A Ka-band Balanced Feed Antenna with High Selectivity

Yuanchen Sun
Nanjing Institute of electronic technology No. 8 Guorui Road, Yuhuatai, NanJing.210000

Abstract. In order to obtain a high-selectivity antenna array, a filter antenna based on balanced feed system is investigated in the paper. The balanced feed structure excites the each sub-array with the same phase and amplitude so that the radiation beam is stable steering to normal direction over the entire working bandwidth. Meanwhile, in order to reduce the overall size of the system and improve the selectivity of the antenna array, the filter will be integrated into the input port of the antenna array. The simulated bandwidth of VSWR less than 1.5 is 28.2 GHz~31.2GHz, and the maximum gain of the antenna is 16.43 dB.

1. Introduction
With the development of communication technology, microwave devices receive more requirements. However, the increasing number of devices in the system not only causes the entire system to become larger, but also generates more noise. In order to reduce the size of the system and reduce the transmission noise, the demand for high system integration is constantly increasing and the filter antenna is a method to improve system integration. The idea of the filter antenna is to integrate the filter with the antenna array to reduce size, transmission loss and costs of the system.

Waveguide longitudinal slot array antennas are selected because of its high gain, low loss, low cross-polarization levels and mass reproduction[1]. The slot antenna is based on the SIW structure. This SIW antenna not only has the advantages of the traditional waveguide antenna, but also has high integration, compact structure, easy processing, and low cost[2]. In order to ensure that the sub-array are excited with equal phase and amplitude, the number of antenna elements must be odd so that each antenna element is at the peak of the standing wave[3]. The antenna array is shown in fig.1. It is a single layer 4*5 SIW slot antenna. The material is Rogers 5880 and the thickness is 0.508mm. The balanced feeding system is closely connected with the power divider to reduce the entire size of the antenna array and reduce insertion loss.

Fig.1 SIW antenna array
2. Design and Simulation Results

2.1. Design of slot antenna
In SIW structure, the diameter of metal via is 0.4mm, and the distance between adjacent via is 0.95mm. In the balanced feed system, the ABCD matrix of the equivalent circuit of a sub-array is shown in (1)[3].

\[
\begin{bmatrix}
A & B \\
C & D
\end{bmatrix} = \begin{bmatrix}
1 & 0 \\
\sum_{i=1}^{N} \frac{Y_i}{G_0} & 1
\end{bmatrix}
\] (1)

According to the Stegen’s factorization[4], the Y and G of sub-array can be calculated by the width, length and offset of the slot. Due to balanced system, the impedance of the slots can be matched when C=2.

2.2. Design of power divider
The design of 4-way power divider is similar to [5]. A metal via is placed at the front of each output port to prevent electromagnetic wave from being reflected on the SIW wall. The width and position of coupling windows is used to control the output amplitude and phase. The simulation result of the power divider is shown in fig.2.

![Fig.2.Simulation result of power divider](image)

2.3. Design of filter
The filter uses a fourth-order cross-coupled filter, which has a simple structure and high transmission efficiency. The resonant frequency of each resonant is shown in (2)

\[
f_c = \frac{c_0}{2\sqrt{\varepsilon_r}} \left( l - \frac{d^2}{0.95p} \right)
\] (2)

The d is the diameter of the SIW via and p is the distance between the SIW via. The resonant cavity realizes the cross-coupling of each cavity through the coupling window between the cavities. The degree of coupling between the resonators is achieved by controlling the size of the coupling window. The simulation result of the filter is shown in fig.3.
2.4. **SIW planar arrays**

The overall simulation results are shown in fig. 4. The balanced feed makes the beam more stable, concentrated in the normal direction, and the filter makes the antenna array highly selective. The gain of antenna array is 16.43dB.

3. **Conclusion**

This paper presents a design idea for a new type of antenna array. This antenna uses integrated filters and balanced feed system, which effectively improves the stability and selectivity of the antenna radiating element. By using the space as fully as possible to tightly combine these units, the antenna unit has a compact structure and low cost. The working bandwidth of the antenna is 28.2GHz–31.2GHz and the relative bandwidth is 10.1%. The gain is 16.43dB, and the overall size is 41.28mm*67.43mm*0.508mm.

**References**

[1] J. F. Xu, W. Hong, P. Chen and K. Wu, "Design and implementation of low sidelobe substrate integrated waveguide longitudinal slot array antennas," in IET Microwaves, Antennas & Propagation, vol. 3, no. 5, pp. 790-797, August 2009.

[2] Li Yan, Wei Hong, Guang Hua, Jixin Chen, Ke Wu and Tie Jun Cui, "Simulation and experiment on SIW slot array antennas," in IEEE Microwave and Wireless Components Letters, vol. 14, no. 9, pp. 446-448, Sept. 2004.

[3] T. Yang, W. Hong and Y. Zhang, "Balanced dual fed SIW slot antenna array for Q-Link PAN high gain application," 2013 IEEE International Wireless Symposium (IWS), Beijing, 2013.
[4] R. J. Stegen, “Slot radiators and arrays at X-band,” IEEE Trans. Antennas Propag., vol. AP-1, pp. 62–64, Feb. 1952.

[5] Sakakibara, Y. Kimura, A. Akiyama, J. Hirokawa, M. Ando, and N. Goto, “Alternating phase-fed waveguide slot arrays with a single-layer multiple-way power divider,” Microwaves, Antennas and Propagation, IEEE Proceedings -, vol. 144, no. 6, pp. 425 430, 1997.