Microstrip Slot Array Antennas Fed by A Microstripline With A Multi Tuning Stubs For Multi-Wideband

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***Abstract*-Microstrip slot antenna fed by matching network of microstrip line to increase very wide-bandwidth and multiband is proposed. The microstrip line composed of multi tuning stubs is used to control slots antenna real impedance to match with impedance characteristic of feeding line so that it could increase the bandwidth. The design are achieves good input impedance in the ranges frequency of 1.3 – 5.1 GHz for single slot, 1.1 – 6.4 GHz for two slots and 7.5 – 36.1 GHz for four slots antenna. The measured return loss S_{11} agrees well with the calculated results for single slot as example.**

I. INTRODUCTION

Recently, ultra-wideband (UWB) antenna technology has found for many applications in communication and radar. The one that has potential to be used in the application of UWB technology is microstrip slot antenna (MSAs). MSAs have the advantage of being able to produce bidirectional and unidirectional radiation patterns. An interesting feature of slot antennas is their greater bandwidth because of bidirectional radiation. Slot antennas are less sensitive to manufacturing tolerance compared with patch antennas.

Narrow and wide slot fed by variation of microstrip line has been proposed by many researchers for increasing bandwidth [1]–[6]. The variation of the end strip from edge slot gives variation strength coupling. Fork-like tuning stub microstripline which is for the excitation of wide radiating slot can results impedance bandwidth to 1.1 GHz in the range frequencies of 1.9 – 3 GHz [4]. Nader [5] had proposed microstrip slot antenna with fictitious short circuit concept has impedance bandwidth from 2.3 to 6 GHz. A printed circular disc monopole antenna had designed for UWB systems [6] with impedance bandwidth from 2.78 to 9.78 GHz. A seven narrow slots had used for aperture-staked antenna that can reach in frequency band of 26-40 GHz [7]. At the same time had found a design of multiloop antennas for multifrequency and wide-band characteristics. The multifrequency (multiresonant) operation is revealed as a function of the number of loops [8]. Meanwhile, a E-shaped patch antenna had been design to improved multiband and wide-band of microstrip antenna [9]. To increase the bandwidth of microstrip antenna and also has multiband characteristic at the same design for multi-ultrawideband application is necessary, especially for microstrip slot antenna. In this paper designed of microstrip slot antenna with single layer, so it is easy to fabricate and more efficiency in using the substrate. To increase the impedance bandwidth we proposed an additional of short tuning stubs which is connected in shunt with the fork-like tuning stubs that has configurations of network impedance. The short tuning stub will function as a lumped capacitor for improving impedance matching over wide frequencies [10]. The combination of fork-like microstripline and short tuning stub can call as a multi tuning stubs circuit. The multi tuning stubs can be configured become a simpler network impedance for array antenna to enhance wider bandwidth.

II. ANTENNAS DESIGN

The geometry of the UWB slot antenna fed by microstrip line with a matching tuning stub is shown in Figure 1. The slot and feedline is constructed on the same substrate where the thickness is 0.152 cm, the dielectric permittivity is ε_r =3.2 and loss tangent is 0.0025. The microstrip slot antenna and the feed line are fabricated back to back on the dielectric substrate. The microstrip line is multi tuning stub composed of fork-like tuning stub under the slot and short tuning stub of length l_s which is connected in shunt with the feedline at a distance d_s from the edge of the slot. The fork-like tuning stub consists of a straight section of length l_3 and two branch sections of equal lengths l_2, and the spacing between the centerline of the two branch sections is l_l. For the case discussed here, the dimensions are as follows : l_1=16,66 mm, l_2=23.33 mm , l_3=3,33 mm, d_s=18,33 mm, l_s=3,33 mm, w_f =3,33 mm, W = 60 mm, L = 43,33 mm. The fixed geometry of antenna was computed by using method of moment numerical technique for solve the problems of electromagnetic field with high accuracy in analyze the antenna parameters. The antenna design in program begin by calculating the width of feed line with entry the value of substrate thickness, dielectric constant and desired impedance of 50 Ohm. The boundary condition for this antenna in the program is 377 Ohm on the top and the bottom layer. The frequencies range that analyzed start from 1 GHz to 6 GHz with the frequency step of 0.5 GHz. The impedance bandwidth was achieved by varying the dimension of radiating slot, the position and dimension of fork-like feedline and tuning stub. Based on design in Fig.1, the it was develop for two slots and four slots with the same program. The antenna use two and four slots are fed by microstripline of impedance network with multi tuning stubs technique. It is used two branches of power divider to fed two slots and four branches for four slots.

