Chapter 8
Microwave Power Protectors: Attenuators and Limiters

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ABSTRACT

In this chapter, microwave power attenuator and limiter theory and technological realization are presented. The chapter is divided in two sections, first section is dedicated to attenuator circuits and the second section is dedicated to power limiters circuits. Authors describe, in first section, principles characteristic and fundamentals of attenuator and detail of the most common topologies such as T-attenuator, PI-attenuator and bridged-attenuator. After a presentation of important equations needed to calculate attenuation rate provided by each of these previous cited topologies, authors present the variable attenuator based on active component (PIN diode, Transistors). In second section, authors present power limiter characteristic and fundamentals. Afterward, they present a state of arts of technological solution to design power limiter based on solid state components such as PIN diode and Schottky diodes.

INTRODUCTION

Since the appearance of RF & microwave systems, the flow of electromagnetic waves of high power presents a serious threat to sensitive electronic components such as low noise amplifiers (LNA), radar and space communications (D. Shiffler, High Power Microwave Source, 2005).There are many factors which may result in high power flows: an outside high power RF source, an inside high power RF resulting from interactions (couplings) between neighbouring microwave guides or reflection of transmitting signal resulting in mismatching between transmitter and receiver (Kacmajor, Michalski, & Mazur, March 27–30, 2012).

DOI: 10.4018/978-1-5225-0773-4.ch008

Below, few examples of damaging effects of high power microwaves:

- **Destruction of Electronic Components:** LNA (Low Noise Amplifier) components are sensitive devices designed to detect very small signal. Consequently, high power microwaves may present a damaging risk for this equipment's. Hence, Failure to control the reception chain may damage these components permanently.
- **Saturation of Radio-Receiving Elements:** In the case where the received power exceeds the sensitivity threshold of the receivers, the performance of radio receivers is not linear and therefore, these receivers cannot filter the useful signal.
- **Generation of Interferences:** Mobile cellular telecommunications systems such as CDMA, WCDMA and LTE systems are based on the power control signals to prevent mutual interference between neighbouring cells and between different mobile devices covered by the same cell. (Müllner, Ball, Ivanov, Lienhart, & Hric, 2009) Mobile devices around the radio cell must reduce their emission power in order to transmit low power signals compared with the power of signals to be emitted by devices located in a remote area of the cell. Equivalent mechanism is implemented in Digital Subscriber Lines (DSL) Networks to prevent known problem called Near Far Problem (Yu, G. Ginis, & Cioffi, 2002).

Therefore, there is a permanent interest to integrate into the RF receiver chains power control circuit, in order to avoid equipment malfunction or destruction of the sensitive elements of the receiving chain. In literature, the microwave device protection against high power signal is provided by two kinds of circuits: Power attenuator (Sun, Choi, & Weide, JUNE 2005) and power limiter circuits (Maloratsky, 2004). The main difference between the two circuits lies in the fact that the attenuator reduces the power signal by a predetermined ratio while the power limiter tends clipping incident signal below a threshold power.

This Chapter is divided on two sections. First section is dedicated to attenuator circuits and second section is dedicated to Power limiter circuits. In each section authors present necessary definition of power control circuits and the main concerns about design and conception of these circuits. At the end of each section, examples are presented and discussed to point out best practice to design and optimize power attenuator and limiter circuits.

BACKGROUND

Sophisticated telecommunications systems will have to solve problems increasingly difficult associated to two types of constraints:

- **Detect and Recognize the Signals:** Of increasingly varied in power and frequency, which will increase the range and sensitivity of the systems but also increase its vulnerability towards its electromagnetic environment.
- **Protect Against High Power Signals:** Can cause the destruction of sensitive components and saturating the system. This protection is achieved by power limiters and attenuators.

As a result, the reliability of an efficient system depends on the robustness of the protection systems inserted before sensitive components.