One Possibility to Increase the Scope for Radar Module HB100 and Fields of Application

Peter Z. Petkov[1], Rosen Vitanov[2] and Ivaylo Nachev[3]

Abstract – **This paper presents modification that extends the range of HB100 radar module. It is a typical example of doppler radar and consists of Dielectric Resonator Oscillator (DRO), microwave mixer and patch antennas. Disadvantage is the low gain stock antennas have and thus become non-functional for use on large areas. An antennas that increase its coverage are proposed in this article, thus extending applications of this radar - to control flight of drones and other unmanned vehicles.**

Keywords – **Radar, Antenna, Patch antenna, Patch array.**

I. Introduction

In the last years doppler radars found a wide application in intelligent systems and devices. Development of new technologies made it possible to minimize weight, dimensions, power consumption and also improve their overall performance. Proposed design replaces the integrated patch antennas of the radar module with a series fed patch array with a higher gain. The antenna of the radar HB-100 has low gain - approximately 1-2dBi, (assumed 1,5dB) at an operating frequency of 10.525GHz [1]. Fig. 1 shows structure of a series fed patch array developed for to achieve larger coverage of the Doppler signal.

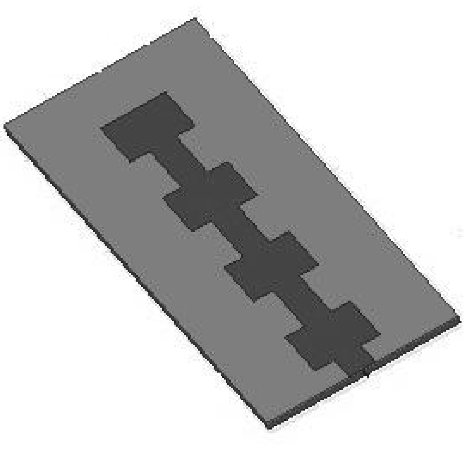

Fig. 1. Series fed patch array – simulation model

[1]Peter Petkov is Associate Professor with the Faculty of Telecommunications at Technical University of Sofia, 8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria, E-mail: pjpetkov@tu-sofia.bg.

[2]Rosen Vitanov is PhD student with the Faculty of Telecommunications at Technical University of Sofia, 8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria, E-mail: rosenvitanov@gmail.com

[3]Ivaylo Nachev is a student at Faculty of Telecommunications at Technical University of Sofia, 8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria, E-mail: ivaylonachev@yahoo.com

Microstrip antenna array consists of many space separated independent radiating slots – horn, dippol, microstrip lane. Their advantages over traditional antennas are: low cost in serial production, construction resistant to shock and vibration, different types of design, big gain (up to 10 dBi per patch) and other microwave equipment can be integrated in patch array construction [2].

II. Series Fed Patch Array Design

An important step when designing patch antenna is to take into account dielectric substance on which patches are made. The employed substrate for the proposed design is Rogers RO 4003 with thickness h=0.508mm and dissipation factor tanδ = 0.00027 [3]. In order to improve the bandwidth and efficiency of antennas, a design method called "suspended substrate" is chosen, where the thickness of the gap between ground plane and antenna is Δ=1mm. In this method we use the equivalent dielectric constant (1.7). Distribution of the elements of the simulated model, as with radars frequency f_c = 10.525GHz we have wavelength λ = 28.50mm, and λ_g = 22.6150mm. For calculation of antenna dimensions a straightforward basic algorithm is proposed:

Step 1: Calculation of width (W): Width of the Micro strip antenna is given by the equation:

$$W = \frac{c}{2 \cdot f_c}\left(\frac{\varepsilon_r + 1}{2}\right)^{-\frac{1}{2}} = 12.2208\ mm,\ \frac{W}{h} > 1, \qquad (1.1)$$

where c is the speed of the light c=3*10^8, ε_r is a dielectric constant of substrate, f_c is radar frequency and h is substrate thickness.

Step 2: Calculation of Effective Length (L): Length of the microstrip radiator is given by:

$$L = \frac{c}{2 \cdot f_c \sqrt{\varepsilon_{eff}}}, \qquad (1.2)$$

where f_c is radar frequency and ε_{eff} is effectively dielectric constant of substrate.

