Design of Feed Structure for 2×2-Element Waveguide Slot Arrays by Filter Design Theory

Takashi Tomura* (1), and Jiro Hirokawa (1)
(1) Tokyo Institute of Technology S3-20, 2-12-1 O-okayama, Tokyo 152-8552, Japan.

This paper presents a design of a 2×2-element waveguide slot array having band pass characteristics by filter design theory. Waveguide slot arrays realize high efficiency in the millimeter wave band (T. Tomura, et al., IEEE Trans. Antennas Propag., vol. 62, no. 10, pp. 5061-5067, Oct. 2014.). The authors have designed E-band plate-laminated waveguide filters and their integration into a corporate-feed slot array antenna (X. Xu, et al., IEEE Trans. Microw. Theory Tech., vol. 64, no. 11, pp. 3592-3603, Nov. 2016.). However, it is difficult to integrate filters with monopulse circuits because space is limited. The objective of this paper is to realize radiating elements having band pass characteristics.

Figure 1 shows structure of the designed antenna. It is composed of a waveguide, a coupling slot, a cavity #1, four exciting slots, four cavities #2 and four radiating slot pairs. The cavity #1 excites the four cavities #2 and radiating slot pairs with uniform amplitude and phase. Figure 2 shows an equivalent circuit of the antenna. The coupling and exciting slots are expressed as transformers, the cavities as LC series resonators and the radiating slot pairs as resisters. The equivalent circuit is same as a coupled-resonator circuit of a filter. Therefore, circuit parameters can be obtained from desired transmission characteristics. For example, Chebyshev response with 4% fractional bandwidth and 0.05-dB passband ripple gives $Q_{ext} = Q_{rad} = 17.3$, $k_{12} = 0.064$.

Figure 3 shows external quality factor between the waveguide and the cavity #1 as a function of the coupling slot length. Resonant frequency is controlled to 78.5 GHz by the cavity #1 width. The analysis model for the calculation of the external quality factor is composed of the waveguide, the coupling slot, the cavity #1 and an output waveguide placed on the cavity #1. The external quality factor can be controlled by the coupling slot length. Its minimum value is 17.6 corresponds to about 4% fractional bandwidth. The other design results are presented in the conference.

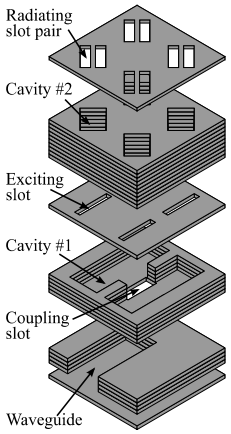

Figure 1. Antenna structure.

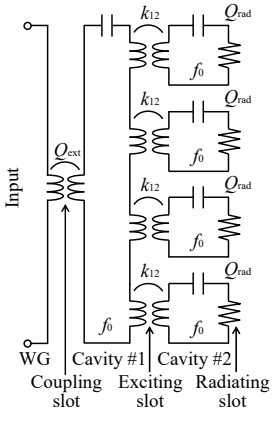

Figure 2. Equivalent circuit.

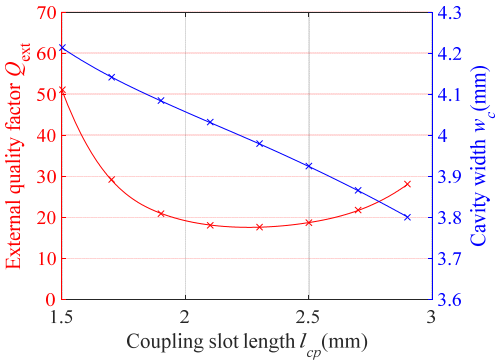

Figure 3. External quality factor.