A COMPUTER-CONTROLLED INTEGRATED MICROWAVE MEASUREMENT SYSTEM IN FINLINE TECHNIQUE FOR AUTOMATIC MATERIAL PARAMETER MEASUREMENTS

Adalbert Beyer, Wolfhardt Müller-Gronau and Ingo Wolff

Duisburg University, Department of Electrical Engineering, Bismarckstr. 81, D-4100 Duisburg
Fed. Rep. of Germany

Abstract

Integrated circuit elements in finline technique have been developed for the application in an automatic measurement system which determines the complex material parameters of ferrites and dielectrics. These elements render possible a very fast tuning of the measurement setup in comparison with mechanically controlled systems. They can also be produced much cheaper and more easily than waveguide elements. The design of fully integrated microwave measurement systems in finline technique will be discussed.

Introduction

The realization of automatic measurement systems for measuring e.g. the complex material parameters of ferrites and dielectrics requires the use of electronically controllable components, such as attenuators, phase shifters, switches etc.. The consideration of possible concepts for the construction of these components yields that integrated circuits in finline technique show certain advantages with respect to other principles like conventional diode-waveguide attenuators or electromechanically controlled rotary vane devices.

Such advantages are, besides others, that in generalfinline components can be produced much cheaper and more easily than waveguide elements.Furthermore, the use of pin-diodes renders possible a very fast tuning in comparison with mechanically controlled systems employing servo motors; in contrast to conventional diode-waveguide attenuators, the pin-diodes can be easily integrated into the finline.

Details of system design

In a first version, we have designed a computer-controlled integrated microwave unit in finline technique, which uses a finline attenuator and a finline isolator. Basically, a finline attenuator consists of three sections: a homogeneous center section, where one or more diodes are located, and two taper sections, which provide the necessary matching between the impedances of the waveguide and the diodes. The resulting performance of the attenuator largely depends on the properties of the taper sections. Therefore, extensive research with respect to the characteristics of these tapers was done, the results will be discussed in the oral presentation. Since a single diode does not meet the required specifications with regard to bandwidth and attenuation behaviour, the use of two or more diodes is necessary. Investigations show that a configuration according to Fig. 1 yields the best results.

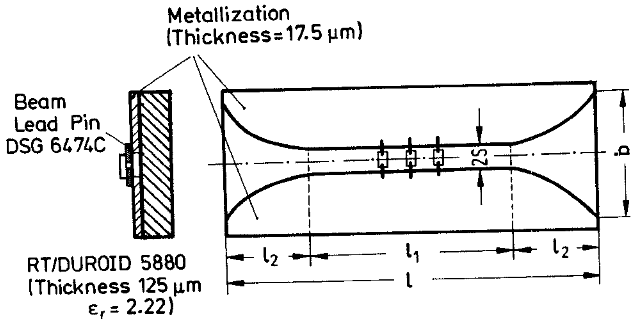

Fig. 1: The finline attenuator.

In Figs. 2 and 3, the measured results for the insertion loss and the reflection loss of the attenuator are plotted versus the frequency with the overall bias current I_D of the three diodes as a parameter. It can be seen from Fig. 2 that the attenuation for a constant bias current is frequency-dependent; therefore the application of the attenuator for precise wide-band measurements requires the use of a correction mechanism for the bias current in order to achieve a frequency-independent attenuation.
In Fig. 4, the bias current I_D, which is frequency-dependent for a constant value of the attenuation, is plotted versus the frequency with the insertion loss as a parameter.

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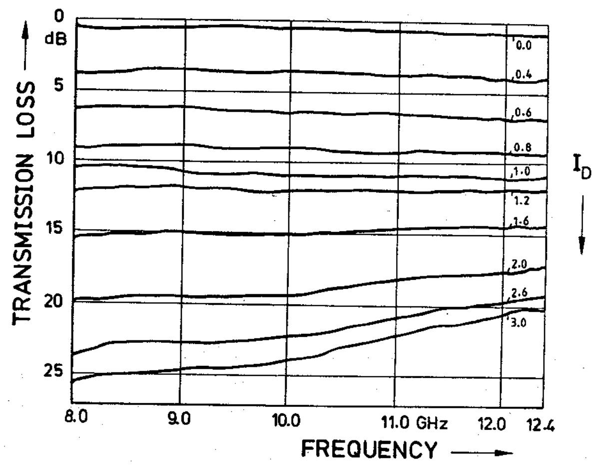

Fig. 2: Insertion loss of the finline attenuator.

