Journal of Physics: Conference Series

PAPER • OPEN ACCESS

C/X/Ku triple-band all-metal slot antenna

To cite this article: Xiaoyu Cheng *et al* 2022 *J. Phys.: Conf. Ser.* **2384** 012002

C/X/Ku triple-band all-metal slot antenna

Xiaoyu Cheng[1], Shaofeng Bi[1], Yunfei Sun[1] and Chengwei Yuan[1,2]

[1] College of Advanced Interdisciplinary Studies, National University of Defense Technology, Changsha 410073, China

[2] Corresponding Author, cwyuan@nudt.edu.cn

Abstract. Most multi-band all-metal slot antennas are dual-band. Their design concept is not feasible for triple-band antennas. A triple-band all-metal slot antenna is designed using an electromagnetic band gap structure (EBG). The antenna can work at C/X/Ku-band. Simulated results are presented to demonstrate the feasibility of the design. The compact antenna expands the working frequency of an all-metal slot antenna, which is especially appealing for high-power antennas.

1. Introduction

With the development of communication technology, the demand for multi-band antennas has been growing. Microstrip is widely used in multi-band antenna [1-4]. However, microstrip antennas are not suitable for high frequency. Due to low loss, high structural strength, and high power capacity, multi-band all-metal waveguide slot antennas have been studied [5-8]. At present, most multi-band slot antennas are dual-band antennas. In this article, a triple-band slot antenna is proposed. By placing the EBG structure in the ridge waveguide, a slot waveguide antenna can work at the C/X-band, and the Ku-band antenna is placed above the C/X-band antenna. The proposed antenna is a standing wave antenna with three bands. The central frequencies are 4.3 GHz (C-band), 8.5 GHz (X-band), and 12.5GHz (Ku-band).

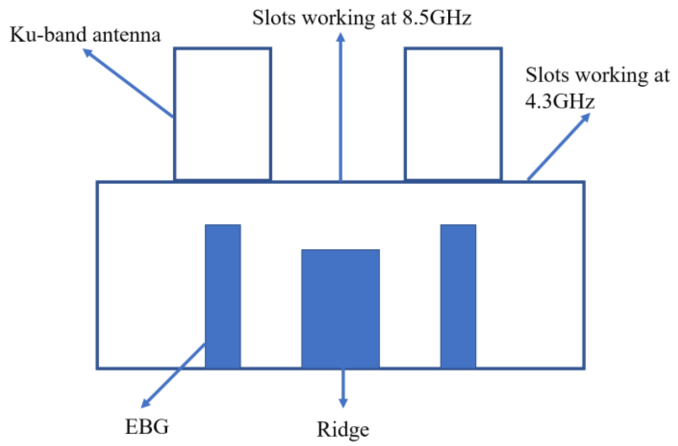
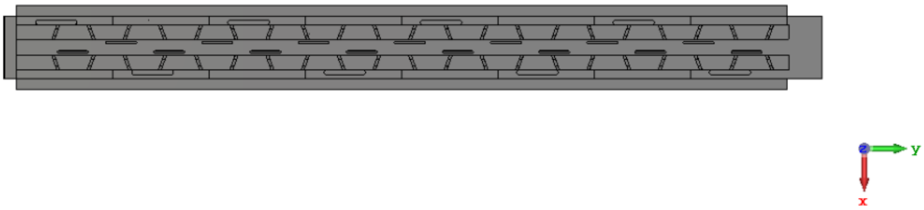


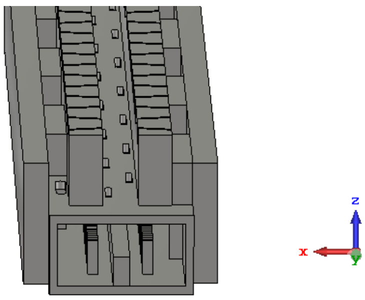
Figure 1. Diagram of the triple-band antenna

2. Antenna configuration and design

The antenna diagram is shown in Figure 1. EBG structure can stop the propagation of electromagnetic waves at the cut-off band. Placing a nailed EBG structure with suitable dimensions on both sides of the ridge can block electromagnetic waves at 8.5 GHz and pass electromagnetic waves at 4.3 GHz. The electromagnetic wave at 8.5 GHz can only propagate in the central area of the waveguide, while the electromagnetic wave at 4.3 GHz can propagate throughout the waveguide. There are X-band slots near the middle of the waveguide, and C-band slots are close to the edge of the waveguide. Since electromagnetic waves at 8.5 GHz cannot pass through the EBG structure, they can only radiate through slots near the middle. As for electromagnetic waves at 4.3GHz, the middle slots are too close to the center, so little energy radiates through them.



