Design of Amplifier using Defected Ground Structural DC block

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Abstract **In this paper, after applying DGS (Defected Ground Structure) to DC block, changes of width, gap and length of λ/4 coupled line are investigated. As a result, the width of λ/4 coupled line is widen from 0.1mm to 0.46mm by 0.36mm and the length of λ/4 coupled line gets shorter from 17.7mm to 13.2mm by 4.5mm. It is easy to design by extension of gap and is possible to miniaturize according to occupying little space.**

Key words: **DGS, DC block, amplifier**

1. Introduction

Recently due to fast development of mobile communication and trend of miniaturization and light weight in mobile communication equipment and component, slow-wave structure using microstrip line or waveguide using periodic structure and necessity of high dielectric materials have been demanded in various mobile communication part. So as an example of slow-wave structure, DGS(Defected Groud Structure) is a structure having not periodic structure but one or more than one defects on ground surface, and has characteristics of depletion region at special frequency range[1]. Also an advantage of DGS is that it is easy to design microstrip used widely as a structural material of especially high frequency component, by adding artificial structure to conventional ground plane. These characteristics are applied to design a phase shifter and a power amplifier to increase efficiency, and a filter to remove harmonic component, resonator, RF switch[2]. In this paper, after making DC block applying DGS, characteristics of power amplifier which has DGS DC block is investigated.

2. Design Of A DGS DC Block

A section of parallel coupled symmetric transmission line can be used to transmit certain range of microwave frequencies without attenuation, but acts as an open circuit at dc[3]. La Combe and Cohen have named such a device a DC block[4]. DC blocking capacitors take an important role in design of microwave component using DC bias circuit. And these chip, deposited capacitors are attractive at lower microwave freqencies typically through S band, although reported on as high as X band[5]~[7]. These chip capacitor has self resonance and sometimes introduce unwanted parasitics in higher frequency bands[3]. To solve these problems DC block is necessary.

1) Design of A Typical DC block

This paper describes an modified extension of the inter-digital type DC block reported on by Stinehelfer which has the advantage of being "printed" simultaneously with other microstrip circuitry[8]. The basic circuit, illustrated in Fig. 1, consists of a single quarter-wavelength coupling section[3]. In this paper, result property of coupling section of DC block is investigated by using EM simulation. At this time, a PCB having permittivity of 2.5 and thickness of 31 mils is used. And width of quarter-wavelength line is 0.52mm, length of quarter-wavelength is 17.7mm, gap between coupled line is 0.1mm. Width of 50 ohm feed line is 2.2mm, gap between 50 ohm feed line and quarter-wavelength line is 0.2mm.

2) Design of A Defected Ground Structural DC block

3-dimensional structure of DC block intended to design in this paper is showed in Fig. 2 and EM simulation result of modified DC block using DGS is showed in Fig. 3. When dimension of defect is considered, a is 2.4mm, b is 4.77mm, c is 0.6mm, g is 0.4mm and p is 8.5mm. But after applying DGS to DC block, an additional advantage, which is change of the gap between quarter-wavelength line and the length of quarter-wavelength line, is obtained. As applying 2 defects, s is widen from 0.1mm to 0.46mm and the length L gets shorter from 17.7mm to 13.2mm. At this time, w, the width of quarter-wavelength line is unchanged. This change of length illustrates the possibility to design without difficulty. Actually it is very difficult to design gap of 0.1mm because in spite of a few errors, the characteristics can be changed. But it is very easy to design gap of 0.42mm increased by 0.32mm. Also shortening of the length of coupled line illustrates the possibility to miniaturize by

slow-wave effects. And photographs of DGS DC block designed in this paper are shown in Fig. 4 and Fig. 5.

