

Extension of the operating band of printed emitters using distributed excitation

Dmitriy Voskresenskiy, Elena Ovchinnikova*, Nguen Dinh To, Pham Van Vinh, and Ye Htut Khaung

Moscow Aviation Institute (National Research University) "MAI", 125993 Volokolamskoe Highway, 4, Russia

Abstract. Models of printed emitters are developed. The possibility of expanding the operating band with the help of spikes is displayed. The directional and frequency characteristics of printed emitters are determined.

1 Extension of the operating band of the strip emitter with spike matching elements

One of the main guidelines for the development of antenna technology is the expansion of the operating band [1-6]. Broadband emitters are required to create digitally controlled beamforming antenna systems. The general requirements for the operating frequency band and beam width, known for similar arrays are excluded in digital chart formation, which makes it possible to realize ultra-wideband (UWB) antennas. Unlike analog excitation systems, which use frequency or phase beam control, in digital chart formation scanning can be performed using temporary methods by means of shift registers [7-9]. Switching to modernized systems leads not only to an increase in frequency, but also to an expansion of the operating band. With that said, the development of broadband printed antennas is particularly relevant, which would allow performing a radiating and exciting system in a single technological process. The structure of printed antennas allows you to switch various parameters on a wide scale such as base materials and shapes, types of exciters, configurations of emitters, etc. Light-weight and compact design of such antennas allows you to place them on mobile carriers. The multilayer printing technology is currently mastered [10-12]. Its main advantage is high reliability and density of the elements. However, emitters made using printing technology have a narrow band. Among the disadvantages can also be attributed to the loss, which complicate the construction of data transfer antennas.

There are ultrawideband (UWB) emitters such as complementary structures, long-wire antennas, etc., which are placed in open space. When these broadband antennas are placed above the screen base, they are transformed into micro-band resonators. The radiation occurs due to the gap emitters formed at the structure edge. Since this radiation is not intense enough, a high quality factor of the system is obtained, which limits its operating

* Corresponding author: oea888@gmail.com

band. If the radiation takes place from the surface of the emitter, then the screen leads to a significant change in the shape of the beam, which depends on the size of the screen and the thickness of the dielectric. This research paper we consider a number of options for expanding the band of printed emitters and presents the results of modeling printed emitters of various configurations. In order to ensure the expansion of the band, it is desirable to maintain the shape of the angular pattern (AP) of the element, and design modifications lead to a violation of the desired shape of the angular pattern. As it is known, the amount of stored reactive electromagnetic energy determines the operating band of the emitter. In low-frequency technology, an increase in volume is used to expand the operating band of the antennas. This direct way into microwave scanning unit leads to distortion of the angular pattern, therefore, an increase in size is unacceptable. To obtain broadband radiation, it is necessary to meet a number of conditions: the broadband excitation device that matches and emits elements.

Fig. 1a shows a printed radiator excited by a coaxial line with a shock drag of 50 Ohms. The excitation of the same print emitter with a single-ground-plane line has a narrower band. To expand the band, it was offered to introduce three spikes from the side of the base to the partial depth of the dielectric layer in Fig. 1b. Calculations of various options showed the best depth of the spikes.

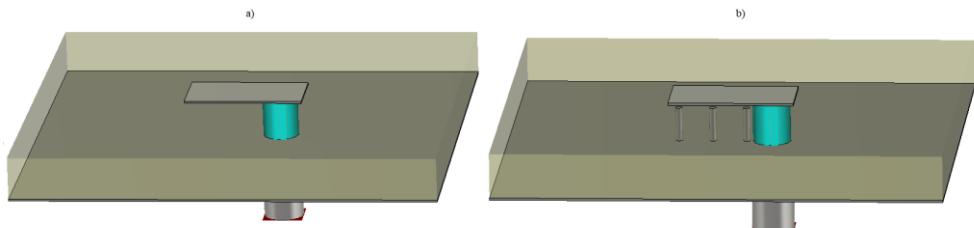


Fig. 1. Models of printed emitters without spikes (a) and with spikes (b).

