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Novel Microstrip Antenna Array for Anti-Jam Satellite Navigation System

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Abstract—We present results of theoretical and experimental investigations of a novel dual band right hand circularly polarized microstrip antenna array with adaptive space-time processing capability for terminal of GPS/GLONASS/GALILEO satellite navigation systems. The array structure is composed from 10 microstrip radiators excited independently via separate coaxial input ports. Two central radiating elements for two frequency bands (L1 and L2) have got circular shapes with slits and are stacked to provide compact sizes and coincidence of their phase centers. Peripheral radiators have got annular ring shapes with slits topology. The main feature of the array is its compact packaging of radiating elements that causes significant levels of electromagnetic mutual coupling. Geometric parameters of the array were selected using high-efficiency multi parametric particle swarm optimization to provide optimum performance of each radiator in the compact array packaging. Moreover, several right hand circularly polarized radiators of the array assembly were rotated around their centers to improve their characteristics and to increase the quality and effectiveness of space-time processing of adaptive antenna system. The novel design of the dual frequency right hand circularly polarized array and somewhat imperfectness of the obtained characteristics are experimentally validated.

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INTRODUCTION

Application of adaptive smart antenna technology can radically increase the signal-to-noise ratio in telecommunication and navigation systems and radars. The most typical cases are distinguished when the sources of informational and jamming signals are principally mobile or their angular locations in space are unknown a priori. The good signal-to-noise ratio can be achieved by adaptive tune of the values of weighting coefficients for each array element. The kernel of adaptation procedure is rapid space time processing algorithms applied to the sampled in time complex signals received by radiators separated in space. These algorithms are potentially able to filter the signals coming from the directions of jamming and simultaneously to amplify the useful ones, incoming from informational sources [1].

Various adaptive algorithms [2], like least mean square or maximum likelihood approaches that explore different criteria and priori conditions, were developed for smart antennas starting from the times of publication of the pioneer work [3]. However, the practical realization of smart antennas is usually associated with a great number of technological and economic constraints. To increase the number of independent array radiators or the absolute value of operating frequency bandwidth, the required number of synchronized analog transmitting/receiving modules and data rates of analog-to-digital converters as well as the clock frequency of digital signal processors and minimal allocated memory volume are being proportionally increased. As a result, the system becomes prohibitively expensive, not enough reliable or unrealizable at all.

Thus, up today, only relatively small sized smart antenna arrays with several dozens of independent radiators and with operating frequency bandwidth limited to 30–40 MHz were designed [4, 5]. It should be noticed that successful realization and good enough overall performance of even relatively small-sized and narrowband systems can suffer from many other factors caused by non-ideal properties of smart antenna elements as well as non-identity of its channels. One should consider the nonidentity of electromagnetic characteristics of radiators in small sized array environment, non-equal gain factors of analog