3. Design Of An Amplifier Using A Defected Ground Structural DC Block

In order to investigate the effects of defected ground structural DC block, three-type amplifiers using a blocking capacitor, a typical DC block and a DGS DC block are designed. At first, the class AB amplifier using blocking capacitor is designed using FLL55MK of Fujitsu and has a bias condition of V_{ds} of 10V and I_{ds} of 900mA. As this time, operating frequency of amplifier is 3.2±0.05GHz and a PCB used in design has permittivity of 2.5, thickness of 31mil and is made in TACONIC co.. When a blocking capacitor is used, showed in Fig. 6, an amplifier has S_{21} of 9.02dB, S_{11} of –20.22dB and S_{22} of –19.80dB. And when the output power of dominant frequency is 25dBm, the difference between dominant signal and 2nd harmonic component is –44.83dBc illustrated in Fig. 7. At this time, the 3rd harmonic component is not occurred because this component is out of specification range of an amplifier. Next instead of output blocking capacitor, characteristics of power amplifier applying DGS DC block and power amplifier applying typical DC block are investigated. As a result according to using typical DC block having a same condition with using blocking capacitor, showed in Fig. 8, an amplifier has S_{21} of 9.72dB, S_{11} of –12.06dB and S_{22} of –17.50dB. And when dominant signal output power of amplifier is 25dBm, a harmonic characteristics of an amplifier is showed in Fig. 9. This Fig. 9 shows that the difference of dominant signal and 2nd harmonic component is –66.84dBc. And as a result according to using a DGS DC block having a same condition with using blocking capacitor, showed in Fig. 10, an amplifier has S_{21} of 9.48dB, S_{11} of –21.02dB and S_{22} of –30.3dB. When a dominant signal output power of amplifier is 25dBm, a harmonic characteristics of an amplifier is showed in Fig. 11. This Fig. 11 shows that difference of dominant signal and 2nd harmonic component is –64.33dBc.

4. Conclusion

In this paper, after designing DC block applying DGS which are much researched these days, DGS DC block is applied to power amplifier output stage instead of DC blocking capacitor. Actually three various power amplifiers which are amplifier using blocking capacitor, that using typical DC block and that using DGS DC block are designed. When typical DC block is used, difference of dominant signal and the 2nd harmonic signal is –66.84dBc and when DGS DC block is used, difference of dominant signal and 2nd harmonic signal is –64.33dBc. So case of using typical DC block is worse by 2.51dB than case of using DGS DC block. But when physical changes of λ/4 coupled line are considered, gap between λ/4 coupled lines of DC block applying DGS is increased from 0.1mm to 0.46mm by 0.36mm to design easily, and the length of λ/4 coupled line is decreased from 17.7mm to 13.2mm by 4.5mm to miniaturize. In conclusion, applying DGS to DC block has an advantage that is to easily design and miniaturize the size, so then these characteristics can be widely applied to other microwave devices.

Acknowledgements

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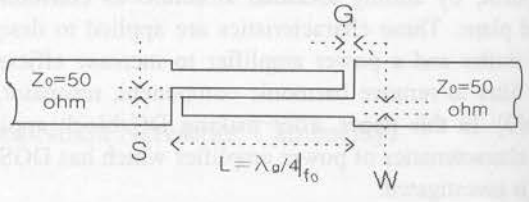

