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The Wideband Microstrip Antenna with Capacitive Feed with the Low Level of the VSWR

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In order to increase the operating frequency band of the microstrip antenna by the level of the VSWR ≤ 1.2, we propose to use capacitive feed. Simulation was performed using HFSS. The results showed that the use of capacitive feed can expand the operating frequency band to 16.8 %, while the antenna without capacitive feed was 10.9 %.

Keywords: microstrip antenna, wideband antenna, VSWR, capacitive feed.

INTRODUCTION

Antennas intended for onboard radio systems with a limited power reserve must have a small the VSWR. This is due to the fact that the smaller the VSWR of the antenna, the greater the radiated power (at a fixed input power) and the longer the radio range (at a fixed signal level at the input of the receiver). In addition, such antennas should be small size and not protruding (low profile). The microstrip antennas meet these requirements. However, these antennas often have a resonant frequency characteristic of the VSWR. As a result, the operating frequency band of these antennas is small and, basically, does not exceed a few percent. There are microstrip antennas, whose operating frequency band by level of the VSWR ≤ 2 is 10 % or more [1–5]. However, by level of the VSWR ≤ 1.2 (|S(1,1)| ≤ −20 dB) their operating frequency band is usually less than 10 %. In this regard, an actual task is to develop the wideband microstrip antennas with small the VSWR.

In the previous work [6], such the wideband microstrip antenna with the VSWR ≤ 1.2 in the frequency range of 1.87–2.07 GHz was developed (operating bandwidth – 200 MHz or 10.9 % relative to 1.87 GHz). The antenna had a square reflector with the width of 100 mm or ≈0.7 λ at the upper frequency of the operating frequency band.

The aim of this work was to increase of the width of the operating frequency band by the level of the VSWR ≤ 1.2 and reduce the operating frequencies of the previous antenna while maintaining the size of its reflector.

ANTENNA DESIGN

The antenna design is shown in Fig. 1. The antenna is the microstrip antenna having two microstrips (*E* and *U*-form) and the reflector.

In the previous work [6], a coaxial cable core was connected to an *E*-form microstrip. An additional rectangular microstrip was used to expand the operating frequency band (highlighted in color in Fig. 1*b*). The designation of the dimensions of an additional rectangular microstrip is shown in Fig. 1*c*, where *w* is the width and *l* is the length.

This microstrip is connected to a 50 Ohm coaxial cable core. The excitation of the *E*-form microstrip is carried out by means of a capacitive coupling between it and an additional rectangular microstrip. This excitation is called capacitive (capacitive feed) [7–8].

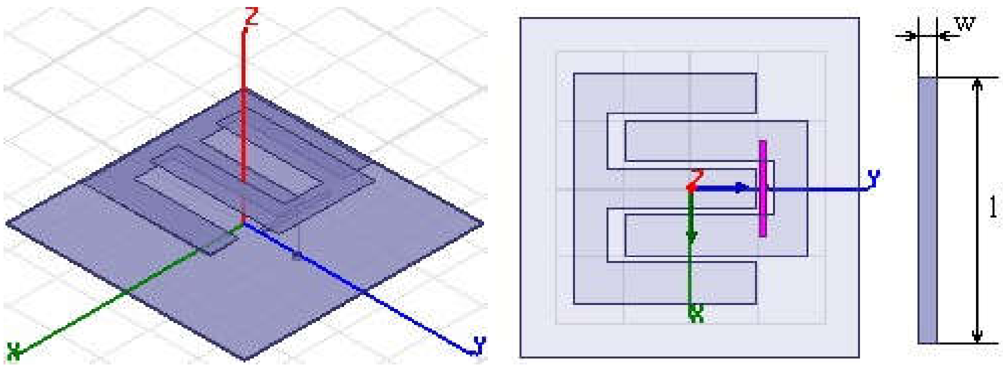

Figure 1. Antenna design: general view (*a*); top view (*b*); rectangular microstrip (*c*)

THE RADIATION CHARACTERISTICS OF THE ANTENNA

Let us consider the radiation characteristics of the antenna. Characteristics were studied in the frequency range 1.6–2.1 GHz with 10 MHz step. Simulation was performed using HFSS[1].

Fig. 2–4 are shown the frequency characteristics of the VSWR, gain and radiated power for different values *w* (*l* = 28 mm).

