Design of a High-Power Radar Waveguide Beam-Steering Antenna and Compensation for Level Degration

Yoonseon Choi
Department of Radio and Information Communications Engineering
Chungnam National University
Daejeon, Republic of Korea
choiyoonseon9173@gmail.com

Bang Chul Jung
Department of Electronics Engineering
Chungnam National University
Daejeon, Republic of Korea
bcjung@cnu.ac.kr

Jong-Myung Woo
Department of Radio and Information Communications Engineering
Chungnam National University
Daejeon, Republic of Korea
jmwoo@cnu.ac.kr

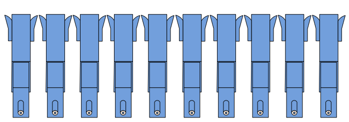
Abstract— This paper proposes a novel mechanically steered 1 by 8 array waveguide antenna that can be installed in a confined space by supplying transmission power to each array antenna through power distribution from a single high power source. The proposed antenna features beam steering capabilities through mechanical adjustment of the waveguide length. Additionally, we present an antenna arrangement designed to compensate the degraded gain levels from neighboring array groups caused by beam steering.

Keywords—Waveguide antenna, Mechanical beam steering, Gain compensation

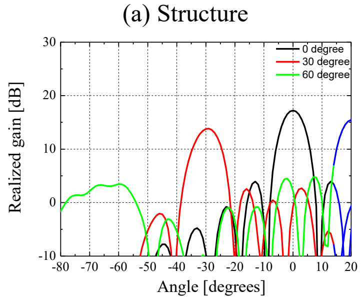
In modern radar systems, electronically steered antennas allow for rapid beam scanning by adjusting the phase, which is particularly advantageous for detecting multiple targets [1]. However, these electronically steered antennas are vulnerable to strong EMPs (Electromagnetic Pulses) and require cooling systems to dissipate the heat generated by the amplifiers attached to each antenna element. Therefore, there is a need for antennas that are resistant to EMPs and can be installed in confined spaces.

In this paper, we proposed a novel 1×8 array waveguide antenna that allows for beam steering through mechanical waveguide length adjustment. Additionally, we present an example of compensation from neighboring array groups for level degradation caused by beam steering. Fig. 1(a) shows a 1×8 rectangular waveguide array antenna capable of mechanical beam steering. The length of each rectangular waveguide was adjusted to direct the E-plane pattern at 0°, -30°, and -60° as shown in Fig. 1(b). As a result, the maximum level at -60° decreased by 12 dB compared to the level at 0°, and the beam width increased. This is because beam steering reduces the effective projection cross-section of the array. Fig. 2(a) shows the structure where the array antennas are configured into a hexagonal array group to compensate for the degraded gain levels. The level degradation at -60° caused by the central array group can be compensated by the beam steering of the left array group, resulting in gain level recovery at -60° as shown in Fig. 2(b).

In this way, this paper presents the design of a mechanically steered beam antenna for tracking radar in the confined space at the rear of an aircraft and discusses the resulting characteristics.

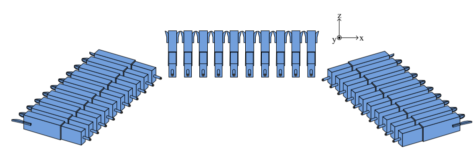


(a) Structure

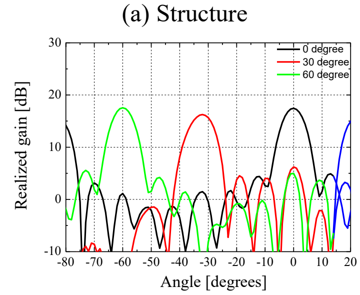


(b) Realized Gain

Fig. 1. 1 × 8 array beam-steering waveguide antenna structure and gain characteristics



(a) Structure



(b) Realized Gain

Fig. 2. Array antenna configuration and gain characteristics for compensating degraded levels

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[1] *Gopal, Maloth, and K. P. Ray., "Design of 16 × 16 Phased Array Antenna for X-band Radar." in Proceedings 2022 3rd International Conference for Emerging Technology (INCET). IEEE, 2022.*