MILLIMETER-WAVE FILTERS FOR WIRELESS COMMUNICATIONS AND RADAR APPLICATIONS – AN OVERVIEW

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Abstract

The purpose of this paper is to present an overview of the various microwave and mm-wave filter technologies for wireless systems, especially future high capacity broadband wireless data communication networks at 60 GHz, radio-over-fiber systems, 4G networks, vehicular systems and telematics transceivers.

Introduction and Historical Overview

The explosive growth in commercial interest in millimeter-wave wireless systems, especially in future high capacity broadband wireless data communication networks at 60 GHz, radio-over-fiber systems, 4G networks, vehicular systems and telematics transceivers, has provided a significant challenge to conventional mm-wave circuits and their design methodologies. High performance filters, couplers, diplexers and antenna filters having a low insertion loss, low development, low manufacturing cost, easy interface with mm-wave MMICs, compact size, wide stopband and a high selectivity are important for future wireless systems. At present most filters at mm-wave frequencies are produced either in waveguide (air-filled metal pipe, dielectric-filled or micromachined air-filled) [1-2], E-plane metal waveguide [3] , finline [4] with high performance but heavy, bulky and with high associated machining costs, dielectric image guide [5], and nonradiative dielectric guide (NRD) [6-9] with high associated loss, dielectric resonators [10] or using multi-layered low-temperature-cofired-ceramics (LTCC) and printed circuit board (PCB) technologies. Planar guiding structures (microstrip, suspended substrate stripline, coplanar waveguide and substrate integrated waveguide) are the common choices for planar circuit designers in the multi-layered low-temperature-cofired-ceramics (LTCC) and PCB [11-17]. Generally these filter structures are not able to achieve high selectivity characteristics because the Q values are limited by loss and radiation. Although in principle highly selective characteristics can be achieved by using elliptic function filters, this technique becomes less viable at mm-wave frequencies· Ideally a mm-wave MMIC transceiver chipset is needed for low cost mass production units. Low loss and good selectivity filtering is one of the major MMIC technology shortcomings due to the low quality factor [18-19]. From the above it is obvious that a hybrid solution should be pursued that will combine the above technologies in such a way that each technology's advantages are retained while power efficient transitions and interconnects between technologies is achieved. Realization of resonators, filters, couplers, power dividers, diplexers and antenna filters with a low insertion loss, low development, low manufacturing cost, easy interface with mm-wave MMICs, compact size, and a high selectivity using substrate integrated dielectric image guide (SIDIG) [20] is seen to be an attractive approach which provides numerous advantages such as design flexibility, low loss properties, and assembly cost. This can be achieved by artificially lowering the effective dielectric constant around a guided channel. By using the high-resistivity silicon as a substrate material the guide attenuation value as low as 0.07 dB/λg at 94 GHz can be obtained. In this paper the above mm-wave filter technologies are presented with respect to performance for wireless communications and radar applications.

Millimetre-wave Filter Technologies for Current and Proposed Wireless Systems

Some of the major implemented or proposed mm-wave filter technologies for wireless communications and radar applications are shown in Table1. Filter selection for commercial wireless systems is dictated by size, weight and cost being of significant interest, while the performance is often a secondary consideration, in contrast with filters designed for defence application where performance is the prime consideration while cost is secondary.

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Table1. Types of Filters Typically Used in Millimeter-wave Wireless Systems

System	Filter Technology
Point-to-point Radio	E-plane metal insert waveguide, Finline
Point-to-multipoint Radio	Standard rectangular waveguide, E-plane metal insert waveguide, Finline
MVDS/LMDS base station	Iris-coupled Cavity, E-plane metal insert waveguide, Finline
60 GHz P-MP Wireless Access Links	Multi Chip Module (MCM) concept based on LTCC, planar dielectric waveguide for flip-chip modules
V-band and W-band FMCW Radar Front-Ends	Standard rectangular waveguide, E-plane metal insert waveguide, quasi-planar (Finline), substrate integrated waveguide, multilayer LTCC, integrated waveguide on Liquid-Crystal Polymer (LCP) substrate, micromachined rectangular waveguide
Radio-over-fibre	Planar dielectric waveguide, substrate integrated waveguide (SIW), integrated waveguide on LCP substrate
60 GHz-band ASK transceiver	Non-Radiative dielectric (NDR) guide, LTCC based embedded dielectric waveguide, multilayer MCM
60 GHz Data Link for ITS	Quasi-waveguide filter using multi-layer PTFE-based organic softboards, integrated waveguide on (LCP), multilayer LTCC
High Definition Television (HDTV)-signal transmission system	Dielectric planar filters mounted in the cavities of the LTCC substrates as packages using flip-chip bonding technique (MCM)
24 GHz RADAR Sensor for Distance and Velocity Measurement	Photoimageable thick film substrate integrated waveguide, multilayer MCM, multilayer LTCC
Wireless Gigabit Ethernet Link	MCM, LCP, LTCC
Wireless Broadband ADSL at 60 GHz	NDR guide
Ka-Band Front-End for Software Define Radio (SDR)	SIW, Substrate integrated image dielectric guide (SIIDG), substrate integrated non-radiative guide (SINDR)

Conclusion

A detailed overview of several different filter technologies and mm-wave wireless systems especially future high capacity broadband wireless data communication networks at 60 GHz, radio fiber systems, 4G networks, vehicular systems and telematics transceivers has been presented. Several examples of mm-wave wireless filter designs will be presented at the conference.

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