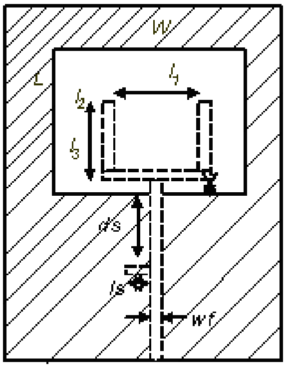

Figure 1. Geometry of ultra-wideband single rectangular microstrip slot antenna

III. RESULT AND DISCUSSION

The proposed antenna for single slot was constructed and measured. Using the Network Analyzer, the measured return loss of the proposed antenna is obtained. The measured return loss S_{11} agrees well with the calculated one. A comparison between measured and simulated return loss characterization of the antenna are shown in Fig. 2, where VSWR ≤ 2 is achieved throughout the band of 1.3 to 5.1 GHz. This impedance bandwidth is achieved by controlling the length of l_1, l_2, l_3, and the distance of d_s. The antenna impedance bandwidth is enhanced by controlling microstripline inserted S ($l_2 + l_3$) under the slot. The coupling effect give low quality factor Q occurs when the microstripline inserted S under the slot approaches $L/2$. The impedance decreases as the microstripline feed S moves more or less from $L/2$. To reduce VSWR on the feedline, a short tuning stub is used for matching the slot over wide frequencies. Wide impedance bandwidth is obtained when short tuning stub at the distance d_s of 18.33 mm. The bandwidth will be narrower when d_s made shorter or longer from the slot edge. The configuration of multi tuning stubs is a impedance matching technique between characteristic impedance of the feed line and the radiating slot. Because of the impedance of the line is real where the radiating element is complex. Thus matching condition can reach by short tuning stub. In this case we used a short tuning stub connected in shunt. The distance of short tuning stub d_s is used to made real part from impedance of radiating slot is the same with the impedance of the feed line. This technique is more effective for increasing bandwidth of slot antenna.

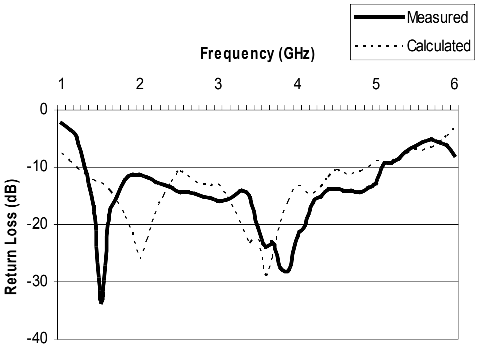

Figure 2. Measured and calculated return loss vs frequency for single slot antenna.

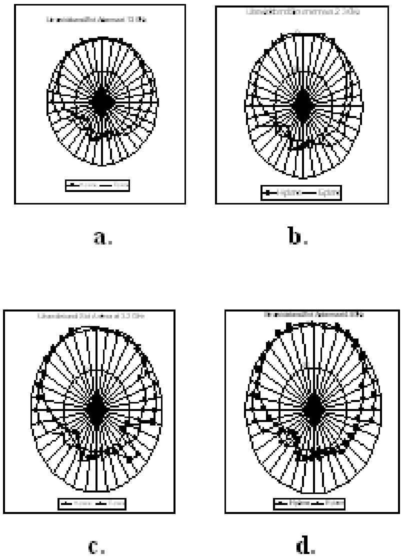

Figure 3. Measured radiation pattern for single slot antenna.

