A Comprehensive CAD for Microstrip, Coaxial and Waveguide Circuits

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Abstract: - This paper presents a visual user-oriented comprehensive computational program used for a wide range of microstrip, coaxial, and waveguide applications. For microstrip application it is used for active and passive circuits design such as microstrip amplifiers, oscillators, couplers, and mixers. For waveguide application, it is used for the design of rectangular waveguide oscillators and amplifiers with post and disc assembly used for the tuning of the active element (IMPATT or Gunn diode). For coaxial application, it is used for the design of coaxial amplifiers and oscillators with the design of the tuning circuit of the active element. The new developed program is compared to other available commercial ones.

Key Words: - Computational Microstrip Circuit Design, Microwave Circuits, Computer Aided Design

1 Introduction

Since the mid-1970s, a number of computer programs for microwave circuit design had become commercially available [1-3]. All of these programs have certain advantages and some disadvantages. In this paper we introduce a new comprehensive microwave solid-state circuit design software named MSDES_WIN with visual windows interface.

MSDES_WIN is a user oriented CAD program used for a wide range of microstrip, coaxial, and waveguide applications. For microstrip application it is used for active and passive circuits design such as microstrip amplifiers, oscillators, couplers, and mixers. For waveguide application, it is used for the design of rectangular waveguide oscillators and amplifiers with post and disc assembly used for the tuning of the active element (IMPATT or Gunn diode). For coaxial application, it is used for the design of coaxial amplifiers and oscillators with the design of the tuning circuit of the active element.

Comparing with some of the existing programs, the new program has the following features. 1) visual windows interface for input and output parameters, 2) applicable for microstrip, coaxial cavity and waveguide microwave circuit design, 3) draw the smith chart for design parameters (input/output matching circuits, stability circles and gain circles), 4) draw a circuit layout, 5) Perform rate-race and one/two-section branch line couplers, 6) Takes into consideration a full discontinues of microstrip lines, 7) can be used

to perform a complete design of integrated circuits such as microstrip receiver with amplifiers, oscillator, and mixer, 8) Have wide applications, and 9) It can be used in case of change from unconditional stability to potential unstability and vice versa, either by connecting a series feedback stub with certain length or connecting a cascaded resistor to the transistor terminals.

A variety of examples of passive and active microwave circuit design are presented.

2 Program Description

The developed program (MSDES_WIN) is used not only for microstrip circuit design, but it can be used also for coaxial and rectangular waveguides circuit designs. Figure 1 shows the main architecture of the program

2.1 Microstrip Circuit Design

Our developed program (MSDES_WIN) is used for designing of MICs, especially for microstrip amplifiers, oscillators, couplers, and diode mixers

2.1.1 Microstrip amplifiers

The design of microstrip amplifier is performed with feedback or without feedback circuits [2-9]. The program performs all the required calculations needed for transistor stability, simultaneously

