

## Comparison of integrated feed, probe feed, and edge feed in MSA

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### Abstract

It is observed that consumer often ask to have edge fed antenna in some of the applications. Probe feeding technique is very common in practice due to high efficiency of antenna but the feed is always available on the back of antenna. In this paper probe feed and MS line feed is combined to propose an integrated feed. It is observed that the proposed feed is equally efficient and can give designer an option to feed antenna from any side with good efficiency.

**Keywords:** MSA, gain, impedance matching, return loss, probe feed

### Introduction

Printed technology has contributed in a big leap in printed circuit. Printed microstrip antenna (MSA) is now an essential component in the field of wireless communication. Since 1970 only there has been continuous improvement in the design and analysis of MSA. Complete theory of antenna can be found in literatures [1]. In every literature it is mentioned that the feed location plays very important role in achieving a matched condition of antenna. But, for a designer, information should be available in terms of data. In this paper a complete analysis about the feed location and its impact on return loss and efficiency is done and can be very useful for any novice working in the area of MSA.

MSA can be fed in different fashion like from the back of ground plane called as probe feed, using MS line feed and is commonly known as edge feed. Probe feed is a coaxial cable connecting patch and ground plane with source [2]. The other feeding technique is aperture coupled feed technique but difficult to design [3]. There are several literatures available which compares all these feeding techniques and giving an idea about the optimum location of feed to have good return loss [4]. Best known to authors, this is the first kind of paper where probe and MS line feeding technique is proposed. Section II is dedicated to the analysis of location of probe feed on antenna performance. Further, probe feed is divided in two sections. First analysis is dedicated to feed along the antenna axis and second part is dedicated to analysis of feed along diagonal of the antenna. Also, the impact of feed location on the antenna efficiency is analyzed. Section III is dedicated to analysis of impact of edge feed on antenna performance and finally in section IV the two techniques are integrated and its impact on antenna performance is analyzed.

### Analysis of Impact of Feed Location on Antenna Performance

Feed location is categorized in two parts, one along the y-y' axis of the antenna and other along the diagonal of the antenna. Fig. 1 shows the two cases.

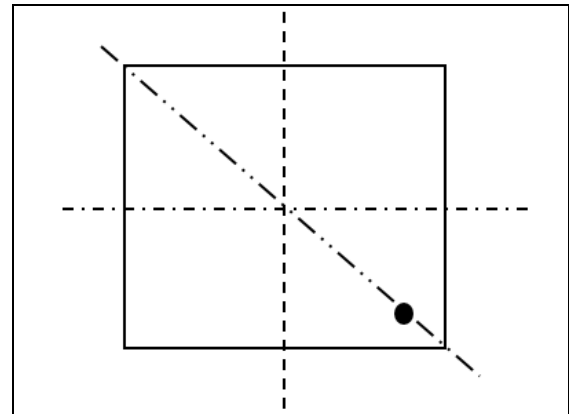


Fig 1: A MSA with feed different feed locations.

Antenna feed can be of microstrip or probe feed. Microstrip feed has got the advantage of impedance matching using impedance transformation through different lines. Probe feed does not require any design but it is difficult to locate it with correct impedance matching. A microstrip antenna (MSA) of 81x81 mm<sup>2</sup> is chosen to resonate at 866 MHz. Substrate is FR-4 with thickness of 1.6 mm. Ground plane of the antenna is 130x130 mm<sup>2</sup>. Entire analysis if executed using CST studio. Table 1 shows the antenna impedance when feed is along y-y'.

Table 1: Impact of feed location along y-y' axis on antenna impedance and return loss.

Feed location (mm)	Antenna impedance		Return loss (dB)
	R	X	
0	0.059	7.5	0
5	2.2	6.5	-0.8
10	9	5	-3.24
15	19.6	2.8	-7.16
20	31.6	-0.19	-12.97
25	43.9	-3.24	-22.7
30	54.6	-5.6	-23
35	61.4	-8.6	-17.8

Feed location 0 in Table 1 shows the center of the antenna. It can be concluded from the table that if feed is away from center and near the edge of the antenna then the antenna impedance is higher and matching can be achieved easily. Since the antenna dimension is 81x81 mm<sup>2</sup>, then F/W should be 30% to 43%, where w is width of square patch antenna. Now, another case can be taken as feed along the diagonal of MSA.