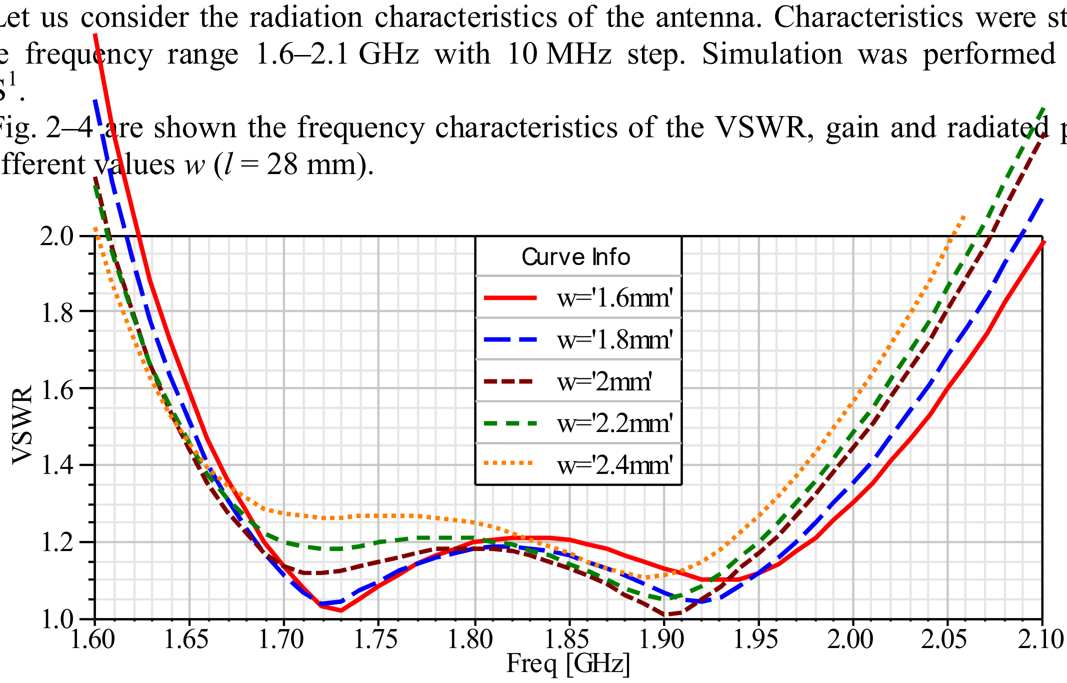

Figure 2. The frequency characteristics of the VSWR

[1] Available at https://www.ansys.com/products/electronics/ansys-hfss

From Fig. 2 it is seen that the largest operating bandwidth by the level of the VSWR ≤ 1.2 has the antenna with w = 1.8 mm. The decrease in w leads to a shift in the operating frequency band towards the upper frequencies and an increase of the VSWR in the frequency range of 1.80–1.95 GHz. The increase of w leads to a significant reduction in the operating frequency band by the level of the VSWR≤1.2.

Fig. 2 are shown that the operating frequency band of the antenna with w = 1.8 mm is in the frequency range of 1.685–1.968 GHz (bandwidth – 283 MHz or 16.8 % relative to 1.685 GHz). For comparison, the previously developed [1] microstrip antenna had the VSWR ≤ 1.2 in the frequency range of 1.87–2.07 GHz (bandwidth – 200 MHz or 10.9 % relative to 1.87 GHz). That is, the use of capacitive feed allowed reducing the operating frequencies of the antenna and increasing the operating frequency band by 83 MHz.

Fig. 3 are shown that the change in w leads to a slight change in the gain (less than 0.1 dB). This is because the gain is more dependent on the size of the antenna, which has not changed. Antenna gain with w = 1.8 mm (in the operating frequency band by the level of the VSWR ≤ 1.2) is in the range of 8.0–8.5 dB.

