Wideband Microstrip Antenna

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Abstract— The article concerns the issue of narrow-banding of microstrip antennas. In the article methods of increasing operation bandwidth of microstrip antennas have been presented and examples of the structure of microstrip antennas with significant working band have been shown. Results obtained during simulation and design of antennas have been confirmed through the measuring way.

1. INTRODUCTION

A fast development of technology of wireless Internet access and requirements of meeting norms imposed on WLAN, WiMAX and other wireless network technologies extort the demand for devices, which apart from reliability and functionality, will be characterized by a small size. Since a necessary element of each wireless system is antenna, it forces also on these elements miniaturization as well as possibility of operation in more than one frequency band. Antennas which due to their properties best meet the above requirements are microstrip antennas [4, 5].

Narrow band is the main defect of microstrip antennas. Typical working bandwidth of antenna is almost always too small. Currently wireless communication systems need antennas with broad frequency band. For instance, cellular telephony systems (GSM 900: range: 890–960 MHz) require band: 7.5%, for GSM 1800 (range: 1710–1880 MHz) band at the level 9.5% is necessary and for systems UMTS 12.2% [6, 7]. To meet these not easy requirements special methods have been designed for broadening frequency working band of microstrip antenna such as: increase of thickness of dielectric base, application of structures using electromagnetic coupling with an extra radiant patch or parasitic elements, two-layer configurations supplied by coupling with aperture, introduction of matching elements in the radiant patch supply system, e.g., supply by capacitance [1–3].

2. METHODS OF INCREASING WORKING BAND

One of basic problems connected with using planar antennas in radio communication links is their relatively narrow frequency working band, which has been mentioned in Introduction. Increase of frequency working band of planar antenna can be realized through using

- frequency-retuned planar radiators,
- dual-frequency radiators,
- multilayer structures [4];

The simplest way for broadening working band of microstrip antenna is conducting it on its thicker base under a radiant patch. Disadvantages of this method is the fact that thicker dielectric base decreases antenna efficiency and is conducive to occurrence of surface waves, thereby causing undesirable effects in radiation characteristics. Moreover along with the increase of base thickness problems with coaxial probe supply appear.

Retuning of antenna frequency band is obtained by change of resonant frequency of planar radiator, which with its determined dimensions depends on permittivity of dielectric base [4, 6]. There are three ways to change that permittivity. One of them is that varactor diodes are inserted into the dielectric area and they can be used to change value of its permittivity. In a similar way one can influence permittivity of dielectric base by placing pins in it which contain radiator and conductive base in selected points. Third method is that between dielectric layer and conductive base an air-gap is used which decreases effective permittivity of the area between radiator and that base [1, 8–10]. It should be stressed that in these cases we do not deal with actual broadening of working band but only with a possibility of retuning work frequency of such antennas.

Some variant of the described above frequency-retuned planar radiators are dual-frequency radiators which have two various resonant frequencies. It can be carried out with the use of planar radiator stimulated to work in properly selected two kinds of its stimulation with which such an antenna maintains the same or similar electric properties. The other way to obtain dual-frequency work of planar radiator is its loading with reactance element in the form of shorted asymmetric strip line. A similar result can be obtained by using two-layer planar antenna [2, 3, 11, 12].

In the situation when retuned or dual-frequency planar antenna does not meet requirements for frequency working band resulting from the system needs, absolute broadening of its working band is necessary by using planar structures: two-layer with electromagnetic coupling, multilayer supplied by capacitance or multilayer with radiant elements coupled with aperture [13, 14].

A different unmentioned above method of increasing working band of planar antenna is using for building such an antenna dielectric base with properly large thickness. However this method has a number of drawbacks, e.g., it reduces efficiency of antenna radiation and is not recommended to be used in practice.

We can obtain the broadband character of antenna by using additional radiant patches coupled directly with radiant or non-radiant edges of rectangular microstrip antenna. In such configuration bandwidth can be even up to 5 times higher than in antenna with one rectangular radiator. Nevertheless broadening of antenna working band is obtained at the cost of increase of antenna dimensions. Moreover, by choosing radiators with slightly different resonant lengths we will induce modes at frequencies close to each other. Thus the band will be broadened more than in case of antenna with one extra radiator coupled directly.

In multilayer structures radiant elements supplied by capacitance provide significant broadening of frequency bandwidth of microstrip antennas. Typical values of bandwidth for such configurations comprise within the range from 15 to 60% [5].