**Table 2:** Impact of feed location along diagonal on antenna impedance and return loss.

Feed location (mm)	Antenna impedance		Return loss (dB)
	R	X	
0	0.059	7.5	0
5	4.9	6.4	-1.68
10	18.5	3.2	-6.72
15	38.6	-1.5	-17.72
20	61.78	-6.86	-18.25
25	84.74	-11.8	-11.3
30	104	-15.4	-8.7
35	115	-19.5	-7.7

From Table 2 it can be concluded that the impedance matching can be achieved away from the center of the patch as it is observed in earlier case. The diagonal length is 144.55 mm. Therefore, if the ration F/D is from 10% to 17% then matching can be achieved. Though MSA suffers with poor efficiency, improper feed location leads to further degradation of antenna performance as shown in Table 3.

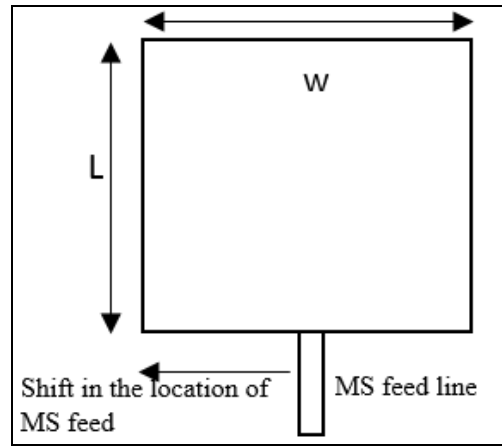
**Table 3:** Antenna efficiency for feed location along diagonal of antenna.

Feed location (mm)	Antenna Efficiency (%)	Antenna Efficiency (%)
0	0	0
5	3.3	6
10	10	15
15	15	19.4
20	18.6	19.5
25	19.6	18.4
30	19.66	17.2
35	19.4	15.5

It can be observed that the antenna efficiency is maximum when antenna is highly matched. This is true as the antenna reactance improves in near field radiation and very less power is available in far field which leads to fall in antenna efficiency. The maximum efficiency of the antenna is nearly 20% for both the approaches of probe feed.

**Analysis of Impact of Edge Feed Location on Antenna Efficiency**

Microstrip is also stimulated using edge feed and microstrip line plays very important role in it. The feed arrangement is shown in Fig. 2.



**Fig 2:** A MSA with feed edge MS feed.

L and W represents length and width of the patch antenna which is fed with a MS (microstrip) line whose width and length can be optimized to attain matched condition. Generally, the feed is located at the center of W but here its location is varied from one end of the W to another end is attempted and analyzed.

Though MS feeding (edge feed) is widely used but is not suitable for thick substrate of the patch as it leads to increase in width of the MS line and increases with increase in substrate thickness. This behavior of the MS line is shown in Table 4. Width of the MS line is calculated for impedance of 50 Ω. Table shows that for increase in substrate thickness H, the width w of the microstrip increases.

**Table 4:** Substrate thickness v/s width of the MS line.

H (mm)	W (mm)
0.8	1.5
1.6	3
3.2	6
4.8	9

Now, in order to analyze the impact of edge feed on the antenna performance, MS feed is moved from one end of the antenna to the center as shown in Fig.2. MS feed is shifted from center to the left in step of 5 mm and the result is tabulated in Table 5 and 6. It can be observed from Table 6 that as the antenna feed moves to left side there is another resonant frequency at 0.7 GHz and the design frequency of 0.866 does not shift. Table 6 shows the efficiency of the MSA antenna. The efficiency is 20.54% for the design frequency and has maximum efficiency of 13.7% for second resonant frequency at 0.7 GHz.

**Table 5:** Impact of feed location on antenna resonant frequency.

Feed location (mm)	Resonant frequency GHz	Return loss dB	Resonant frequency GHz	Return loss dB
0	0.87	-24	---	---
5	0.87	-25	---	---
10	0.87	-23	---	---
15	0.87	-23	---	---
20	0.87	-23	0.7	-9.5
25	0.87	-23.8	0.7	-18
30	0.87	-25	0.7	-28
35	0.87	-25.6	0.7	-24.6
40	0.87	-28	0.7	-18.5

**Table 6:** Impact of antenna feed location on its efficiency.

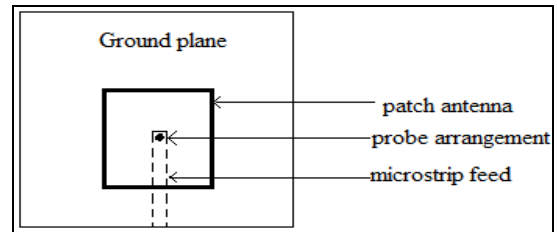
Feed location (mm)	Antenna Efficiency (%) @ 0.87 GHz	Antenna Efficiency (%) @ 0.7 GHz
0	20.5	0.5
5	20.1	2.2
10	20.1	6
15	20.1	10
20	20.1	12
25	20.1	12.5
30	20.1	13
35	20.1	13.7
40	20.1	13.4

If compare with the probe feed then it is observed that the MS edge feed has Better efficiency. But the advantage of the probe feed is that it does not required extra space on PCB to feed antenna.