Step 3. Calculation of the Length extension (L_{ext}): The actual length is obtained by the equation (accounting for the fringing fields):

$$L_{ext} = 0.412 \cdot h \cdot \frac{(+0.3)\cdot\left(\frac{W}{h} + 0.264\right)}{(-0.258)\cdot\left(\frac{W}{h} + 0.8\right)} = 0.8825\ mm. \qquad (1.3)$$

Step 4: Calculation of the actual length of the Patch (L): The actual length of the patch is given by:

$$L_{eff} = L + 2L_{ext} = 12.9650\ mm\ . \tag{1.4}$$

Determination of effective dielectric permittivity ε_{eff} :

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + 10\frac{h}{w}\right)^{-0.5} = 1.5886\ mm\ . \tag{1.5}$$

The length of the guided wave:

$$\lambda_g = \frac{\lambda}{\sqrt{\varepsilon_{eff}}}\ . \tag{1.6}$$

Influence of the gap is taken into account:

$$\varepsilon_{eq} = \frac{\varepsilon_r \cdot (h + \Delta)}{\varepsilon_r \cdot h + \Delta} = 1.72\ mm\ , \tag{1.7}$$

where ε_r is a dielectric constant of substrate and Δ is a the thickness of the gap.

The connection between designed antenna and a radar module is established by using SMA connectors with characteristic impedance Z_0=50 Ω. To determine the width for micro strip line a method suggested by Wheeler и Schneider [4] is used. By these methods width of the micro strip lines is calculated to be 5.3010 mm. The length of microstrip line is half the wavelength $\lambda_g/2$ and feed line is a quarter of the wavelength $\lambda_g/4$.

To determine the dimensions of the antenna Eqs. (1.1) - (1.6) are used with electromagnetic simulator, a model of the proposed antenna was synthesized using the results from the calculations above. The CAD tool gives the opportunity for fine tune of the design and determination of the actual size of antenna components for given operating frequency. The final results is shown in Fig. 2.

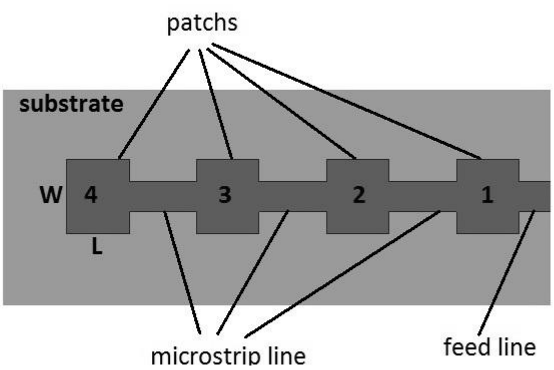

Fig. 2. Distribution of the elements of the simulated model

In Table 1 are presented the values obtained for dimensions of the antenna components.

TABLE 1
VALUES OBTAINED FOR DIMENSIONS OF THE ANTENNA COMPONENTS

	W [mm]	L [mm]	w [mm]	Microstrip line [mm]	Feed line [mm]
Calculated	12.2	12.96	5.3	12.4	6.2
After simulation	13.1	11.0	5.3	12.4	6.2

In Fig. 3 is displayed the return loss of the antenna. Figs. 4*a* and 4*b* display the polar radiation pattern of the designed patch array compared which HB-100 stock antennas. Fig. 5 shows directivity in 3D pattern. In Figs. 5*a* and 5*b*, the radiation pattern of proposed array is displayed in Cartesian coordinate system. The gain is 15.14d Bi, which corresponds to 32.65 times amplification. Results of Table 2 show the comparison with integrated manufacturer antennas and designed in this publication.

TABLE 2
COMPARISON WITH INTEGRATED MANUFACTURER ANTENNAS AND DESIGNED IN THIS PUBLICATION

Gain	dBi	linear
HB 100 antennas	1.5	1.41
Proposed patch array	15.14	32.65

Results show that this design method and using dielectric substrate RO4003, gain increases significantly and thus increasing the radius of operation /range/ and selectivity of the radar.

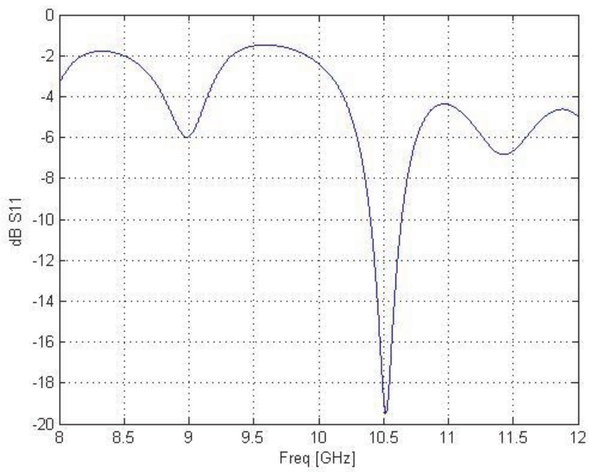

Fig. 3. Antenna bandwidth (S_{11})