This allowed to expand the band approximately 2.5 times as agreed. The simulation of the print emitter shown in Fig. 1a and 1b was carried out using the CST Microwave studio electrodynamic simulation program using the space-time method. **Fig.2** shows the dependencies of the SWR on the frequency of the emitter without and with spikes.

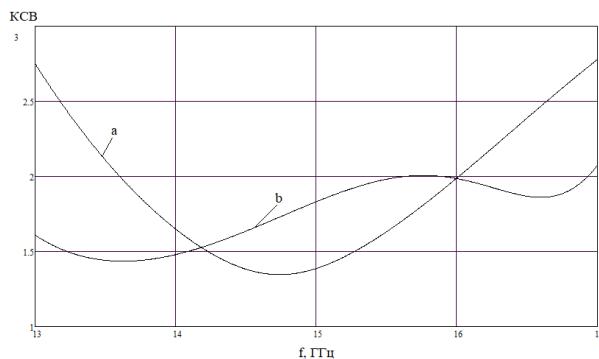


Fig. 2. Dependencies of the SWR on the frequency of printed emitters without spikes (a) and with spikes (b).

The expansion of the band is achieved through the change in the field inside the resonator, which leads to a redistribution of currents in the radiating slots. Fig. 3 shows the space angular patterns of the emitters.

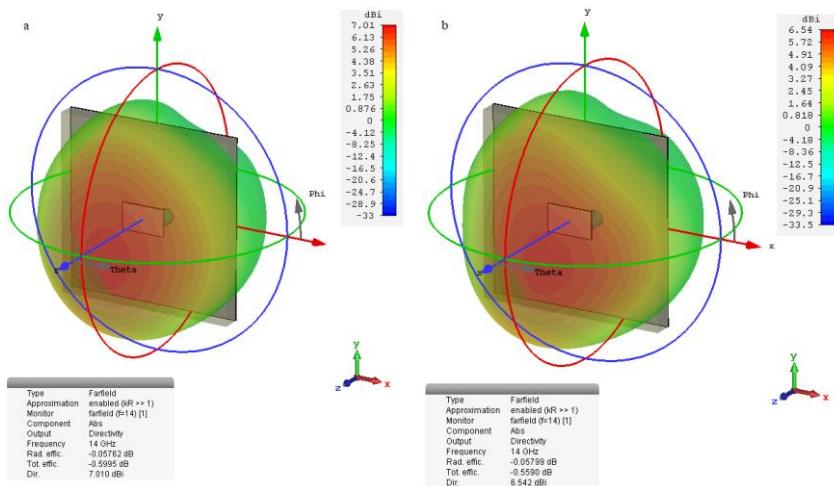


Fig. 3. Space radiation patterns of printed emitters without distributed excitation (a) and with distributed excitation (b).

It is clear from the calculations that the spikes have a weak effect on the shape of the pattern and lead to a decrease in the directivity factor. **Fig. 4** shows the dependencies of the directivity factor on the frequency of printed emitters.

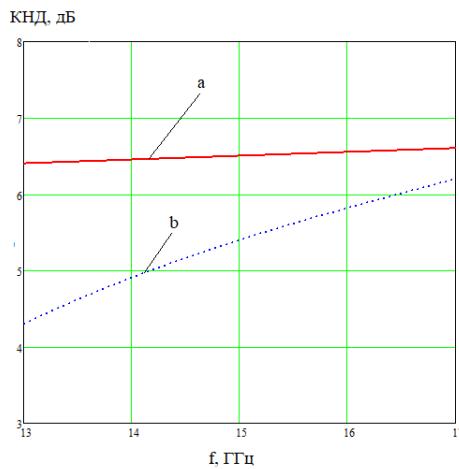


Fig. 4. Dependencies of the directivity factor on the frequency of printed emitters without spikes (a) and with spikes (b).

The physics can be explained in the following way: the inserted spikes concentrate the electric field, which increases the stored electric energy. At the same time, an increase in reactive energy leads to a decrease in the radiation efficiency.