(a)



(b)

Figure 2. Configuration of the proposed antenna array. (a) Top view. (b) Front view

However, due to the limited isolation of single-row EBG structures, branches are placed beside the C-band slots to reduce the length of the slot. Adjusting the propagation constant makes the C-band slots located at the position where the wall current at 8.5GHz is low, further reducing the interference. Step structure is placed in the ridge waveguide to offset reflection at C-band. The C/X-band antenna is extended at the end to increase the bandwidth. The antenna working at the Ku band is a narrow side inclined slot antenna placed between the slots. The structure of the antenna is shown in Figure 2.

3. Results and discussion

The antenna shown above has 8 C-band slots, 15 X-band slots, and 2 * 21 Ku-band slots. Its radiation pattern is shown in Figure 3, and its reflection is shown in Figure 4. Side lobes are -12.7dB at X-band and below -14dB at C-band. The bandwidth with a reflection below -15dB is 124MHz at C-band and 125MHz at X-band. That demonstrates a slot antenna proposed above can work at C/X-band.

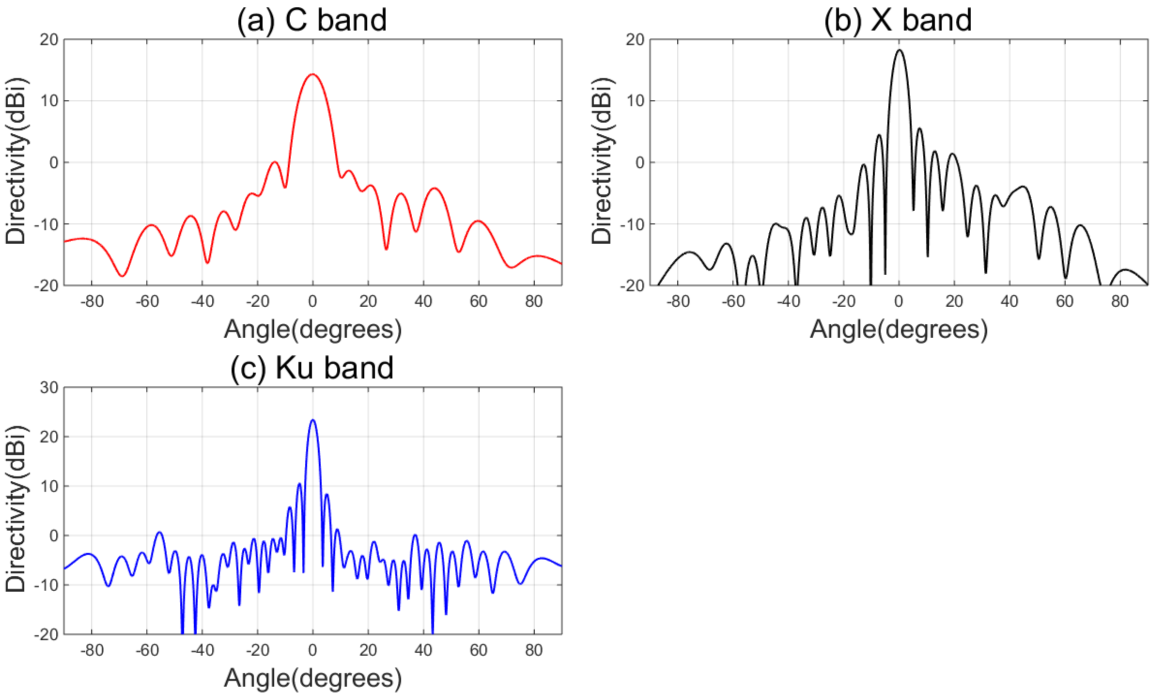


Figure 3. Radiation patterns (Y-Z plane) at the C/X/Ku band

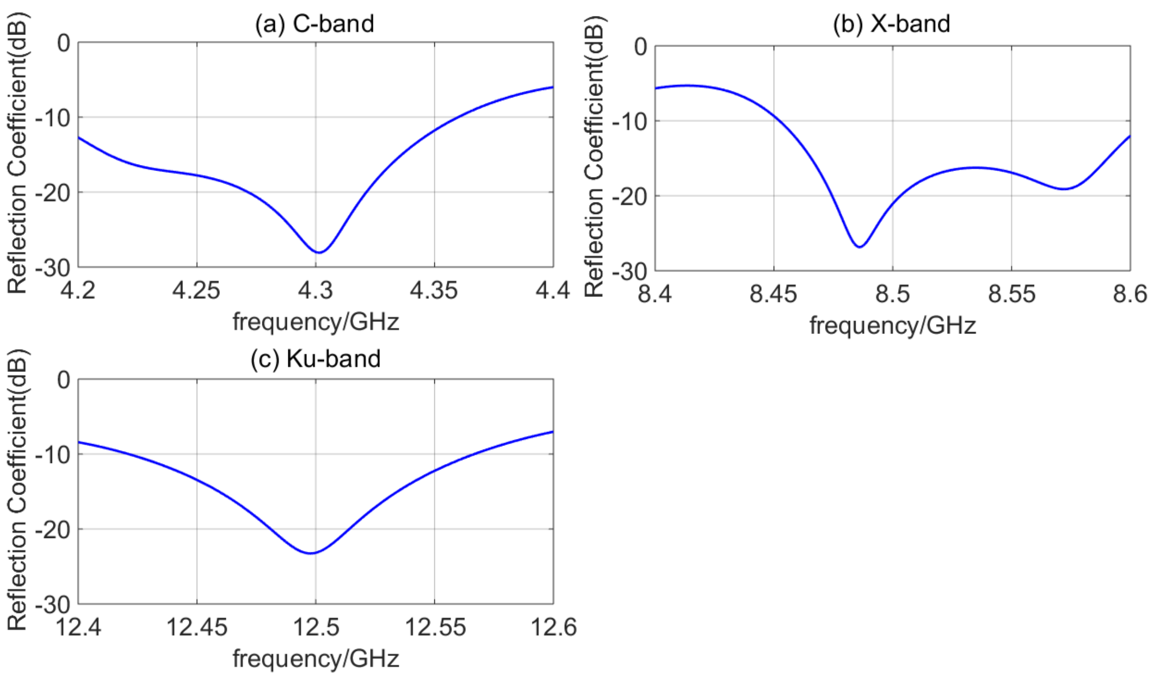


Figure 4. Reflection coefficient at the C/X/Ku band

To demonstrate the feasibility of composing array at X/Ku-band, a small antenna array model is established, as shown in Figure 5. Its radiation pattern is shown in Figure 6. There is a very low grating lobe in the figure, which demonstrates the size of the antenna meets the needs of the array.

