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Diplexer Integration Into a Ka-Band High-Gain Gap Waveguide Corporate-Fed Slot Array Antenna

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***Abstract*—A multilayer integrated diplexer-antenna array module for Ka-band high capacity point-to-point backhaul links is presented. The proposed module is composed of three unconnected metal layers with a simple mechanical assembly and no electrical contact requirements between the distinct layers based on gap waveguide technology. A 7^{th} order hybrid diplexer-splitter with a novel architecture is successfully integrated into a ridge gap waveguide corporate distribution network of a 16×16 slot array antenna. The measured input reflection coefficients for both Tx/Rx channels are below -13 dB with measured total efficiency better than 60% in the designed passband. The measured isolation of gain between the two channels is more than 55 dB.**

I. Introduction

The next generation 5G wireless system needs more network capacity due to demands for higher data throughput and speed. The use of millimeter wave frequency bands, such as 28, 39, V-, and E-band is one solution to access higher bandwidth and consequently higher data rate. Frequency-division duplexing (FDD) communication backhaul links are widely used to increase spectral efficiency and transmit and receive data simultaneously. High gain antenna connected to a diplexer are key passive components of such systems, and by integrating them significant reduction of the total size and cost of the system can be achieved. Metallic hollow waveguide slot array antennas [1] have better performance in terms of efficiency compared to dielectric based microstrip and substrate integrated waveguide (SIW) array antennas [2], especially in millimeter wave frequencies. However, in hollow waveguide slot array antennas, good electrical contact between the different metal blocks is needed, which is an expensive and complicated procedure. The gap waveguide technology presents a solution to overcome the problem of the electrical contact between the different building blocks in hollow waveguide array antennas, which increases manufacturing flexibility. Gap waveguide is based on a parallel-plate waveguide configuration and a semi-periodic array of electromagnetic bandgap structure that controls the direction of propagation. No electrical contact is required between the different metal blocks. In [3] a planar array antenna is presented for high-gain V-band application based on gap waveguide technology. In this paper, we introduce the integration a of diplexer into the feed-network of a high-gain array antenna in a compact form, with unconnected multilayer configuration.

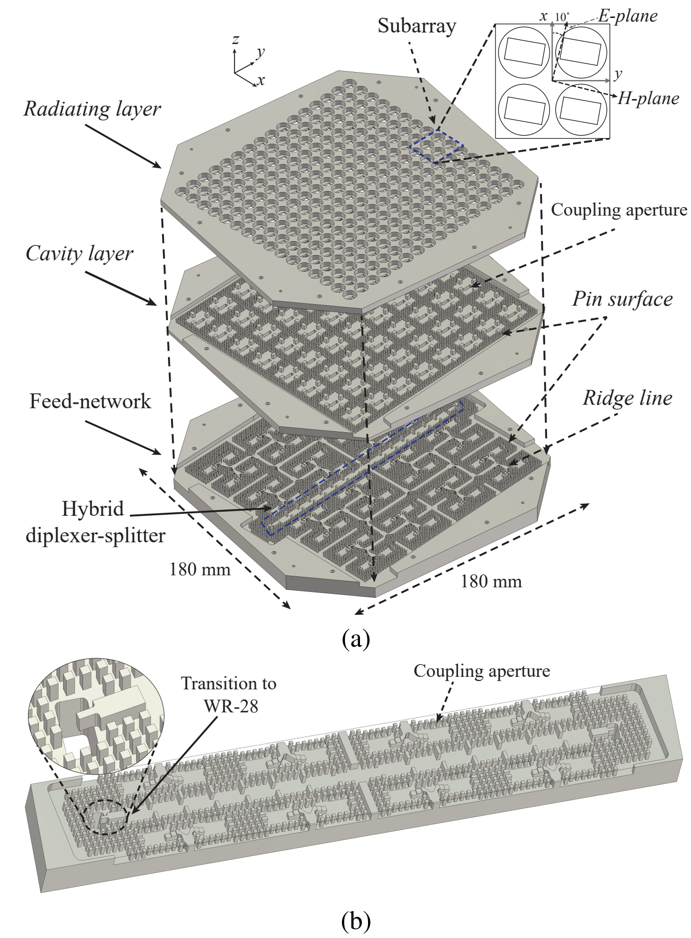

Fig. 1. (a) Distributed view of the proposed integrated diplexer-antenna module. (b) The integrated hybrid diplexer-splitter.

