

一种宽带微带贴片天线的新设计

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摘要:设计和制作了一种宽带微带贴片天线,采用不同介电常数,不同厚度的基板叠加,利用半环形开路微带天线通过接地板上的缝隙耦合馈电。经过仿真计算和实验测试,这种结构的微带贴片天线完全满足平面天线阵的应用。由于采用边沿馈电,所以相对其他宽带微带天线而言,在宽带平面微带天线阵方面应用前景广阔。

关键词:宽带;缝隙耦合;半环馈电;微带天线

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微带天线因具有体积小、重量轻、剖面低、馈电方式灵活、成本低、易与飞行器共形等优点而深受人们的青睐,但微带天线阻抗带宽较窄,一般的微带天线的带宽仅有5%左右^[1]。微带天线的窄频带特性成了限制其广泛应用的主要障碍,因此展宽微带天线的带宽具有十分重要的意义^[2]。近年来,随着微带天线的应用越来越广,展宽微带贴片天线带宽的方法主要集中在以下几种情况:①采用厚介质基板;②附加阻抗匹配网络;③采用低介电常数的基板;④采用多层结构^[3-4];⑤采用特殊馈电方式和特殊形状的贴片天线^[5-8]。本文设计了一种利用缝隙耦合馈电,多层介质基板组成的宽带微带矩形贴片天线,以满足天线阵的应用。

1 天线设计

1.1 天线结构

缝隙耦合馈电多层结构的宽带微带矩形贴片天线结构如图1所示。

图1中层1(ϵ_{r1}, h_1)、层2(ϵ_{r2}, h_2)、层3(ϵ_{r3}, h_3)、层4(ϵ_{r4}, h_4)、层5(ϵ_{r5}, h_5)和层6(ϵ_{r6}, h_6)分别为各层介质基板,其中 $\epsilon_{ri}, h_i (i=1, 2, \dots, 6)$ 分别为相应各层的介电常数和厚度。 $(w_{x1}, l_{y1}), (w_{x2}, l_{y2})$ 和 (w_x, l_y) 分别为贴片1、贴片2和缝隙的宽度和长度, w_f 为馈线宽度, r_f 为环臂的内半径。天线采用半环形开路微带线馈电,环臂和主臂宽度一致。

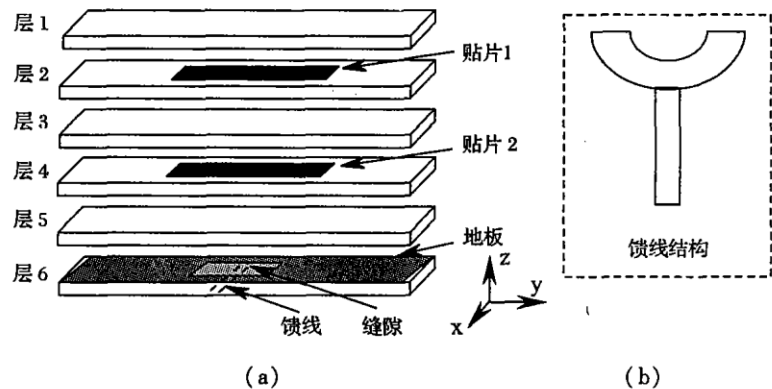


图1 天线结构

1.2 结构分析

通常简单的双层缝隙耦合的微带贴片天线可以通过调整耦合缝隙的宽度和长度来获得较好的匹配,但是在图1所示的多层结构中,由于各层介质的介电常数和厚度不一致,单纯调整缝隙尺寸并不能达到带宽要求。在此,缝隙尺寸和介质基板的厚度是对应的,在调整过程中需要综合考虑。另外,在一定的基板厚度条