conjugate match and for available and operating power gain design. The program performs analytical and graphical matching circuit design for input and output of the amplifier. The design entries of the program are S parameters of the active element, the designed frequency, and the substrate parameters. Figures 2 through 5 show the program entry and the program features for microstrip amplifier design
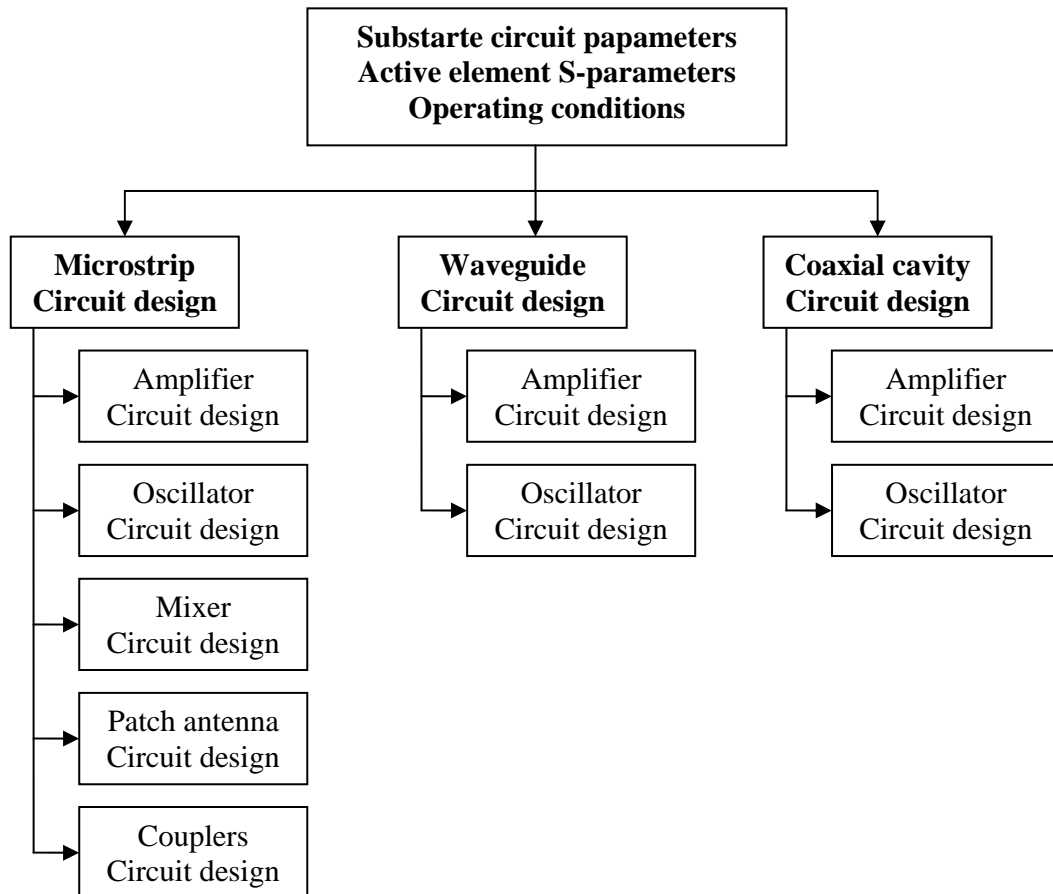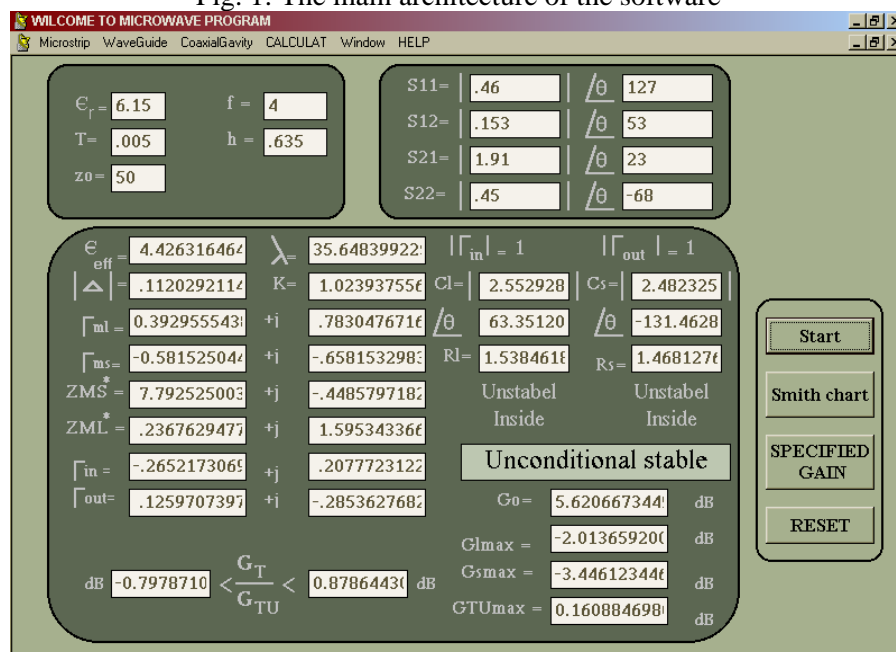