3. BROAD-BAND MICROSTRIP ANTENNA WITH RECTANGULAR RADIATOR

The basic antenna structure consists of rectangular radiator supplied by symmetric microstrip line and shield.

The antenna was made on FR-4 basewith thickness of 1.6 mm and permittivity equal to 4.4 mm. Width of feeder is 2.5 mm.

Rectangular radiator with dimensions 16.6 mm × 12.4 mm was placed within the distance of 11.65 mm from the left base edge and within 11.75 mm from the right base edge. In the middle of the lower edge of radiator symmetric microstrip feeder was placed. It was 2.5 mm wide and 13.6 mm long and placed within the distances of 18.8 mm and 18.7 mm from the base edge. On the other side of the base shield with dimensions 40 mm × 12.5 mm was placed by the base lower edge. The whole metallization was made of copper of 0.4 mm thickness. The designed antenna is connected to 50 Ω SMA joint. The antenna was designed to work in frequency band from 4 GHz to 8 GHz. The model and dimensioning are presented in Figure 1.

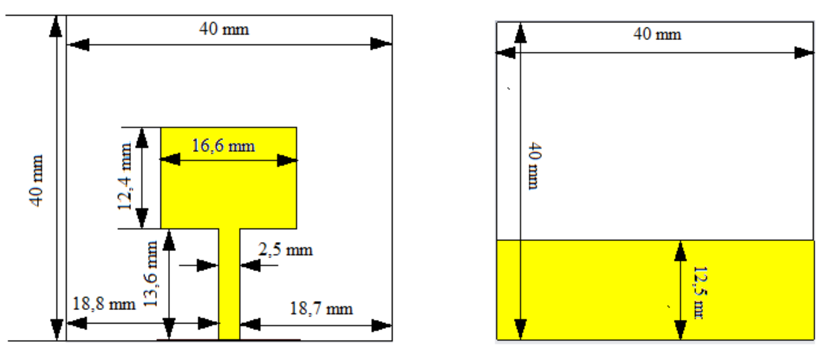

Figure 1: Structure of broad-band antenna with rectangular radiator.

To make an analysis and simulation of antennas the CST environment has been used.

4. BROAD-BAND MICROSTRIP ANTENNA WITH U-SHAPED RADIATOR

The second project presents configuration of broad-band microstrip antenna with U-shaped radiator. The antenna structure consists of U-shaped radiator, supplied by asymmetric microstrip line and shield. Asymmetric feeder means that it was placed asymmetrically towards the lower edge of radiator. That antenna, like the previous one, was made on FR-4 base with thickness of 1.6 mm and permittivity 4.4.

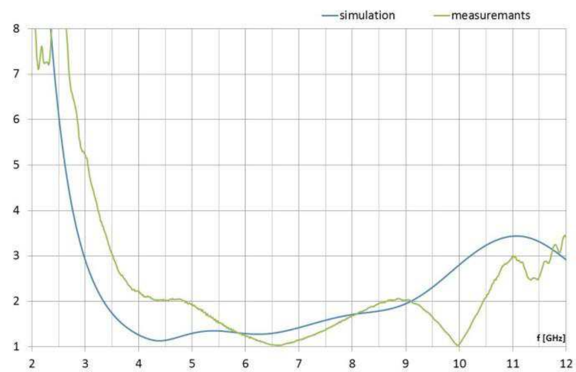

Figure 2: SWR of antenna with rectangular radiator.

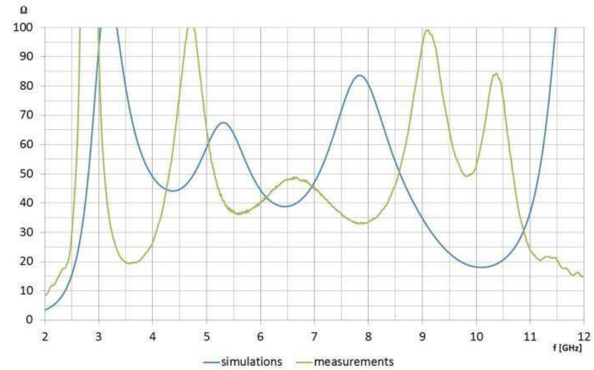

Figure 3: Input resistance of antenna with rectangular radi-ator.