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件下,当贴片1和贴片2尺寸不一致时,通过调整缝隙尺寸,可以形成双频工作。参照图1(a)所示,在不加覆盖层1的条件下,选择天线参数: $w_{x1} = 131.5$ mm, $l_{y1} = 265$ mm; $w_{x2} = 188$ mm, $l_{y2} = 290$ mm; $w_{xs} = 15.4$ mm, $l_{ys} = 144.5$ mm; $w_f = 1.9$ mm。输入驻波比的计算结果如图2所示。在此基础上调整各层介质基板厚度和贴片尺寸: $w_{x1} = 144.3$ mm, $l_{y1} = 231$ mm; $w_{x2} = 162$ mm, $l_{y2} = 214$ mm; $w_{xs} = 22.4$ mm, $l_{ys} = 162$ mm,采用开路微带线馈电,输入驻波比的计算结果如图3。从结果可以看出,与传统的微带贴片天线相比较而言,多层缝耦合贴片天线的带宽可以达到12%,带宽成倍增加,但是由于这种结构自身厚度较大,带宽扩展并没有呈现明显的优势,因此改进馈电结构,采用半环开路微带线馈电,通过调整天线参数以获得更好的阻抗匹配带宽。

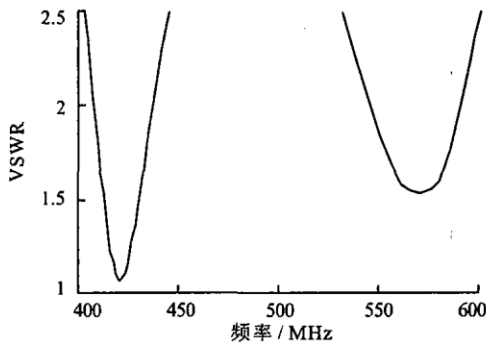


图2 驻波比(天线参数: $\epsilon_{r2} = 2.65$, $h_2 = 6$ mm;
 $\epsilon_{r3} = 1.06$, $h_3 = 15.5$ mm; $\epsilon_{r4} = 2.65$, $h_4 = 6$ mm;
 $\epsilon_{r5} = 1.06$, $h_5 = 15.5$ mm; $\epsilon_{r6} = 2.65$, $h_6 = 6$ mm)

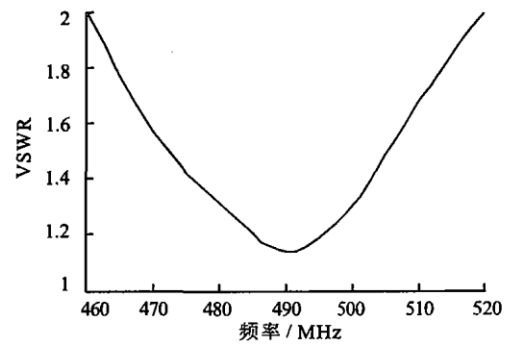


图3 驻波比(天线参数: $\epsilon_{r2} = 2.65$, $h_2 = 8.6$ mm;
 $\epsilon_{r3} = 1.06$, $h_3 = 18$ mm; $\epsilon_{r4} = 2.65$, $h_4 = 8.6$ mm;
 $\epsilon_{r5} = 1.06$, $h_5 = 15.5$ mm; $\epsilon_{r6} = 2.65$, $h_6 = 6$ mm)

2 仿真和实测结果

在图1(a)的基础上,增加覆盖层1,馈电采用半环形微带线馈电,如图1(b)所示。这里增加覆盖层不仅可以有效地减小辐射贴片尺寸,而且减小了馈电网络对辐射元的影响,提高了天线辐射效率。同时,在改变介质基板厚度的情况下,缝隙尺寸也需要随之改变。这样通过调整基板厚度,贴片和缝隙尺寸以及半环半径可以获得更佳的匹配特性。选择天线参数: $\epsilon_{r1} = 4.3$, $h_1 = 6$ mm; $\epsilon_{r2} = 2.65$, $h_2 = 8$ mm; $\epsilon_{r3} = 1.06$, $h_3 = 25$ mm; $\epsilon_{r4} = 2.65$, $h_4 = 8$ mm; $\epsilon_{r5} = 1.06$, $h_5 = 22$ mm; $\epsilon_{r6} = 2.65$, $h_6 = 6$ mm; $w_{x1} = 184$ mm, $l_{y1} = 259$ mm; $w_{x2} = 180$ mm, $l_{y2} = 204$ mm; $w_{xs} = 32.6$ mm, $l_{ys} = 194$ mm; $w_f = 1.9$ mm, $r_f = 15$ mm。