Fig. 1 Microstrip circuit of typical DC block

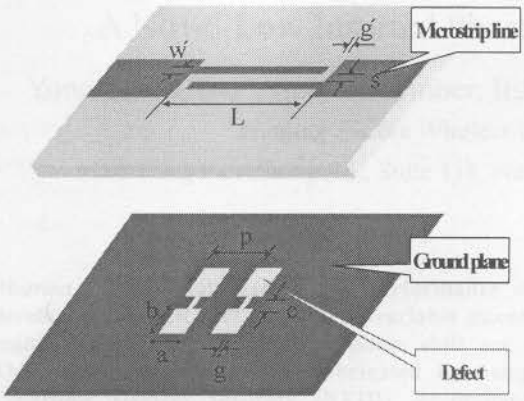

Fig. 2 3-dimensional structure of DGS DC block

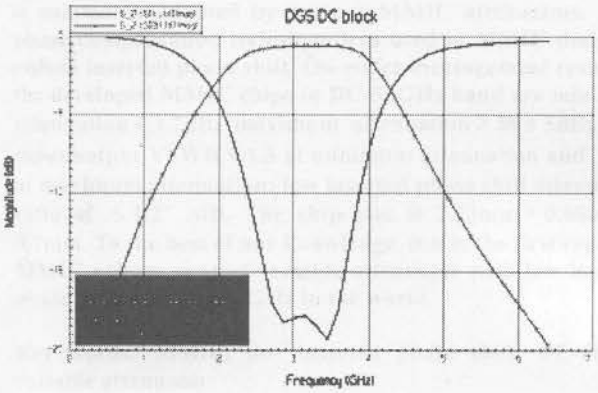

Fig. 3 Simulation result of DGS DC block

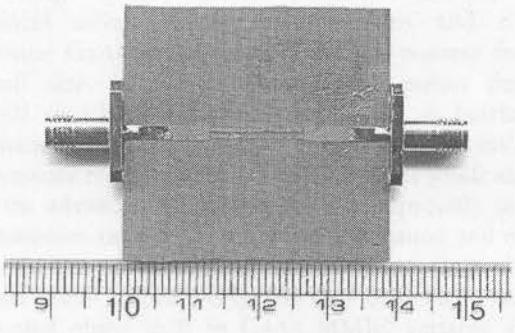

Fig. 4 Front photograph of DGS DC block

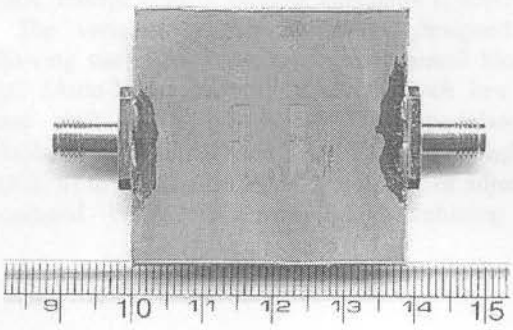

Fig. 5 Back photograph of DGS DC block

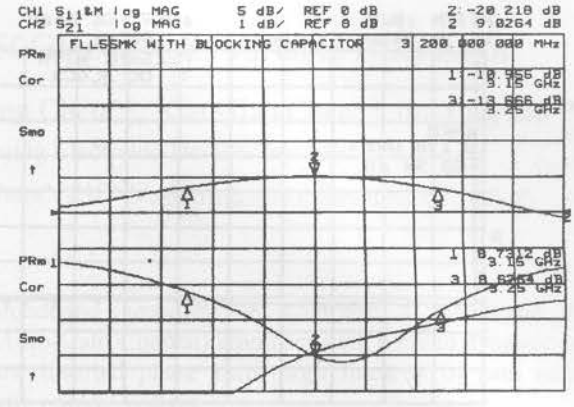

Fig. 6 The output characteristics of amplifier using blocking capacitor

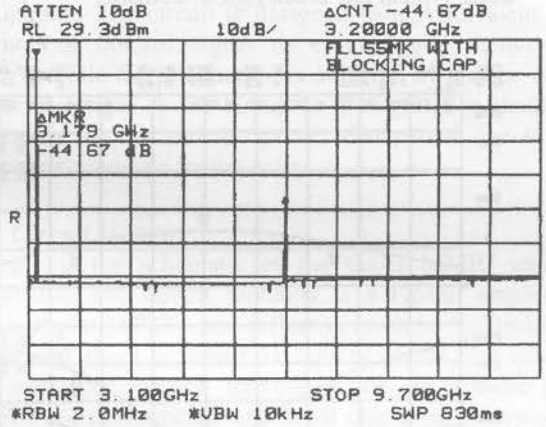

Fig. 7 Harmonic characteristics of power amplifier using blocking capacitor (@Po=25dBm)