a. At freq. 1.3 GHz
b. At freq. 2.3 GHz
c. At freq. 3.2 GHz
d. At freq. 4.5 GHz

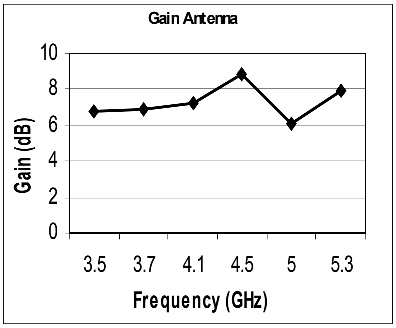

Figure 4. Gain of single slot antenna.

The antenna gain was measured in each step of frequencies from 3.5 GHz to 5.3 GHz. Antenna gains in the range frequencies are reach more than 6 dB, with a peak antenna gain of about 8.9 dB at 4.5 GHz and the 6.87 dB at 3.7 GHz as shown in Fig. 4. Figure 3 shows H-plane and E-plane radiation patterns in frequency steps of 1.3 GHz, 2.3 GHz, 3.2 GHz, and 4.5 GHz, respectively. The results of the proposed antenna have the same polarization planes and similar broadside radiation pattern. From the geometry antenna in Fig. 1, when the slot was made double with using the same substrate (in Fig. 5) has impedance bandwidth of 5.3 GHz from the range frequencies of 1.1 – 6.4 GHz (Fig. 6). All of them have designed with the same program to calculate the antennas. The technique of multi tuning stub serve as network impedance has proven for increasing bandwidth in the wide range frequencies. If we make more branches of multi tuning stubs and slots, the bandwidth antenna will be very wide. The spectacular result is obtained by using four branches of multi tuning stubs form microstrip line to fed four slots antenna. The impedance bandwidth of antenna achieve up to 28.6 GHz in the range frequencies of 7.8 – 36.1 Ghz. If the calculation of four slots antenna made in the range frequency from 0.3 until 100 GHz, the bandwidth antenna is shown multi frequency (multiresonant) operation. Which are each frequencies have wideband characterization as shown in Table 1..

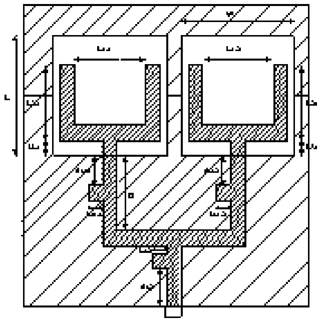

Figure 5. Geometry of ultra-wideband two rectangular microstrip slots antenna ($L_{1,1} = L_{1,2} = 1$ cm, $L_{2,1} = L_{2,1} = 2.5$ cm, $L_{3,1} = L_{3,2} = 0.5$ cm, $D = 2.5$ cm, $ds_{1,1} = ds_{1,2} = 1$ cm, $Ls_{1,1} = Ls_{1,2} = 0.5$ cm, $ds_2 = 1.25$ cm, $Ls_2 = 0.5$ cm, $w_f = 0.5$ cm, $L = 4$ cm and $W = 4$ cm)

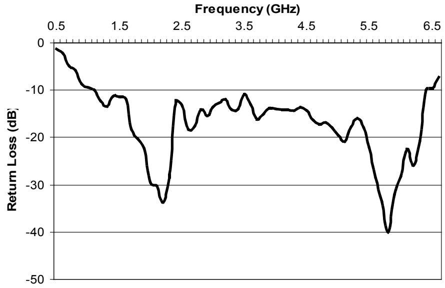

Figure 6. Calculated return loss vs frequency for two rectangular microstrip slots antenna

