A Study on broadband slot antenna employing a short strip.

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***Abstract* – A method for widening bandwidth of a planar slot antenna is proposed. This method only requires a short strip in a rectangular aperture of slot antenna. By using this uncomplicated method, we achieved relative bandwidth up to 55.5% for $|S_{11}|\leq 0.5$(VSWR≤3). Additionally, the gain of the antenna shows stability for frequency in the bandwidth. These results indicate that a short strip generate a second resonance.**

***Index Terms* — Broadband antennas, slot antennas, planar antennas.**

1. Introduction

The broadband antennas are required for high speed wireless communication in recent years. In general, the broadband antennas need large volumes/areas due to multi-resonance or multi-feeding structures [1]-[5]. Hence, we previously proposed broadband slot antennas without changing the overall size of antennas [6]. The broadest bandwidth (36.5%) is achieved in the former report when the feed point is located at the center of the rectangular aperture of slot antennas.

In this study, we propose the slot antennas with a short strip in a rectangular aperture of a slot antenna, in order to obtain a much wider bandwidth than former report [6]. The optimum position of a short strip for the broadest bandwidth is studied also.

2. Antenna Structure

Fig.1 shows the geometry of the proposed slot antenna employing short strip. The material of the antenna and short strip is a copper plate with the thickness of 0.1 mm. First, we define f_0=1GHz, the fundamental frequency of a slot antenna. And then, the width of W=100 mm(=$\lambda_0/3$) and the length of L=250 mm(=$3\lambda_0/4$) are fixed. The aperture of a slot antenna, centered with respect to the copper plate, has area of l_s=150 mm(=$\lambda_0/2$) × w_s=1.0 mm(=$\lambda_0/300$). This antenna is fed with a coaxial cable of Z_0=50Ω at the position of $x=x_f$. x_f is fixed to 0, because broadest bandwidth is obtained with this condition in former report. The squared copper strip is added at the position of $x=x_{sp}$.

3. Results and Discussions

The calculated $|S_{11}|$ of the proposed slot antenna as function of x_{sp} are shown in Fig.2. The $|S_{11}|$ of [6] (without short strip) is also shown as reference. HFSS simulator based on finite element method is employed for this calculation. As can be observed from Fig.2, higher resonance frequency than f_0 appears at 1.7 GHz. We define this f_1. The value of f_1 is independent from x_{sp}, it is dependent on l_s. Then the relation between λ_1, wavelength at f_1, and the slot aperture length l_s is derived as $l_s=0.85\lambda_1$. This indicates that quasi full wavelength resonance occurs at that frequency. Next, shifting focus to the bandwidth, it is obvious that the bandwidth increases along with an increase of x_{sp}.

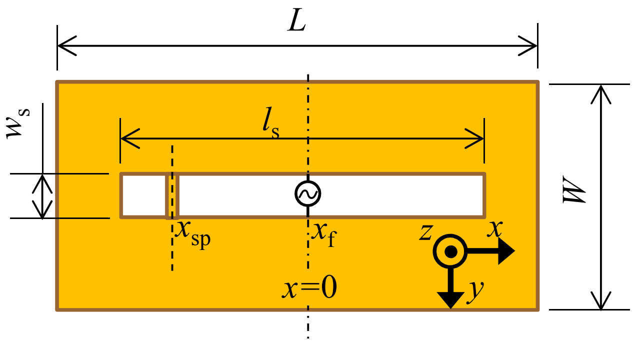

Fig. 1. Geometry of slot antenna employing short strip.

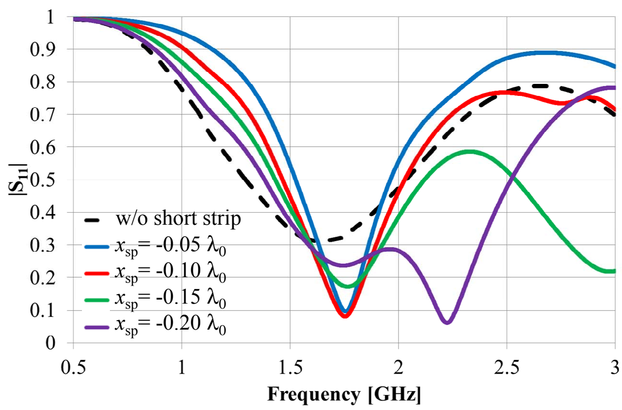

Fig. 1. The calculated $|S_{11}|$ of slot antenna for x_{sp}.