We considered the characteristics of emitters made of real Rogers RO3200 dielectrics with high mechanical strength. The introduction of the spikes reduces the dielectric strength of the antenna, however, when using an element in the antenna array this will not lead to a deterioration of the main characteristics of the phased array antenna (PAR). Unlike other methods of band expansion, the use of spikes does not change the beam shape. A number of attempts were made to change the operating band by inserting additional elements to the design; however, this did not lead to good results, because the magnitude of the reactive field simultaneously changed the directional characteristics.

2 Modeling a printed slit emitter with distributed excitation

One of the possible options to expand the operating band of printed emitters is the output of emitting currents from the resonator to the outer surface of the printed emitter. This technology is known for emitters placed in open space. When placed on a dielectric with a base, the same emitting system acquires other properties. There are other possible ways to expand the operating band of printed emitters placed above the screen by distributed excitation. Further expansion of the band requires a change in both the excitation system and the radiation system. The smallest changes in the angular pattern have a linear emitter with a uniform distribution of currents or fields longwise. Such a radiator can be a split with balanced excitation, which can be implemented using a waveguide or a horn. **Fig.5** shows a model of a slot emitter excited by a horn. **Fig.6** shows the dependence of the SWR on the frequency.

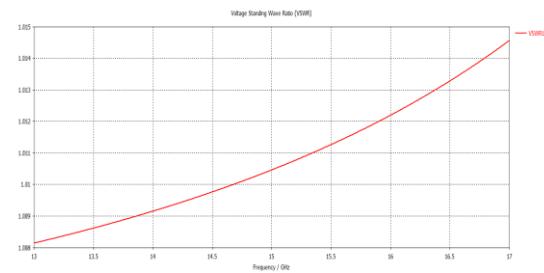
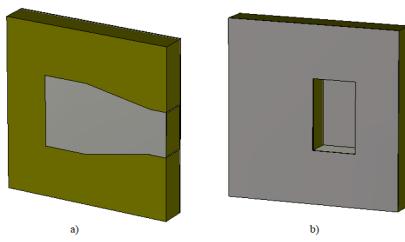


Fig. 5. Emitter model: bottom view (a) and top view (b).

Fig. 6. Dependence of the SWR on the frequency.

Fig.7 shows the space emitter patterns.

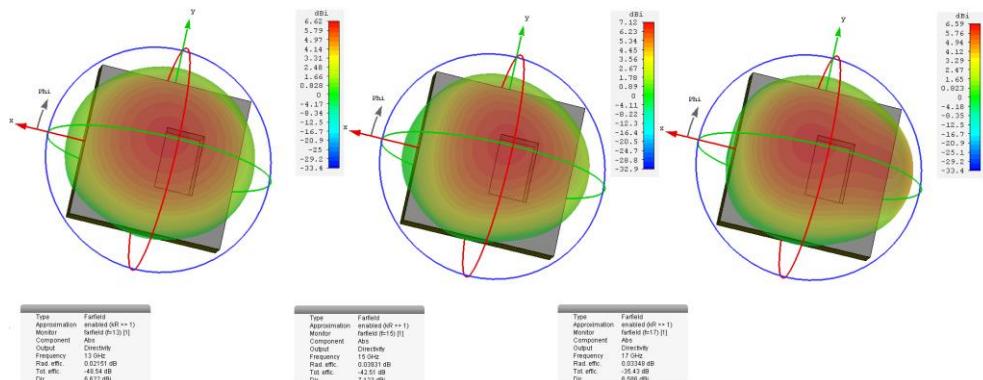


Fig. 7. Space patterns of printed emitters.

The investigated emitter designs were modeled taking into account the characteristics of base made built using the Rogers RO3200 series dielectric.

3 Conclusion

Design models for calculating print emitters of various types have been developed. The possibility of expanding the operating band of printed emitters and slot emitters using spatial excitation is shown. The directional characteristics and frequency characteristics of the emitters are determined.

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