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S-BAND PLANAR STRIP ARRAY ANTENNAS WITHOUT DIELECTRIC SUBSTRATE

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Abstract

Novel designs of two S-band 4-elemnt (2×2) planar strip array antennas for wireless local area networks (WLAN) exploring the standard IEEE802.11b)g) are presented. The radiating elements of the proposed arrays are metal strip stacked patches, that allow to achieve frequency bandwidth more than 10%. The distinguishing feature of the designs is that strip arrays are air filled and completely free from using any dielectric substrates for holding the radiating patch elements. Manufactured prototypes of the arrays demonstrate good mechanical stability of proposed approach. Measured radiation patterns and frequency characteristic of VSWR are well agreed with theoretical models.

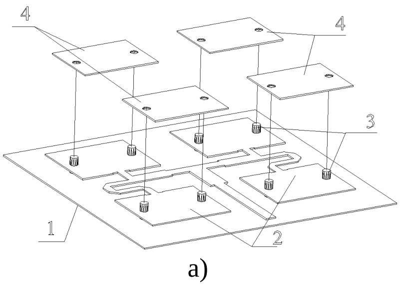
Keywords: Microstrip antenna, microstrip antenna array, stacked patch antenna

1. INTRODUCTION

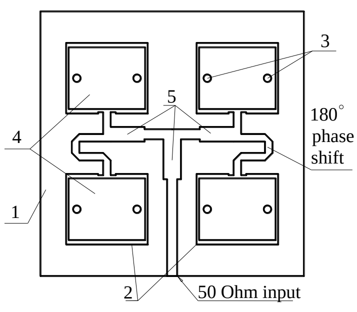
Lower frequency bandwidth and handling power together with dielectric losses are certainly among fundamental disadvantages of microstrip antennas comparing with waveguide horn radiators. It is now well known that there are several ways to increase frequency bandwidth of microstrip antennas: increase substrate thickness [1], use of coupled patch resonators (for example stacked patch design [2]) or use patch resonators with additional energy stored elements like slots and stubs [1]. Stacked patch technology appears to be more attractive comparing with other methods as far as it can potentially increase the frequency bandwidth up to the 50%. Still this technology when applying it to the practical developing of antenna arrays has serious drawbacks. First, in order to realize stacked patches one need to use two or more relatively expensive high frequency copper laminated dielectric substrates. Cost of the commercially available substrates (for example-based on PTFE) become playing a strict limitation role when one try to push multilayered microstrip antennas to mass market. Second, multilayered structure by itself is delicate, not free from intrinsic air gaps, characterized by dielectric losses and has no protection against mechanical and weather influences. So in practice multilayer microstrip antennas require separate mechanically strict weatherproofing plastic box. Paper [3] was pioneered in development of a new promising concept of air filled single strip patch radiators in order to avoid mentioned limitations. Aim of the presented work is the implementation of proposed in [3] concept to the design of planar strip air filled array antennas that is low-loss, reliable and suitable for serial production. Developed array antennas can be applied in the content of modern high speed wireless networks at the frequency range 2,4…2,48 GHz (or similar in S-band). Section 2 contains the description of two different designs of air filled planar 2×2 strip arrays antennas named here array antenna A and array antenna B. Section 3 represents their measured characteristics both with photos of manufactured samples.

2. ARRAY ANTENNA DESIGNS

Geometry of array antenna A is shown in Fig 1. Bottom thick metallic plate with sizes 205×205 mm (pos. 1 in Fig 1) is a screen for 2×2 radiating stacked patch elements. Simultaneously it is functionally a strict mechanical base for them. Pos 2 in Fig 1 is complex strip multielement configuration that integrate input 50 Ohm asymmetric strip line, power dividers,



a)

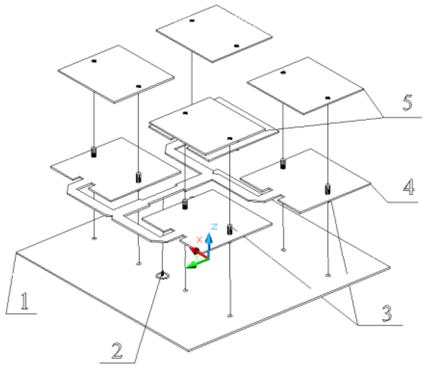


b)

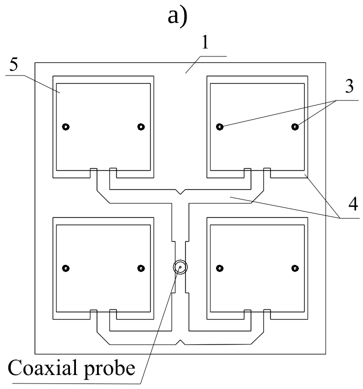
Fig. 1. Array antenna A geometry: a) 3D view, b) top view.

ers of reactive type, two strip 180° delay lines and 4 (2×2) lower patch resonators of stacked patch radiators. This strip structure is fixed 2 mm above the screen plate with the help of 8 metal cylindrical holders (Pos 3 in Fig. 1). These holders also in two points support upper patch resonators (pos. 5) parallel to strip configuration and metal screen plate. The difficulty here to ensure the constant value of air gaps between strip elements and screen metal plate. Still according to our experience 8 holders is enough to guarantee manufactured errors being not exceed ±0,5 mm in described configuration.

