CHAPTER ONE

Introduction

1.1 BACKGROUND AND APPLICATIONS

The microstrip ring resonator was first proposed by P. Troughton in 1969 for the measurements of the phase velocity and dispersive characteristics of a microstrip line. In the first 10 years most applications were concentrated on the measurements of characteristics of discontinuities of microstrip lines. Sophisticated field analyses were developed to give accurate modeling and prediction of a ring resonator. In the 1980s, applications using ring circuits as antennas, and frequency-selective surfaces emerged. Microwave circuits using rings for filters, oscillators, mixers, baluns, and couplers were also reported. Some unique properties and excellent performances have been demonstrated using ring circuits built in coplanar waveguides and slotlines. The integration with various solid-state devices was also realized to perform tuning, switching, amplification, oscillation, and optoelectronic functions.

The ring resonator is a simple circuit. The structure would only support waves that have an integral multiple of the guided wavelength equal to the mean circumference. The circuit is simple and easy to build. For such a simple circuit, however, many more complicated circuits can be created by cutting a slit, adding a notch, cascading two or more rings, implementing some solid-state devices, integrating with multiple input and output lines, and so on. These circuits give various applications. It is believed that the variations and applications of ring circuits have not yet been exhausted and many new circuits will certainly come out in the future.

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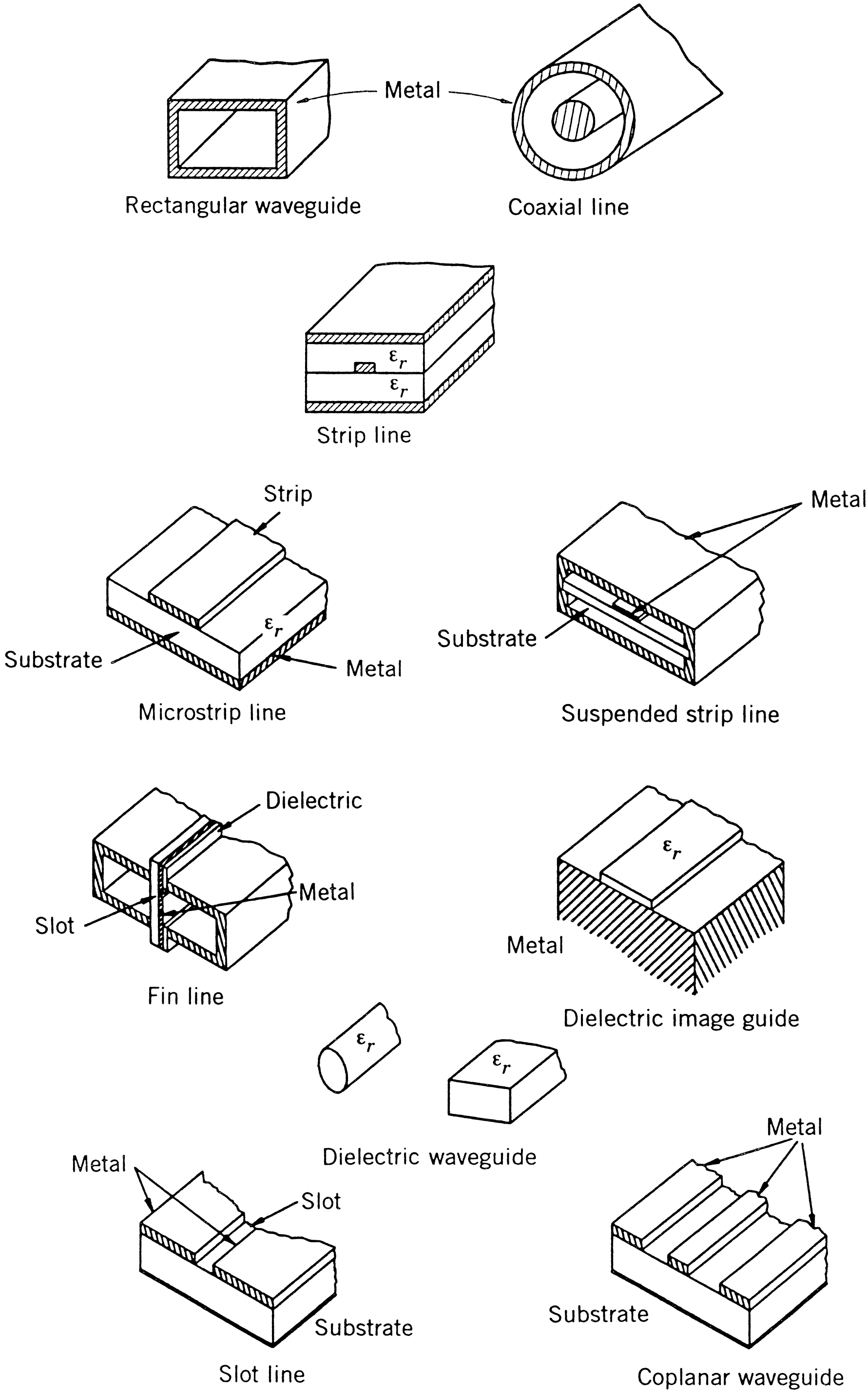