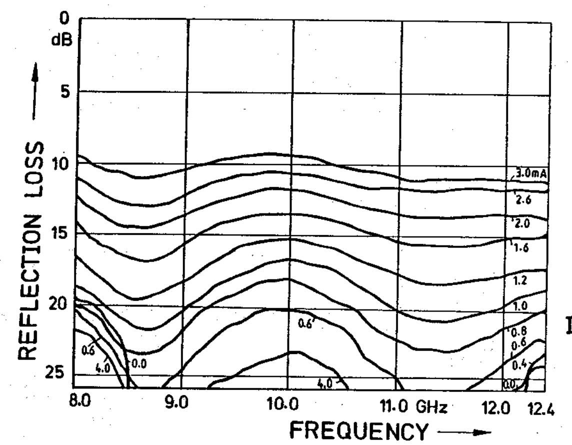

Fig. 3: Reflection loss of the finline attenuator.

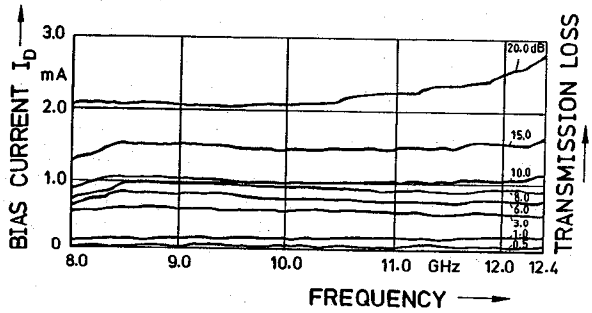

Fig. 4: The bias current of the finline attenuator.

The above-described attenuator was developed as a part of an automatic system for measuring the complex magnetic and dielectric material parameters of microwave ferrites or dielectrics. Employing a recently published method /3/ (and its just completed extension for measuring the imaginary parts of the material parameters), the complex material parameters can be computed from the measured resonant frequencies and Q-factors of resonant modes that occur in a cavity partly filled with the material sample to be measured.

The same desk-top computer that controlls the automatic measurement system shown in Fig. 5 is also used for the computation of the material parameters. The determination of the Q-factor requires an exact 3 dB variation of the microwave power that is available at the input of the transmission-type cavity. The correction mechanism consists of the desk-top computer (microcomputer) in combination with a digital-to-analog converter (DAC). Depending on the frequency, the computer provides the adequate bias current I_D for the desired attenuation. By means of a second DAC, the computer also provides the sweep voltage for the microwave generator. The output signal of the crystal detector is digitized by an analog-to-digital converter (ADC) and, like the output signal of the frequency counter, is then transferred to the computer.

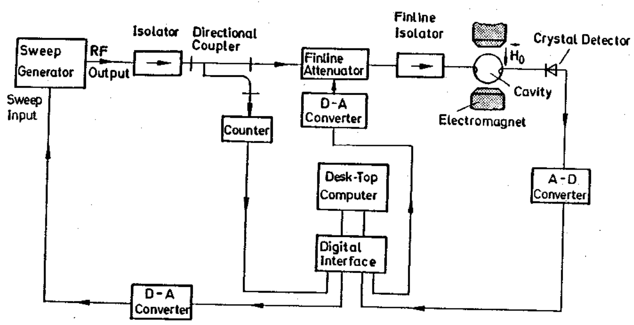

Fig. 5: Block diagram of the automatic X-band measurement system.

An electromagnet generates the premagnetizing dc-field $\vec{H}_0$, allowing a maximum field strength of 16.7 kA/cm. Since the input of the loosely coupled cavity practically forms a short circuit, an additional isolator was inserted between the attenuator and the cavity in order to prevent the occurrence of reflections which could deteriorate the accuracy of the attenuator. The isolator /5/ was also realized in finline technique. Fig. 6 shows a cross-sectional view of the isolator.