Planar air filled strip array antenna B is shown in Fig. 2. It is based on a similar design idea, where pos.1 – metal screen; pos. 3 – cylindrical metallic holders; pos. 4 – functionally integrated multielement strip configuration; pos. 5 – upper patch resonators. The differences between two design are that in design of array antenna B strip configuration has no 180º delay lines and is excited by input 50 Ohm coaxial probe.



a)

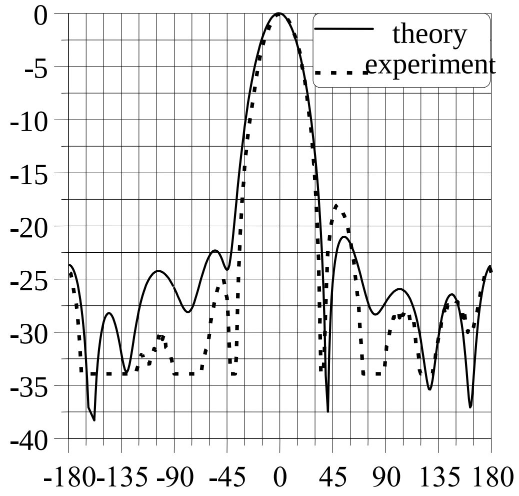


b)

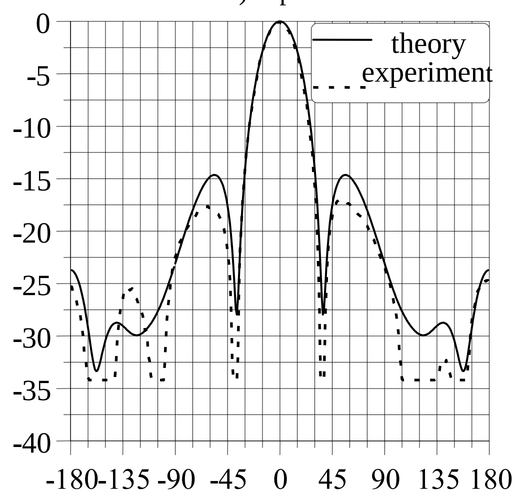
Fig. 2. Array antenna B geometry: a) 3D view, b) top view.

3. Results

Several prototypes of array antennas according to designs A and B (see Fig. 7, 8) have been manufactured and all-round tested at NTUU “KPI”. Calculated by FDTD method and measured radiation pattern of array antenna A and B at the central frequency 2,45 GHz are depicted in Fig. 3, 5 respectively. Their measured and calculated frequency dependencies of VSWR follow in Fig. 4 and 6. Gain Array antenna A and B have gain not less than 15 dB and 14,2 dB respectively that was proved during experimental and numerical tests.



a) *E*-plane



b) *H*-plane

Fig. 3. Radiation patterns of array antenna A at central working frequency 2,45 GHz