FIGURE 1.1 Various transmission lines and waveguides.

TABLE 1.1 Comparison of Guiding Media and Waveguides

Item	Useful Frequency (GHz)	Impedance Level (Ω)	Cross-Sectional Dimensions	Q Factor	Power Rating	Active Device Mounting	Potential for Low-Cost Production
Rectangular waveguide	<300	100–500	Moderate to large	High	High	Easy	Poor
Coaxial line	<50	10–100	Moderate	Moderate	Moderate	Fair	Poor
Strip line	<10	10–100	Moderate	Low	Low	Fair	Good
Microstrip line	≤100	10–100	Small	Low	Low	Easy	Good
Suspended strip line	≤150	20–150	Small	Moderate	Low	Easy	Fair
Fin line	≤150	20–400	Moderate	Moderate	Low	Easy	Fair
Slot line	≤60	60–200	Small	Low	Low	Fair	Good
Coplanar waveguide	≤60	40–150	Small	Low	Low	Fair	Good
Image guide	<300	30–30	Moderate	High	Low	Poor	Good
Dielectric guide	<300	20–50	Moderate	High	Low	Poor	Fair

1.2 TRANSMISSION LINES AND WAVEGUIDES

Many transmission lines and waveguides have been used for microwave and millimeter-wave frequencies. Figure 1.1 shows some of these lines and Table 1.1 summarizes their properties. Among them, the rectangular waveguide, coaxial line, and microstrip line are the most commonly used. Coaxial line has no cutoff frequency, can be made flexible, and can operate from dc to microwave or millimeter-wave frequencies. Rectangular waveguide has a cutoff frequency and low insertion loss, but it is bulky and requires precision machining. Microstrip line is the most commonly used in microwave integrated circuits (MIC) and monolithic microwave integrated circuits (MMIC). It has many advantages, which include low cost, small size, no critical machining, no cutoff frequency, ease of active device integration, use of pbotolithographic method for circuit production, good repeatability and reproducibility, and ease of mass production. In addition, coplanar waveguide and slotline can be the alternatives to microstrip line for some applications due to their uniplanar nature. In microstrip, the stripline and ground plane are located on opposite sides of the substrate. A hole is needed to be drilled for grounding or mounting solid-state devices in shunt. In the uniplanar circuits such as coplanar waveguide and slotline, the ground plane and circuit are located on the same side of the substrate, avoiding any circuit drilling or via holes.

Ring circuits can be built on all these transmission lines and waveguides. The selection of transmission lines and waveguides depends on applications and operating frequency ranges. Most ring circuits realized so far are in microstrip line, rectangular waveguide, coplanar waveguide, and stotline.

1.3 ORGANIZATION OF THE BOOK

This book is organized into 12 chapters. Chapters 2 and 3 give some general descriptions of a simple model, field analyses, a transmission-line model, modes, perturbation methods, and coupling methods of ring resonators. Chapters 4 and 5 discuss how electronically tunable and switchable ring resonators are made by incorporating varactor and PIN diodes into the ring circuits. Chapters 6, 7, 8, 9, and 10 present the applications of ring resonators to microwave measurements, filters, couplers, and magic-Ts. Chapter 11 gives a brief discussion of ring antennas, frequency selective surfaces, and active antennas. The last chapter (Chapter 12) summarizes applications for ring circuits in mixers, oscillators, optoelectronics, and metamaterials.