

Microwave and Millimeter-Wave Integrated Circuits

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Invited Paper

Abstract—A historical sketch of microwave integrated circuits, monolithic microwave integrated circuits, and their application is presented in this paper.

Index Terms—Applications, circuits, communication, electronic warfare, hybrid, integrated, microwave, monolithic, radar, systems.

I. INTRODUCTION

MICROWAVE and millimeter-wave integrated circuits have experienced a tremendous growth over the last 50 years. Circuits have become smaller, highly integrated, lower cost, and have found extensive applications in radar, electronic warfare, and the commercial field. This historical review is divided into three sections: microwave integrated circuits (MICs), monolithic microwave integrated circuits (MMICs), and MIC and millimeter-wave integrated-circuit applications authored, respectively, by Bahl, Pucel, and Niehenke.

II. MICs

A. Introduction

We will divide the historical development of MICs into two categories: microwave printed circuits (MPCs) and hybrid MICs. The MPC technology is exclusively applied to a wide variety of microwave passive components including manifolds for power distribution, filters, couplers, baluns, and printed antennas. The hybrid MIC technologies are commonly used for fabricating active, passive, and integrated microwave functions. Basic building blocks for MICs are planar transmission lines such as stripline, microstrip, proximity-coupled stripline and microstrip, slotline, coplanar waveguide, and finline. Fig. 1 shows cross-sectional views of these lines. They are normally characterized by four basic parameters, i.e., characteristic impedance, phase velocity or effective dielectric constant, attenuation constant, and power-handling capability. The parameters are evaluated in terms of their cross-sectional dimensions, properties of the dielectric substrates, and the conductor materials used.

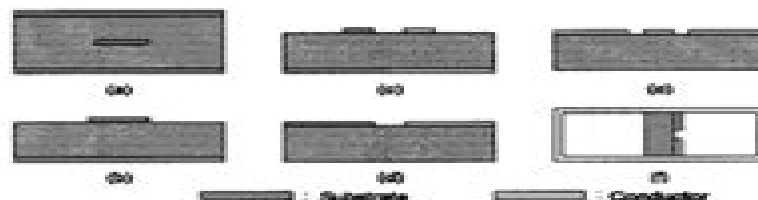


Fig. 1. Planar transmission lines for MICs. (a) Stripline. (b) Microstrip. (c) Coupled microstrip. (d) Slotline. (e) Coplanar waveguide. (f) Finline.

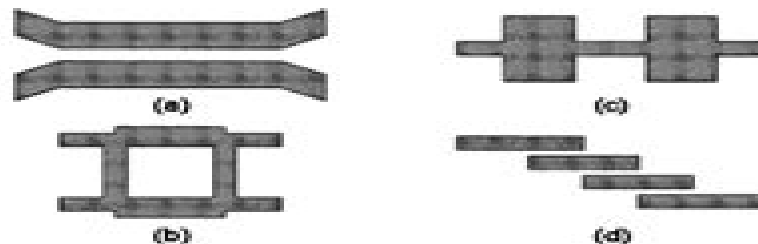


Fig. 2. Stripline-components. (a) TEM-line proximity coupler. (b) Branch-line coupler. (c) Low-pass filter. (d) Bandpass filter.

B. MPCs

An excellent historical overview on MPCs is given in the literature [1]–[3]. The stripline is the basic building block for MPCs. The work on stripline was first reported in 1951 [4], and papers on theoretical design information including characteristic impedance, junction discontinuities, and coupled striplines were published during 1954–1956 [5]–[15]. The first stripline design manual *A Handbook of Tri-plate Microwave Components* was available in 1956 [16]. The first book, entitled *Stripline Circuit Design*, was published in 1974 [17]. Historical accounts of stripline directional couplers and filters are given by Cohn and Levy [18] and Levy and Cohn [19], respectively. Fig. 2 shows popular configurations of these components.

Numerous papers were published in the 1950s and 1960s describing the theory, design, fabrication, and measured data for the TEM-line edge-coupled directional couplers. Among stripline components, directional couplers are the most popular. These couplers can provide coupling in the 8–40-dB range.

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Millimeter Wave Integrated Circuits

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