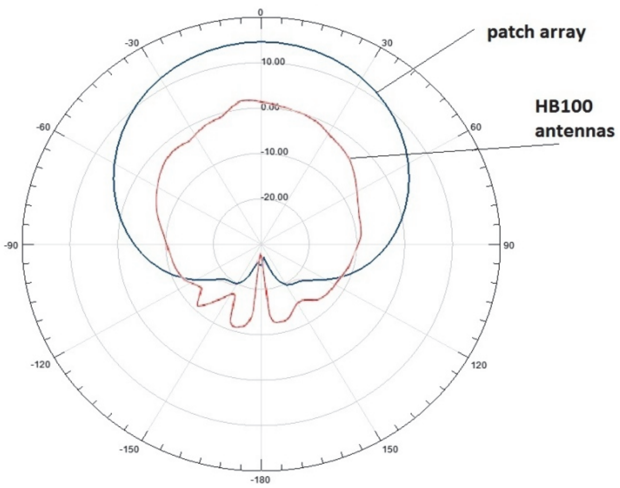

Fig. 4a. Comparison between patch array and HB100 antennas in azimuth plane

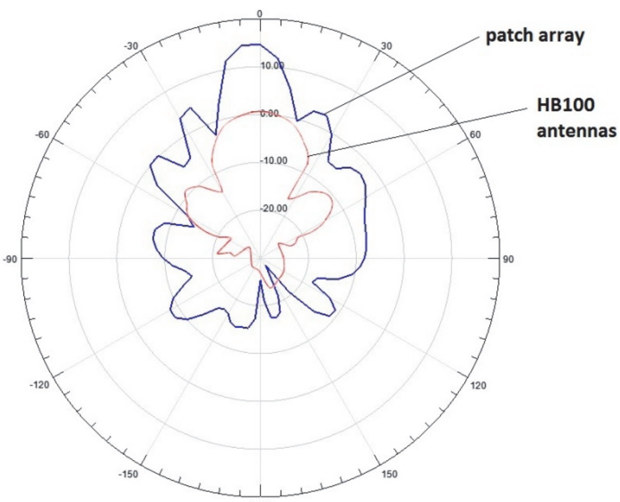

Fig. 4b. Comparison between proposed patch array and HB100 antenna in elevation plane

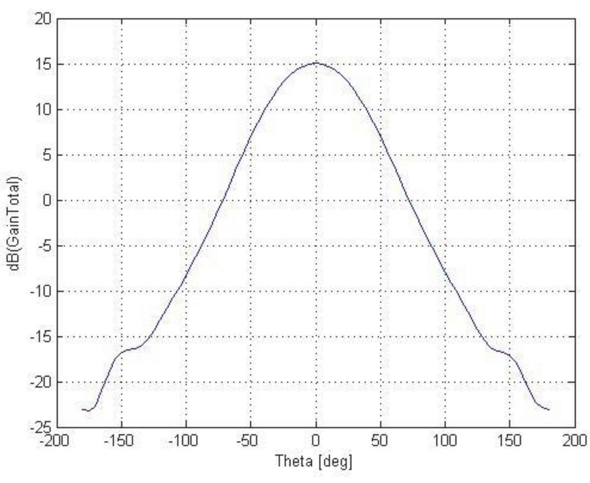

Fig. 5a. Radiation Pattern azimuth

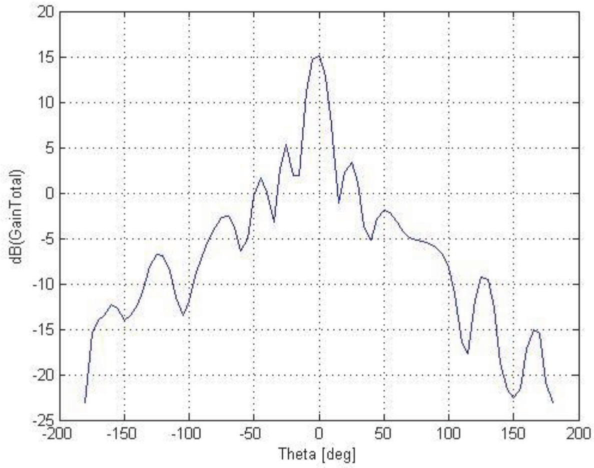

Fig. 5b. Radiation Pattern elevation

III. Conclusion

Modifying HB100 in this article showed multiple increase in its scope and for this purpose a modern method for a patch array desing is used (Table 2). The modified device is fully functionally and may be integrated on real devices.

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