天线的输入驻波比(VSWR)和远场方向图的仿真和实测结果如图4至图11所示。

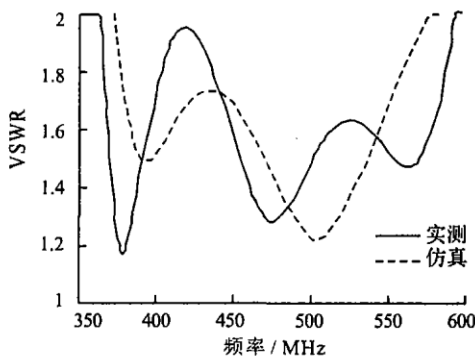


图4 天线驻波比

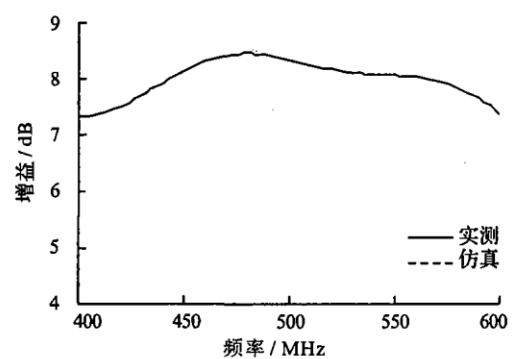


图5 天线增益

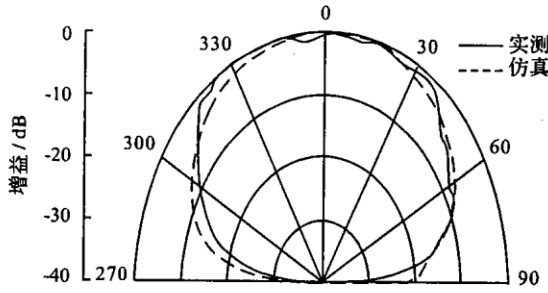


图 6 $f = 400$ MHz E 面方向图

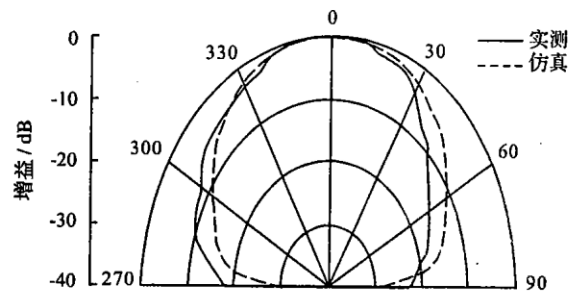


图 7 $f = 400$ MHz H 面方向图

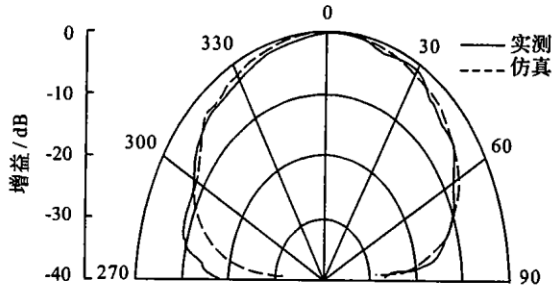


图 8 $f = 500$ MHz E 面方向图

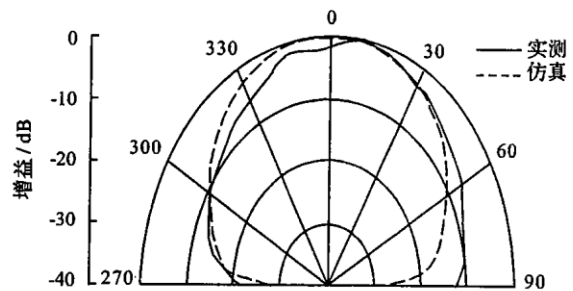


图 9 $f = 500$ MHz H 面方向图

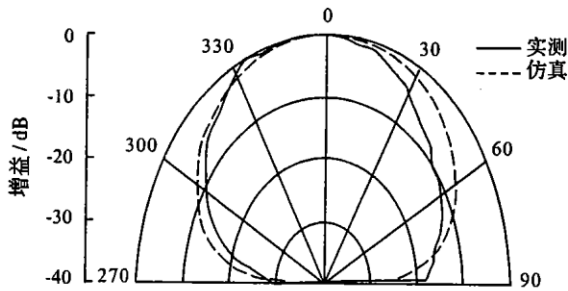


图 10 $f = 600$ MHz E 面方向图

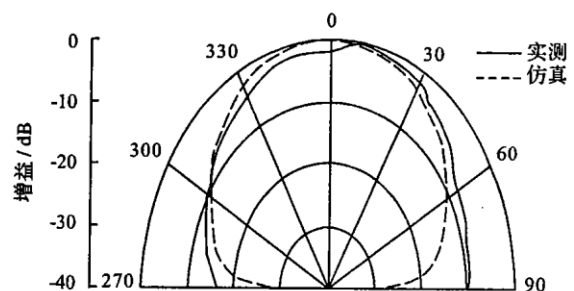


图 11 $f = 600$ MHz H 面方向图

从测试结果可以看出,采用缝隙耦合馈电多层结构的微带贴片天线可以有效地拓展频带。当天线工作于 500 MHz 时,匹配带宽达到 47% ($VSWR < 2$),天线增益达到 8.4 dB,并且由于这种多层结构的微带天线采用微带线边沿馈电,可以方便地用作宽带平面天线阵的辐射单元。仿真结果与测试结果存在一定的偏差,主要是由于仿真计算过程中受计算速度的影响,计算精度不够高所造成的。

3 结论

缝隙耦合馈电多层结构的微带贴片天线尽管厚度较大,但是在基于平面阵的应用这一出发点上,不仅有效地拓展了频带,而且馈电方式适合阵列馈电网络的设计,实用性较强。当然由于耦合缝隙在这种结构中尺寸增大,后向辐射明显增强,文献[3]在距离馈电电路一定间距处增加一反射层对这一问题作了改进,但是厚度增大,制作成本增加,所以如何解决缝隙耦合馈电多层结构微带贴片天线中后向辐射和带宽这一矛盾是下一步需要研究和改进的方面。

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Research on Statistical Characterization of CSD Code for the sharing of Sub - expressions

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Abstract: This paper presents a novel technique to reduce the number of operations in Multiplierless implementations of linear DSP transforms based on shifting and adding , CSD , and sub - expressions. The complexity of multiplier blocks can be significantly reduced by using an efficient number system. First it gives the 10₇ bits CSD representation and definition of Sub - expressions. Then Statistical Characterization of CSD Code is studied , it found that the five - term Sub - expressions elimination . Through the design and implementation of FIR, our method will use the less adders than ordinary schemes.

Keywords: Canonical Signed Digit; Multiple Constant Multiplication ; Common Sub - expression

(上接第41页)

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A New Design of Broadband Micro - strip Patch Antenna

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Abstract: In this paper, a broadband micro - strip patch antenna is designed and manufactured, which is comprised of many substrates with different thickness and dielectric constants. This antenna is fed, through the coupling slot, by a semi - annular micro - strip line. The simulated and tested results show that the 47% impedance band (VSWR < 2) and 8.4dB gain are achieved. This antenna can be widely used in the field of broadband plane array antennas.

Key words: broadband; slot - coupling; semi - annular feed; micro - strip antenna