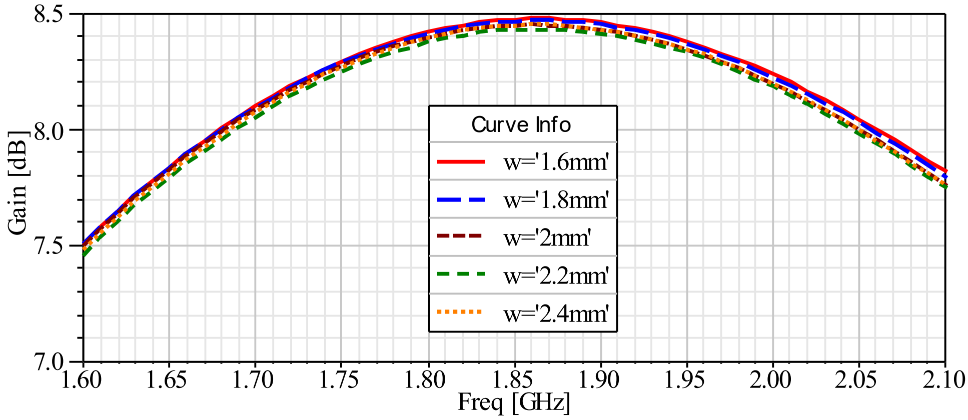

Figure 3. The frequency characteristics of the gain

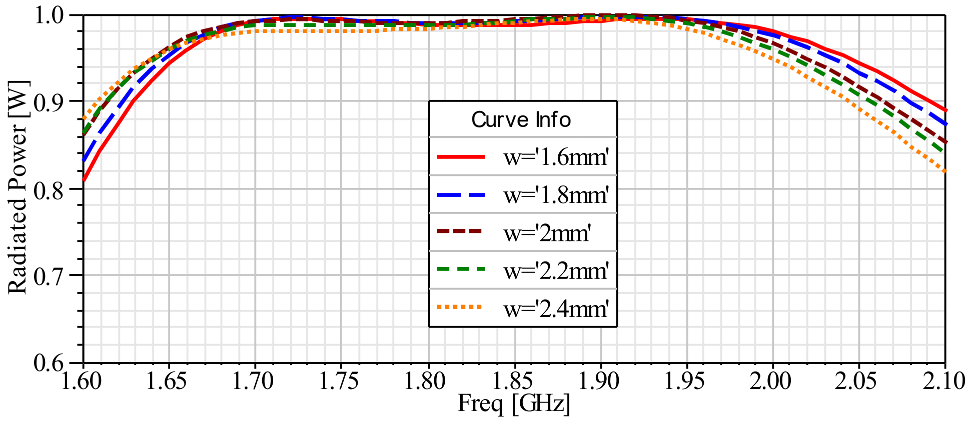

Figure 4. The frequency characteristics of the radiated power

From Fig. 4 it is seen that increasing w leads to a decrease of the radiated power at frequencies of more than 1.95 GHz and an increase at frequencies of less than 1.68 GHz. These changes are associated with changes in the VSWR of the antenna.

Fig. 4 are shown that the radiated power of the antenna with w=1.8 mm (in the operating frequency band by the level of the VSWR ≤ 1.2) is in the range of 0.99–1.00 W (input power – 1 W). This makes it very profitable to use the developed antenna in onboard radio systems with a limited supply of power.

Fig. 5–7 are shown the frequency characteristics of the VSWR, the gain and the radiated power for different values l (w = 1.8 mm).

Fig. 5 are shown that the maximum bandwidth of the operating frequency band by the level of the VSWR ≤ 1.2 of the antenna with l = 28 mm (283 MHz – in the frequency range of 1.685–1.968 GHz). The change in l leads to a shift in the frequency characteristics of the VSWR, an increase of the VSWR and a decrease in the bandwidth of the operating frequency.