II. Integrated Diplexer-Antenna Module Configuration And Design

Fig. 1 shows the configuration of the proposed integrated diplexer-antenna module. The array antenna consists of three distinct metal layers. The parallel-plate mode, leakage, and undesired modes are suppressed by the stopband produced by a texture of pins [4]. The radiating layer consists of 16×16 slots. Four slots with cylindrical cavities on the top of them are fed by an air-filled cavity, which is made up by the pins in form of a subarray. The slots are tilted by 10° in order to separate the E- and H-planes of the antenna from the

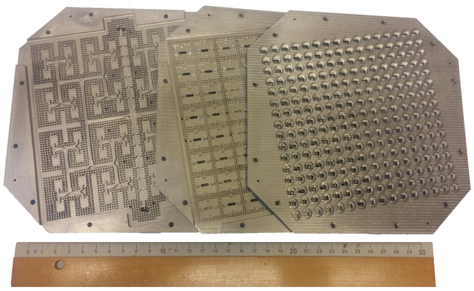

Fig. 2. The fabricated integrated diplexer-antenna array module.

principal planes of the array to improve the far-field radiation characteristics of the antenna. In the lower layer, a ridge gap waveguide corporate-feed network is designed by cascading E-plane ridge gap waveguide power dividers. Fig. 1(b) shows the integrated hybrid diplexer-splitter in more detail. The diplexer consists of two seventh-order bandpass filters with center frequencies at 28.21 GHz and 29.21 GHz with 650 MHz bandwidths. The two channels are combined using a distributing node, which also acts as a power divider. The proposed method in [5] is used to calculate the lumped element model and design the hybrid diplexer-splitter. The designed hybrid diplexer-splitter is integrated into the feed-network of the array antenna at the middle. A simple E-probe transition is designed to match the quasi-TEM mode of the ridge gap waveguide to the fundamental TE_{10} mode of the rectangular waveguide. The proposed module is a compact design with a simple mechanical assembly without any requirement of electrical contact between the layers.

III. Experimental Results

The fabricated module is illustrated in Fig. 2. The measured and simulated input reflection coefficients and gains are presented in Fig. 3. The measured reflection coefficients of the two Tx/Rx ports are below -13 dB with very good agreement with simulated results. The filter response of the module is noticeable in the gain curves in Fig. 3. The measured isolation of gain between the two channels is around 55 dB. The total measured efficiency, considering the loss of the diplexer, is around 60%, while the simulated efficiency is around 70%. This reduction might be due to the high surface roughness of the fabricated prototype. The normalized simulated and measured E-plane radiation patterns of the antenna at the center frequencies of the two channels of the diplexer (28.21 GHz and 29.21 GHz) are shown in Fig. 4. The designed antenna satisfies the ETSI class II Co-polar radiation pattern sidelobe requirement. The measured cross-polarization levels are also presented and it is better than -35 dB.

IV. Conclusion

We have presented a novel integration of a diplexer into a corporate-feed network of a slot array antenna at Ka-band. The proposed module consists of three unconnected metal layers with simple mechanical assembly without the need of electrical contact between the metal blocks based on gap waveguide technology. The measured input reflection coefficients of both Tx/Rx channels are better than -13 dB. The proposed antenna satisfies the ETSI class II Co-polar sidelobe envelope requirement. The measured antenna efficiency is better than 60% in the designed passbands with 55 dB isolation of gain between two ports.

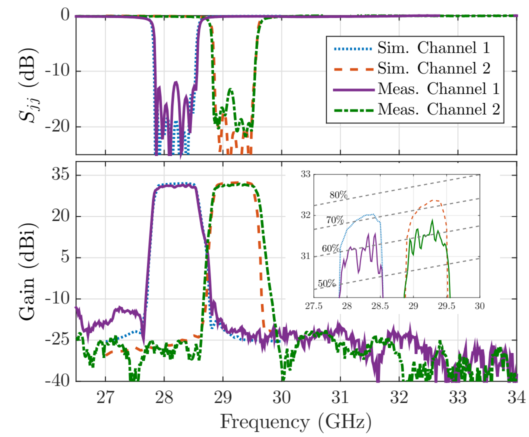

Fig. 3. Simulated and measured reflection coefficient and gain of the proposed integrated diplexer-antenna module.

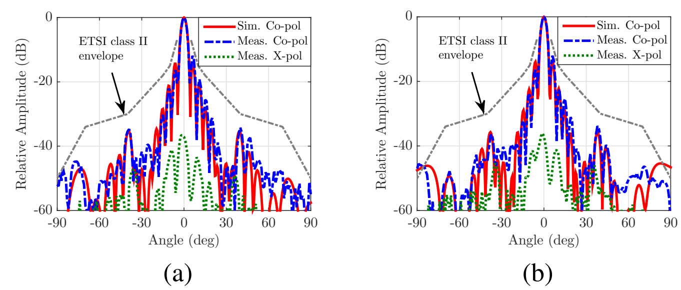

Fig. 4. Simulated and measured radiation patterns of the proposed array antenna at E-plane. (a) 28.21 GHz, and (b) 29.21 GHz.

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