Millimeter wave Bandpass Filter Based on Self-packaged LCP Multi-layer Suspended Coplanar Waveguide

Jiao Zhang\textsuperscript{1,} \textsuperscript{1} Jian-Kang Xiao\textsuperscript{1,} \textsuperscript{2} \\
\textsuperscript{1}School of Electro-Mechanical Engineering, Xidian University, Xi’an, China \\
\textsuperscript{2}Key Laboratory of Opto-technology and Intelligent Control, Ministry of Education, Lanzhou Jiaotong University, Lanzhou, China

Introduction

With the rapid development of wireless communication technology, there are higher and higher requirements for the RF filter in sizes and performance which includes loss, selectivity, out-of-band suppression and higher working frequency such as in millimeter wave. In order to achieve high out-of-band suppression, introducing transmission zeros and increasing the filter order have commonly been used. Transmission zeros can be obtained by source-load coupling, electromagnetic hybrid coupling, cross-coupling, and multimode resonators [1-4].

Design

The three-dimensional structure of the proposed millimeter wave bandpass filter is shown in Figure. It is composed of five-layer LCP dielectric plates with a dielectric constant of 2.7, and thicknesses of 0.1mm, 0.05mm, 0.05mm, 0.1mm, and 0.1mm, respectively. The upper and lower sides of each layer are covered with metal copper, which is represented by G1-G10, while the filter core circuit is distributed on the G5, as shown in Fig.2. The second and the fourth layers are used to support the air cavity, while the first and the fifth layers are mainly used to close the air cavities, and meanwhile introduce electromagnetic shielding.

The core circuit shown in Figure indicates that the proposed bandpass filter is mainly composed of a source-load coupling structure, a short circuit cut three-section stepped impedance resonator (SIR) and a surrounding ground plane. In this design, SIR is used to replace the traditional UIR (Uniform Impedance Resonator) for better performance and more easy control in the design. A pair of Grounded stubs are used to introduce magnetic coupling, while the SIRs coupling gaps introduce electric coupling. Transmission zeros can be produced by electric/magnetic couplings. SIRs are bent for achieving compact structure. Both I/O ports have characteristic impedance of 50Ω.

Analysis

Coupling structure of the bandpass filter is shown in Figure, where R represents the resonator, S and L represent source and load, respectively, while E and M represent electrical and magnetic coupling, respectively. Here, resonator coupling is dominantly through a gap, which introduces electrical coupling. R3 and R4 are connected to the ground through a short stub, which brings magnetic coupling here.

The bandpass filter is designed with a center frequency of 33.9GHz, a fractional bandwidth of about 4%, and a return loss of more than 20dB. The filter coupling matrix can be obtained as:

\[
\begin{pmatrix}
S & R_1 & R_2 & E & R_3 & L \\
R_1 & 0 & 1.5539 & 0 & 0 & 0 \\
R_2 & 0 & 1.5769 & -0.5877 & 1.065 & 0 \\
E & 0 & 0.03079 & 10.85 & -0.1711 & 1.6667 \\
R_3 & 0 & -0.0623 & 0 & 1.6667 & -0.2296 & 1.5539 \\
L & 0 & 0 & 0 & 0 & 1.5539
\end{pmatrix}
\]

Results

The filter frequency responses obtained by the coupling matrix and EM simulation are plotted in Figure. It can be seen that the proposed bandpass filter has a center frequency of 33.9GHz a fractional bandwidth of about 4%, and an insertion loss of about 2.1dB. A pair of transmission zeros which are due to the electromagnetic coupling are produced, and ultra wide stopbands are also implemented.

References