Especially, much higher frequency resonance is observed at 2.2 GHz in condition that the value of x_{sp} is $-0.20\lambda_0$. We define this frequency as f_2. At this frequency, the wavelength λ_2 of 136mm is approximately equal to the shorted slot aperture length $l_s/2+|x_{sp}|$ of 135mm. It is indicated that the full wavelength resonance occurs at 2.2GHz with this length. Fig.3 shows the comparison of simulated and measured results in this condition. The measured result shows the broadband characteristics and a good agreement with simulated result.

The calculated gains of antennas as function of x_{sp} are shown in Fig.4. The Gϕ stands for a ϕ (xy-plane) component of the gain at normal direction of the slot aperture (z-axis). As shown in this figure, the broadband and constant gain is achieved. The broadest bandwidth of the gain is observed in condition of $x_{sp} = 0.20\lambda_0$ in the same manner as $|S_{11}|$ results. It is also observed that the peak values of the gain are about 5.7dBi at 1.7GHz, and are independent on x_{sp}.

The calculated and measured bandwidths when $|S_{11}| \leq 0.5$ (VSWR≤3) are summarized in the TABLE I. It is reveal that the measured maximum bandwidth is achieved 55.5% at $x_{sp}=0.20\lambda_0$, more than 44.5% of [6].

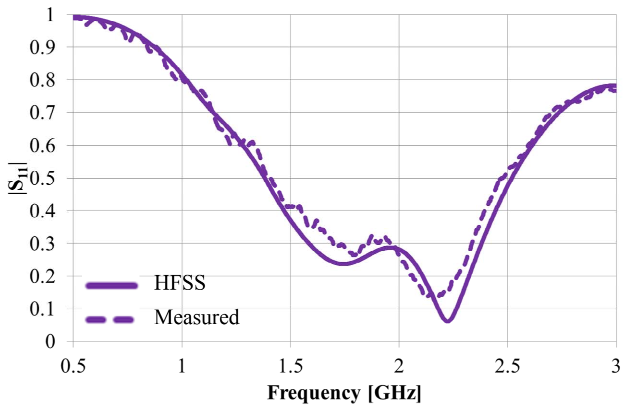

Fig. 1. The calculated and measured $|S_{11}|$ of the slot antenna for x_{sp} (solid : calculated, dash: measured).

TABLE I
Relative bandwidth of the slot antennas for x_{sp}

result	x_{sp}	Bandwidth ($\|S_{11}\|$<0.5)
calc.	w/o short strip	44.5 %
calc.	$-0.05\lambda_0$	25.0 %
calc.	$-0.10\lambda_0$	32.2 %
calc.	$-0.15\lambda_0$	38.7 %
calc.	$-0.20\lambda_0$	58.3 %
meas.	$-0.20\lambda_0$	55.5 %

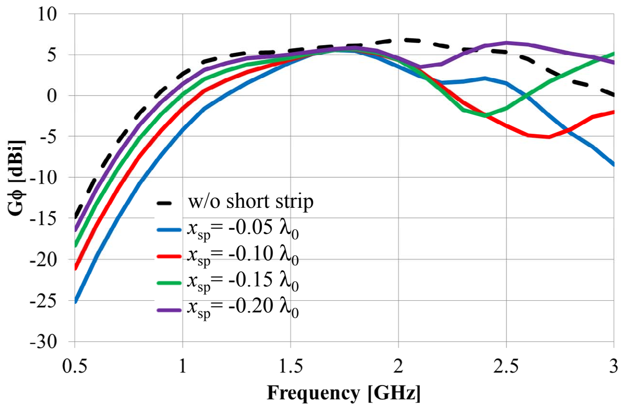

Fig. 4. Calculated Gϕ in normal direction of slot aperture for x_{sp}.

4. Conclusion

The novel method for widening bandwidth of a planar rectangular slot antenna is proposed. The broadband characteristics of $|S_{11}|$ and gain have achieved with putting a short strip in a rectangular aperture of slot antenna. The relative bandwidth for $|S_{11}|\leq 0.5$ is up to 55.5% when the position of the short strip is off-centered at $0.20\lambda_0$. The proposed antenna will be expected to be powerful solution for high speed wireless communication systems, because of uncomplicated structure without changing overall size of antenna.

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