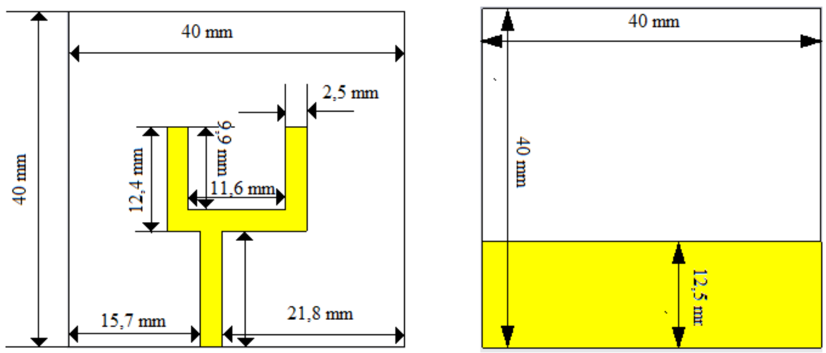

Figure 4: Structure of broad-band antenna with U-shaped radiator.

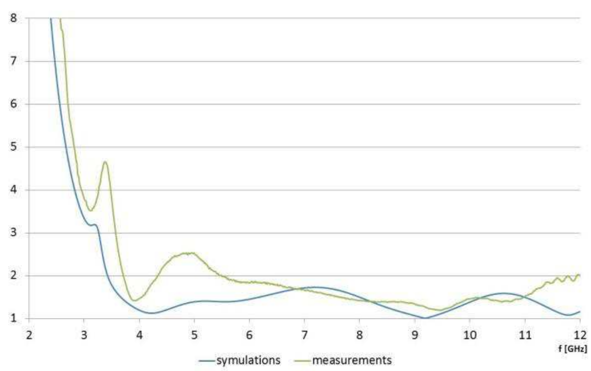

Figure 5: SWR of antenna with U-shaped radiator.

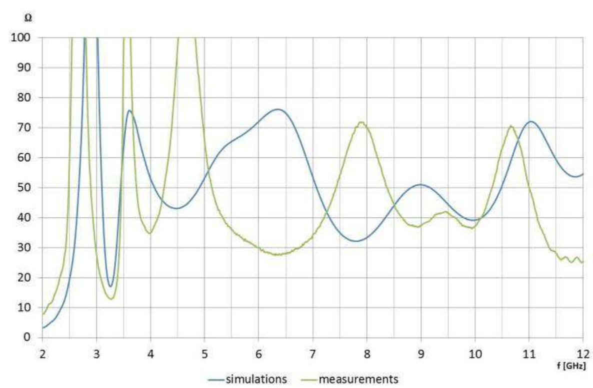

Figure 6: Input resistance of antenna with U-shaped radiator.

U-shaped radiator is 2.5 mm wide, lower edge is 16.6 mm, side edges are 12.4 mm, whereas 'incision' giving radiator the shape of letter U has dimensions: 11.6 mm × 9.9 mm. Asymmetric feeder with dimensions 13.6 mm × 2.5 mm was placed within the distance 15.7 mm from the base left edge. Back of the antenna looks the same as in the first project. The antenna was connected to 50 Ω SMA joint. Asymmetric feeder and U-shaped radiator allowed to broaden the band. An expected working band is 4 GHz to 10 GHz.

5. MEASUREMENTS OF RADIATION CHARACTERISTICS

In order to check correctness of the conducted in the previous chapter analysis and verification of parameters of the obtained final mathematical model of antenna, experimental measurements of radiation characteristics of physical model of antenna built on the basis of the results obtained during the simulation process have been carried out.

In Figures 8–11, juxtapositions of radiation characteristics of the analysed antennas in planes V and H for three selected frequencies within antenna working band have been presented.

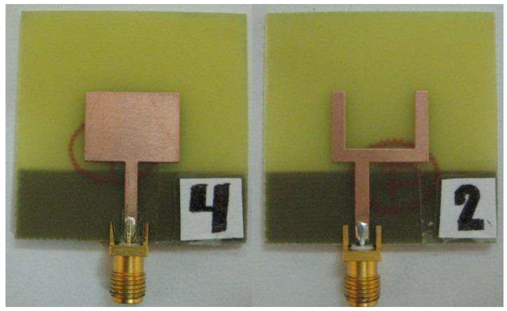

Figure 7: The look of tested antennas.