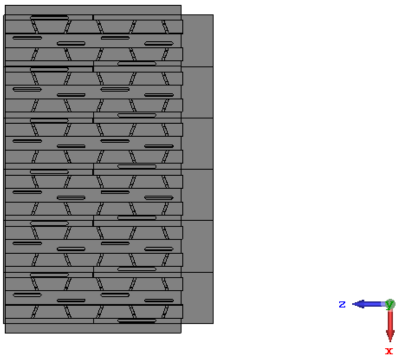


Figure 5. Top view of antenna array

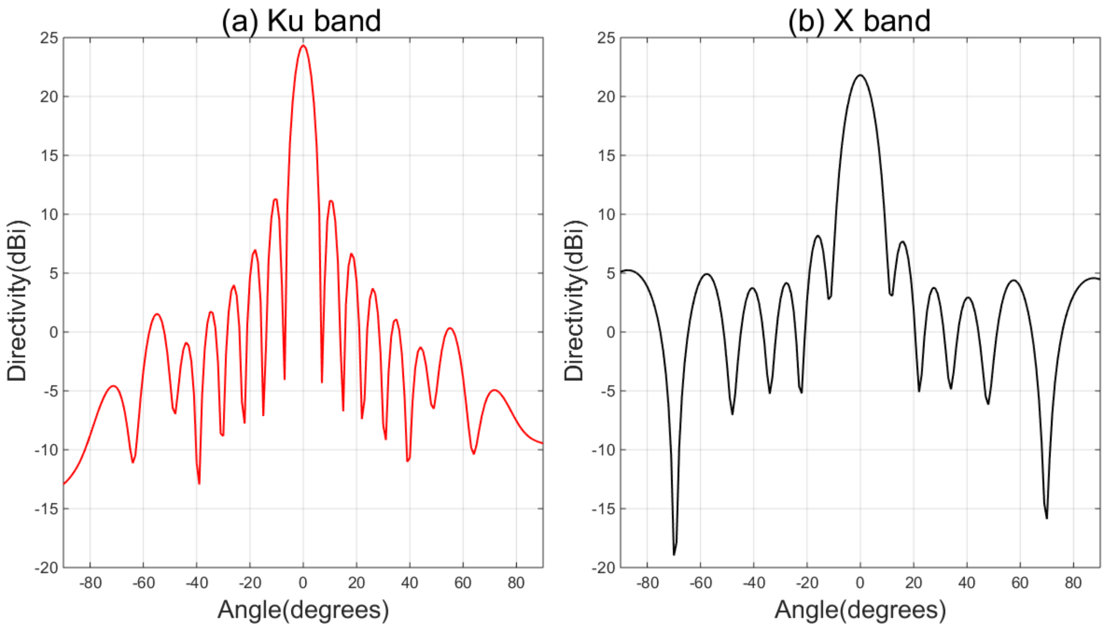


Figure 6. Radiation patterns (X-Y plane) at the X/Ku band

4. Conclusion

The triple-band all-metal slot waveguide antenna at the C/X/Ku band is designed and simulated. Placing EBG in the ridge waveguide, placing branches, and adjusting the position of slots make one slot antenna can work at the C/X band without sacrificing radiation features. The Ku-band antenna was placed above the C/X band antenna. The simulation result demonstrates the feasibility of the design. Compared with traditional all-metal multi-band slot antennas, the most attractive point of the proposed antenna is it can work in three bands.

References

[1] Chen Y, Jiao Y, Gang Z, Fan Z, Liao Z and Yu T. (2011) Dual-band dual-sense circularly polarized slot antenna with a c-shaped grounded strip. *IEEE Antennas & Wireless Propagation Letters*, **10**: 915-918.

[2] Mao C, Gao S, Wang Y, Luo Q and Chu Q. (2017) A shared-aperture dual-band dual-polarized filtering-antenna array with improved frequency response. *IEEE Transactions on Antennas and Propagation*, **65**: 1836-1844.

[3] Vazquez-Roy J L, Krozer V, and Dall J (2012). Wideband dual-polarization microstrip patch antenna array for airborne ice sounder. *IEEE Antennas and Propagation Magazine*, **54**: 98-107.
[4] Zhong S, Sun Z, Kong L, Gao C, Wang W, and Jin M. (2012) Tri-band dual-polarization shared-aperture microstrip array for SAR applications. *IEEE Transactions on Antennas and Propagation*, **60**: 4157–4165.
[5] Chen M, Fang X, Wang W, Zhang H, and Huang G L. (2020). Dual-band dual-polarized waveguide slot antenna array for SAR applications. *IEEE Antennas and Wireless Propagation Letters*, **19**: 1719-1723.
[6] Li T, Meng H, and Dou W. (2014) Design and implementation of dual-frequency dual-polarization slotted waveguide antenna array for Ka-band application. *IEEE Antennas & Wireless Propagation Letters*, **13**: 1317-1320.
[7] Park S, Okajima Y, Hirokawa J, and Ando M. (2005) A slotted post-wall waveguide array with the interdigital structure for 45° linear and dual polarization. *IEEE Transaction Antennas and Propagation*, **53**: 2865–2871.
[8] Chen Y, and Vaughan R G. (2018) Dual-polarized L-band and single-polarized X-band shared-aperture SAR array. *IEEE Transaction Antennas and Propagation*, **66**:3391-3400.