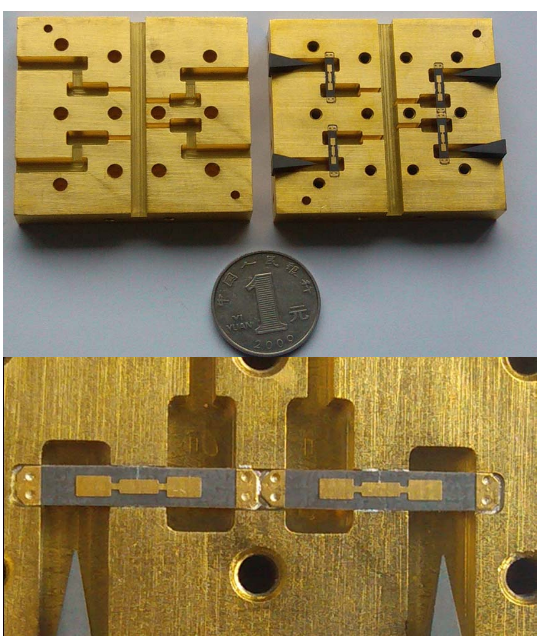

Fig. 5. The picture of the wideband power equalizer and partial enlarged details

The innovation this structure compared to traditions' is that we use micro-strip waveguide transition to get out of the energy we need to remove, and then use another waveguide resonator cavity to absorb the energy completely with electromagnetic wave absorber. We made the wideband power equalizer, as shown in fig 5.

Fig. 6. Measured result of the wideband power equalizer

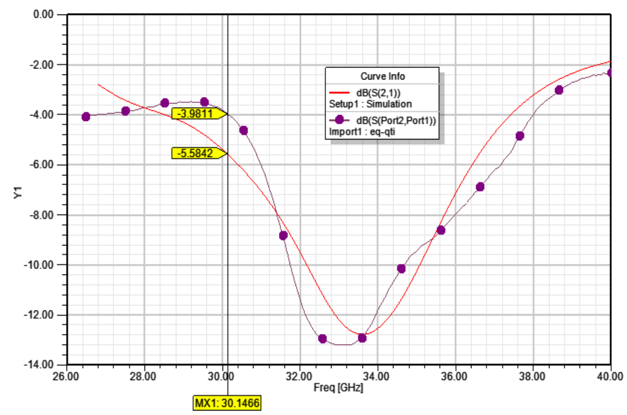

Fig. 7. Simulation result compared with measured result

The measured result is shown in fig 6 and the simulation result compared with measured result is shown in fig 7. From the pictures we can see, this structure has a good performance, the input and output return loss is more than 15dB over the range 26.5-40GHz and the equalize precision is better than 2 dB.

IV. CONCLUSION

In this paper, a wideband millimeter-wave power equalizer working from 26.5~40GHz is designed with new rectangular resonator cavity and transition of microstrip to waveguide structure. Compared with others previous research results, the results in this paper have good performance and higher equalize precision. This paper will promote the research and manufacture of the millimeter wave power module in the future.

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