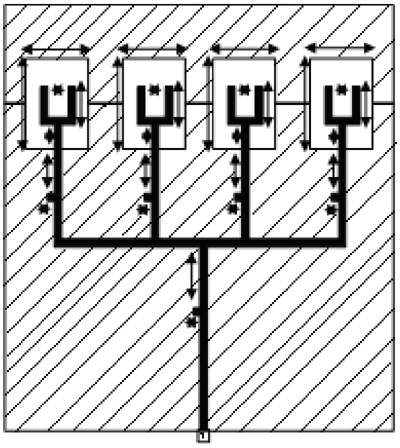

Figure 7. Geometry of four rectangular microstrip slots antenna ($W_1 = W_2 = W_3 = W_4 = 3{,}2$ mm ; $L_1 = L_2 = L_3 = L_4 = 4{,}29$ mm ; $l_{1,1} = l_{1,2} = l_{1,3} = l_{1,4} = 1{,}07$ mm ; $l_{2,1} = l_{2,2} = l_{2,3} = l_{2,4} = 1{,}79$ mm ; $l_{3,1} = l_{3,2} = l_{3,3} = l_{3,4} = 1{,}07$ mm ; $ls_1 = ls_2 = ls_3 = ls_4 = ls_5 = 0{,}357$ mm ; $ds_1 = ds_2 = ds_3 = ds_4 = 2{,}1$ mm ; $ds_5 = 2{,}86$ mm)

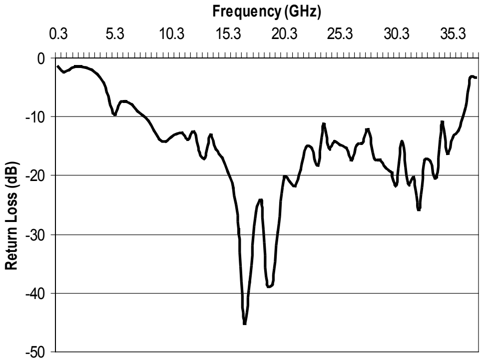

Figure 8. Calculated return loss vs frequency for four rectangular microstrip slots antenna

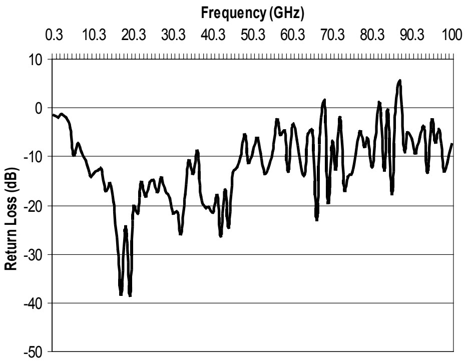

Figure 9. Calculated return loss vs frequency for four rectangular microstrip slots antenna in the range of 0.3 – 100 GHz.

TABLE 1. MULTIBAND OF FOUR RECTANGULAR MICROSTRIP SLOT ANTENNA.

Multiband	Frequency range (GHz)	Bandwidth (GHz)
f_1	7.5 – 36.1	28.6
f_2	36.7 – 47.2	10.5
f_3	52.3 – 55.1	2.8
f_4	61.5 – 63.3	1.8
f_5	65.7 - 66.3	0.5
f_6	69 – 70.1	1.1
f_7	70.5 – 71.1	0.6
f_8	72.9 – 79	6.1
f_9	85 – 85.8	0.8
f_{10}	97.6 – 99.5	1.9

IV. CONCLUSION

This paper presented the microstrip slot antennas fed by microstripline with the multi tuning stub. It was shown from experiment results the impedance bandwidth of VSWR ≤ 2 of the antenna can reach 3.8 GHz for single slot and 5.3 for two slots. The antenna with four slots has very wide bandwidth up to 28.6 GHz and it has multiband characteristic at the same design. The bandwidths will wider when the slots and the multi tuning stubs is added. The matching condition in the multi wide-range frequency was effectively controlled by tuning the stubs under the slots and the short tuning stubs connected in shunt to microstripline. This technique is expandable in array antennas for enhance bandwidth.

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