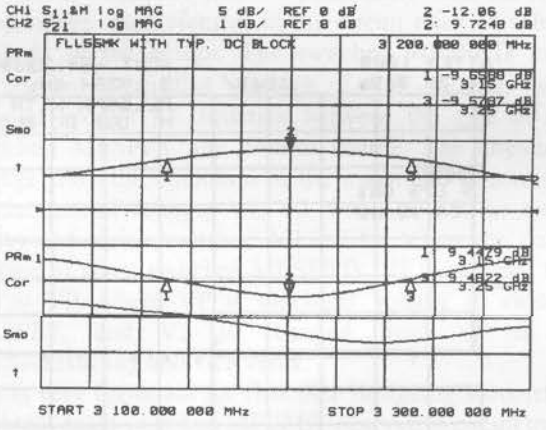

Fig. 8 The output characteristics of amplifier using typical DC block

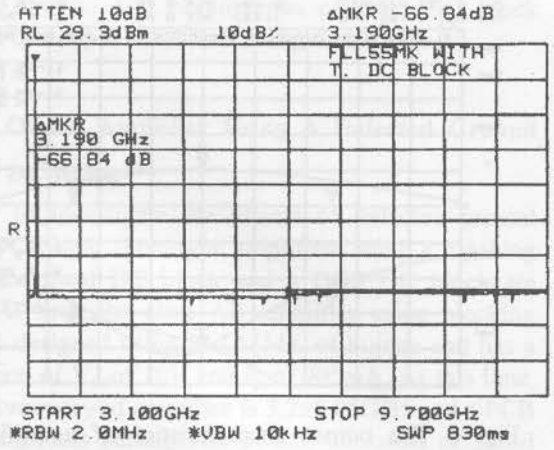

Fig. 9 Harmonic characteristics of power amplifier using typical DC block (@Po=25dBm)

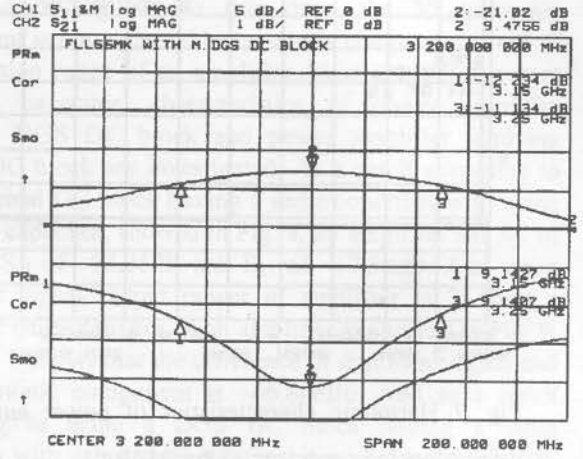

Fig. 10 The output characteristics of amplifier using a DGS DC block

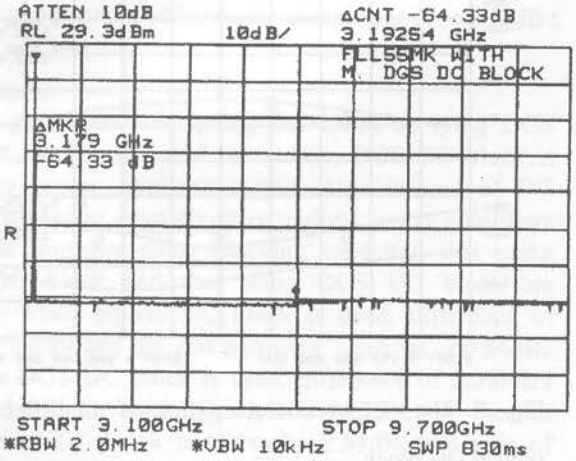

Fig. 11 Harmonic characteristics of power amplifier using DGS DC block (@Po=25dBm)