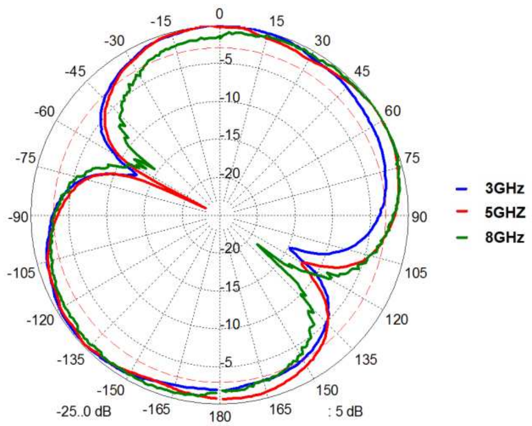

Figure 8: Juxtaposition of radiation characteristics of microstrip antenna with U-shaped radiator for different frequencies from working band in V polarization.

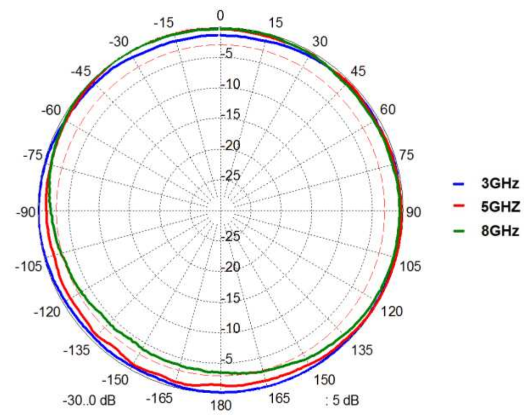

Figure 9: Juxtaposition of radiation characteristics of microstrip antenna with U-shaped radiator for different frequencies from working band in H polarization.

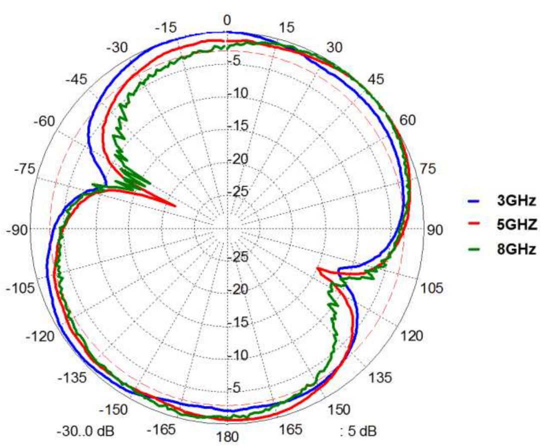

Figure 10: Juxtaposition of radiation characteristics of microstrip antenna with rectangular radiator for different frequencies from working band in V polarization.

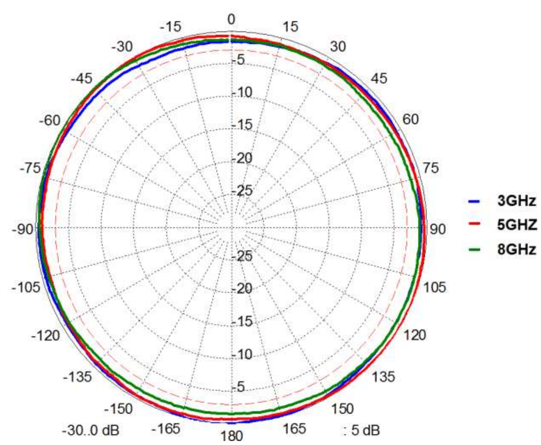

Figure 11: Juxtaposition of radiation characteristics of microstrip antenna with rectangular radiator for different frequencies from working band in H polarization.

6. CONCLUSIONS

The presented antenna models allow to use all current positive properties of planar antennas with simultaneous work in wide frequency range, which is most often the main reason for limitations in using microstrip antennas in many constructions. Taking into account tendencies for miniaturization of aerial devices and development of radio technologies and integrated systems the presented in the article structures seem to be very prospective. The structure of this antenna is a modern solution of aerial device with compact form, which is particularly important in situations of using it on movable objects. The designed antennas operate within the band 4 to 10 GHz and certainly they can be alternative to antennas which are currently used and operating in this band. The results of the conducted measurements fully confirm the possibility of designing planar antennas working in wide frequency range.

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