It is requirement of consumer to have antenna feed at edge and microstrip feed is must in that case but it is observed that by increasing the height of substrate, antenna efficiency can be increased and therefore probe feed is better option when efficiency is the prime component. Therefore, in order to have edge feed and larger efficiency both the techniques can be combined together.

**Integrated Feed**

Figure 3 shows the arrangement of integrated feed. It comprises of the microstrip feed and probe feed. The microstrip line feed is designed on the back of the ground plane of the antenna and a probe is connected at the edge of the microstrip feed. This combination can solve the two purposes to have high efficiency and edge feed. Figure 3 shows microstrip line with dashed line and a back dot dot represents probe arrangement along with microstrip feed.



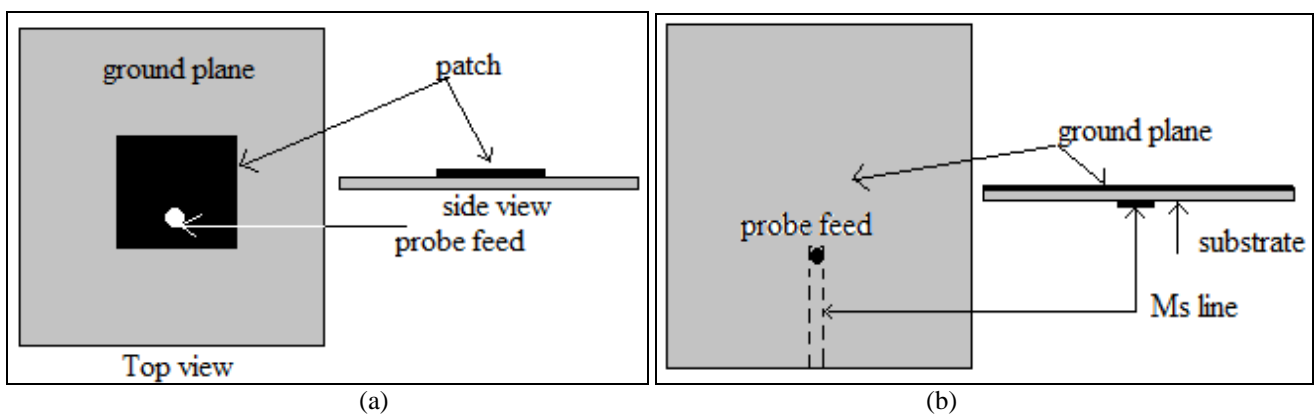
**Fig 3:** A MSA with integrated feed edge.

In order to investigate the impact of integrated feed, three cases are investigated. A simple patch antenna with MS line feed, one probe feed antenna with 1.6 mm height between patch and ground plane and then height is increased to 5 mm. Table 7 shows the impact of these arrangement on antenna efficiency. A patch antenna is designed at 2.4 GHz on FR-4 substrate with thickness of 1.6 mm.

**Table 7:** Impact of antenna feed on efficiency.

Sr. No.	Feed	Efficiency at 2.4 GHz
1	Probe feed with substrate height 1.6 mm	50%
2	MS feed with substrate height 1.6 mm	35%
3	Probe feed with substrate height 5 mm	85%
4	Integrated Feed with substrate height 1.6 mm	70%

It can be observed that when the height of the substrate is increased to 5 mm, antenna efficiency improved to 85% but the feed is behind the ground plane. In order to make an edge feed arrangement, the probe feed is added with a microstrip (MS) line. The arrangement is shown in Figure 3. The integrated feed technique requires two different substrate one single sided for patch, and one double sided for ground plane and microstrip line.



**Fig 4:** (a) Single sided PCB containing only patch (b) double sided PCB with ground plane on top and MS line on bottom.

Since MS line is on second PCB and patch on other, there is no electrical contact between feed and patch antenna. In order to make electrical contact between MS line and feed ground plane is drilled and a conducting wire is inserted to connect patch from top layer with MS line on bottom of second layer. Table 7 shows the comparison among all the four categories of antenna and it can be observed that the proposed feed is better than the MS line feed and gives a 70% efficiency.

**Conclusion**

It is concluded here that probe feed is better feeding technique to have higher efficiency but the feed is always available on the back of antenna. If it is required that the feed should be available at antenna edge then probe feed and MS feed line can be combined to fulfill the need with a good efficiency. The proposed integrated feed technique is a better performer and can give at Least 70% efficiency.

**Reference**

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