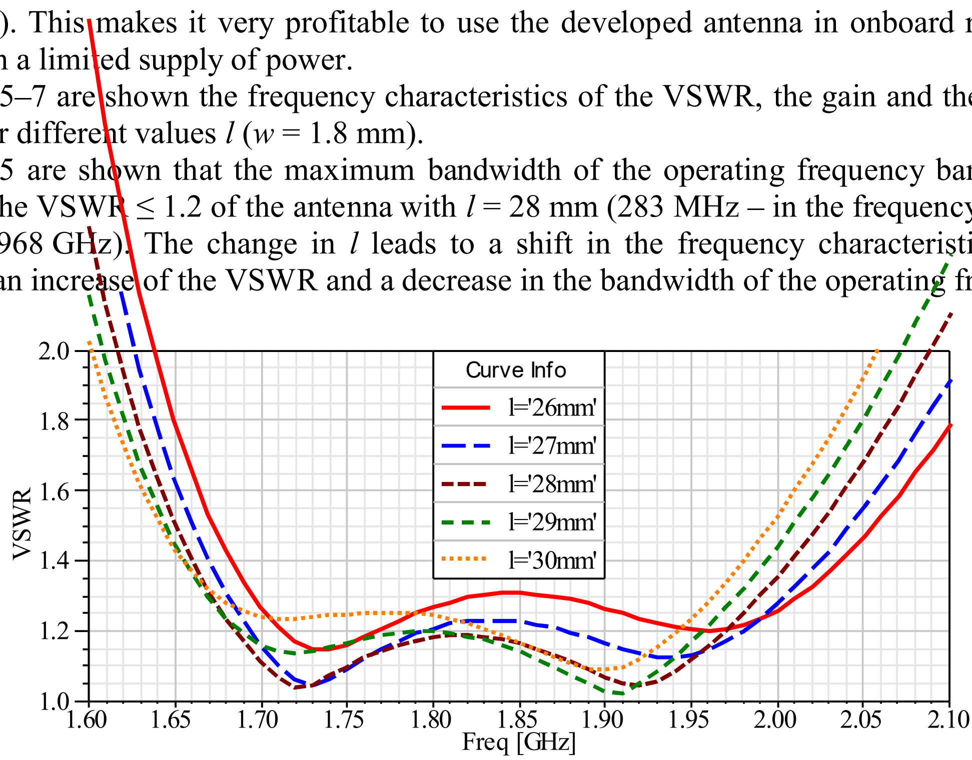

Figure 5. The frequency characteristics of the VSWR

Fig. 6 are shown that the change in l leads to a small change in the gain (less than 0.1 dB). The highest value of the gain in the operating frequency band by the level of the VSWR ≤ 1.2 is observed at l = 28 mm.

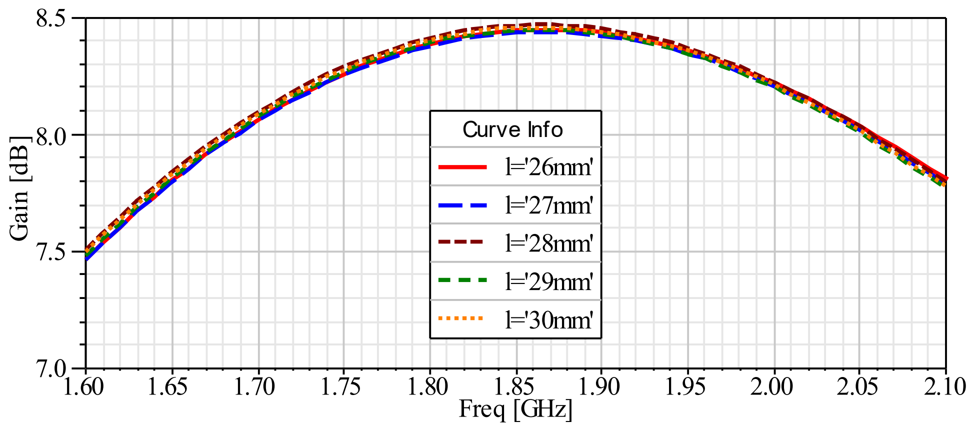

Figure 6. The frequency characteristics of the gain

Fig. 7 are shown that the highest radiated power in the operating frequency band by the level of the VSWR ≤ 1.2 has an antenna with l = 28 mm – more than 0.99 W (power at the antenna input – 1 W). The increase of l leads to a shift in the frequency characteristics of the radiated power towards high frequencies, and the increase of the direction of low frequencies.

Analyzing the dependence of the radiation characteristics of the antenna can conclude that the highest the bandwidth of the antenna by the level of the VSWR ≤ 1.2 has the antenna with the dimensions of a rectangular microstrip $w \times l$=1.8 × 28.0 mm^2.

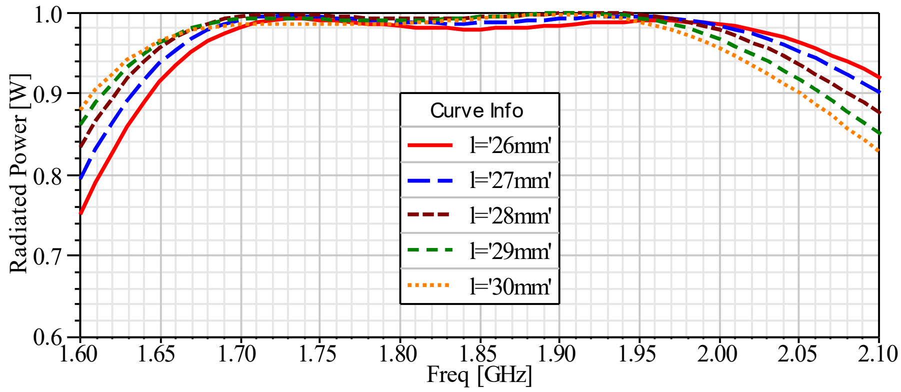

Figure 7. The frequency characteristics of the radiated power

CONCLUSION

Thus, the use of a capacitive feed with the dimensions of a rectangular microstrip $w \times l$=1.8 × 28.0 mm^2, has allowed to increase of the bandwidth of the antenna by the level of the VSWR ≤ 1.2 with 200 MHz (1.87–2.07 GHz) to 283 MHz (1.685–1.968 GHz) or 16.8 % relative to the minimum operating frequency (10.9 % at the source [6]). In the operating frequency band, the radiated power of the antenna exceeds 0.99 W, and the gain is in the range of 8.0–8.5 dB. The obtained characteristics make it very profitable to use the developed wideband antenna in onboard radio systems with a limited supply of power.

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