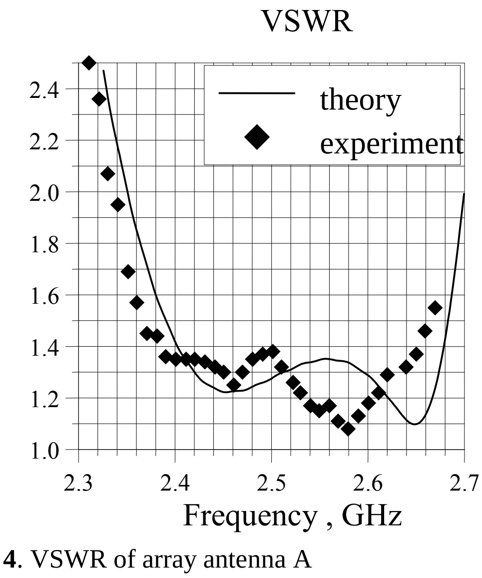
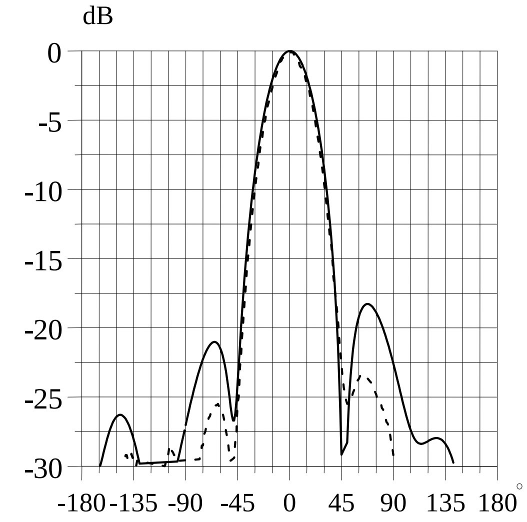
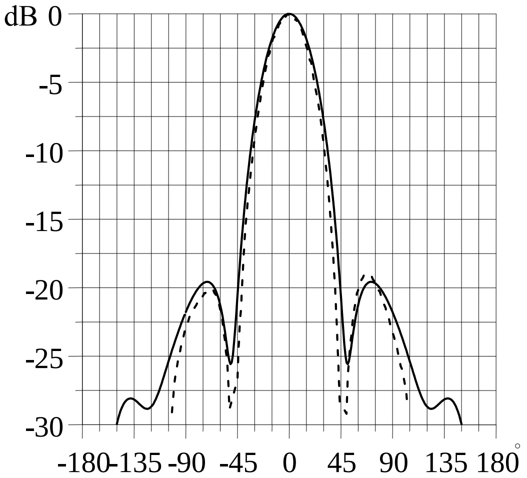


Fig. 4. VSWR of array antenna A



a) *E*-plane



b) *H*-plane

Fig. 5. Radiation patterns of array antenna B at central working frequency 2,45 GHz

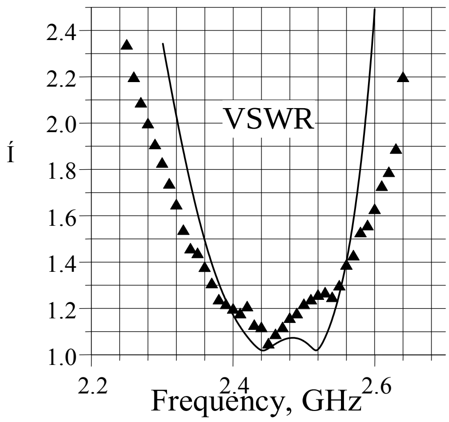


Fig. 6. VSWR of array antenna B.

4. Conclusions

Novel designs of S-band 2×2 strip array antennas are introduced. Designs include only air filled strip elements and do not use expensive high-frequency dielectric substrates. Measured and numerical results are in good agreement and prove that developed array antennas have frequency bandwidth more than 10%, gain factor over 14,2 dB and 3 dB beamwidth near 30° in *E*- and *H*-plane. Proposed technology can be recommended for the creation of low-loss cost/effective array antennas working in *S*- and *L*-bands with frequency coverage up to 1,25:1. Achieved parameters of array antennas allow to apply them for the popular presently high-speed wireless networks Wi-Fi (IEEE 802.11 b,g) and Wi-MAX (IEEE 802.16).

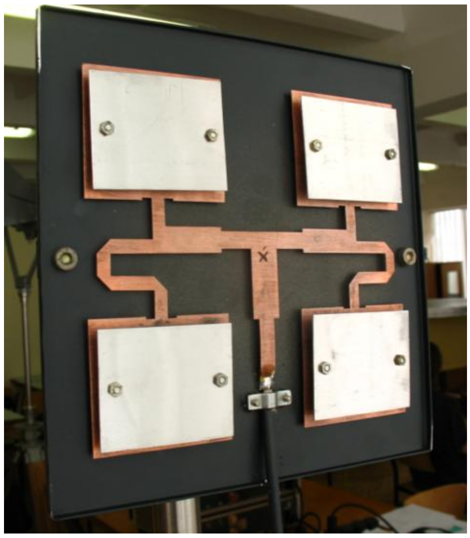


Fig. 7. Photo of array antenna A without plastic radome

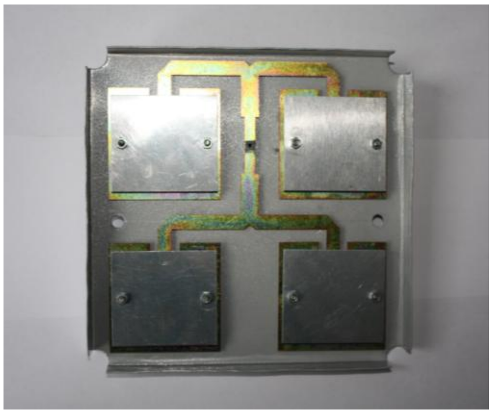


Fig. 8. Photo of array antenna B without plastic radome

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