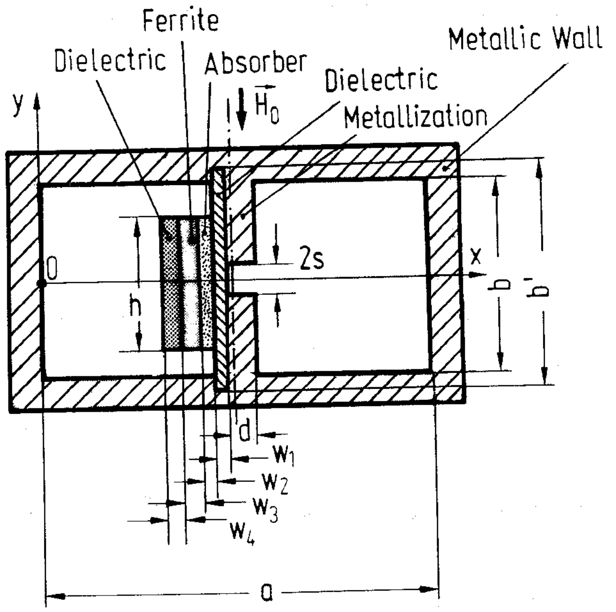

Fig. 6: The cross-sectional view of the isolator in finline technique.

In Fig. 7, measured results for the insertion loss in forward (transmission loss, Fig. 7) and backward (reverse loss, Fig. 7) direction are plotted as a function of the frequency.

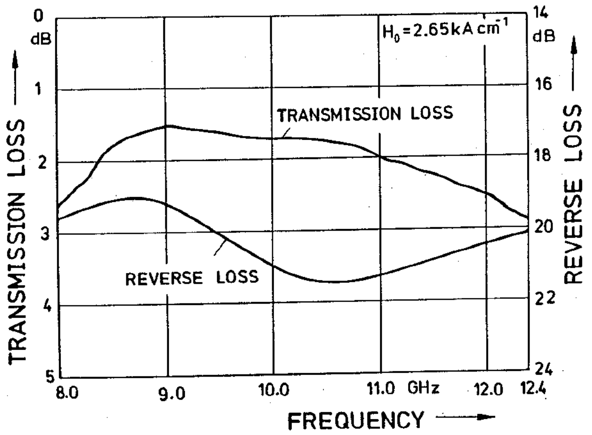

Fig. 7: Characteristics of the finline isolator.

The application of the automatic measurement system yields that the difference between automatically and manually measured resonant frequencies was less than 0.5 MHz, while the automatically and manually obtained Q-factors showed a typical deviation between each other of about 3 %; tests proved that the measurement accuracy for the Q-factor can still be improved.

At present, a second computer-controlled fully integrated microwave unit in finline technique, which includes several of the - up to now - seperate microwave components shown in Fig. 5, is under development: the attenuator, two isolators and two directional couplers (one for levelling purposes) are combined in a compact finline circuit.

Conclusion

For the application in an automatic measurement system, integrated elements in finline technique have been developed, which allow a simpler and more efficient system design than conventional waveguide elements. A wide-band precision attenuator is described, whose bias current is controlled by a microcomputer in order to achieve a frequency-independent attenuation Besides controlling the measurement system, the same computer is also used for the calculation of the material parameters from the measurement data. Furthermore, an isolator also realized in finline technique is described, which improves the accuracy of the attenuator. At present, a fully integrated microwave unit in finline technique is under development, which includes most of the microwave elements of the measurement system.

References

/1/ Beyer, A. and Wolff, I.: Calculation of the transmission properties of inhomogeneous finlines. Proc. of the 10th Eu. M.C., Warsaw (Poland), 322 - 326 (1980)

/2/ Beyer, A.: Analysis of the characteristics of an earthed finline. IEEE Trans. vol. MTT-29, No. 7, 676 - 680 (1981)

/3/ Müller-Gronau, W. and Wolff, I.: A microwave method for the determination of the real parts of the magnetic and dielectric material parameters of premagnetized microwave ferrites. IEEE Trans. vol. IM-32, No. 2, 377 - 382 (1983)

/4/ Meier, P.J.: Integrated finline millimeter-wave components. IEEE Trans. vol. MTT-22, No. 12, 1209 - 1216 (1974)

/5/ Beyer, A. and Solbach, K.: A new finline ferrite isolator for integrated millimeter-wave circuits. IEEE Trans. vol. MTT 29, No. 12, 1344 - 1348 (1981)