Fig. 1: The main architecture of the software

Fig. 2: The program entry and the basic calculations for microstrip amplifier design
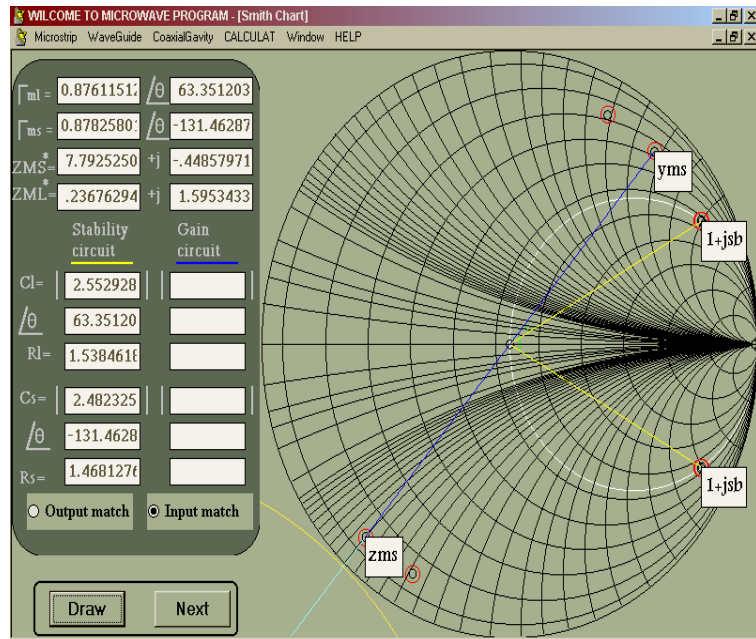
Fig. 3: The graphical design approach for designing of the input matching circuit
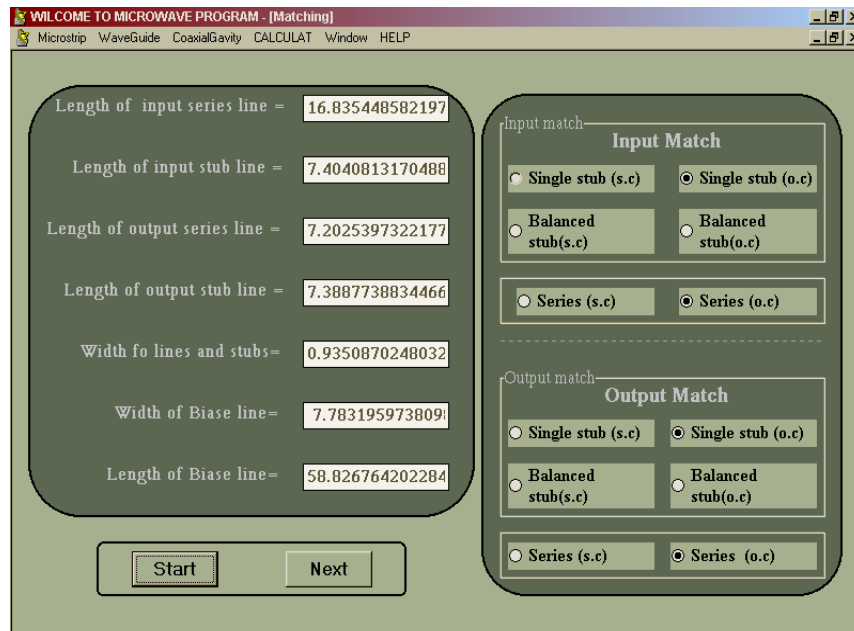

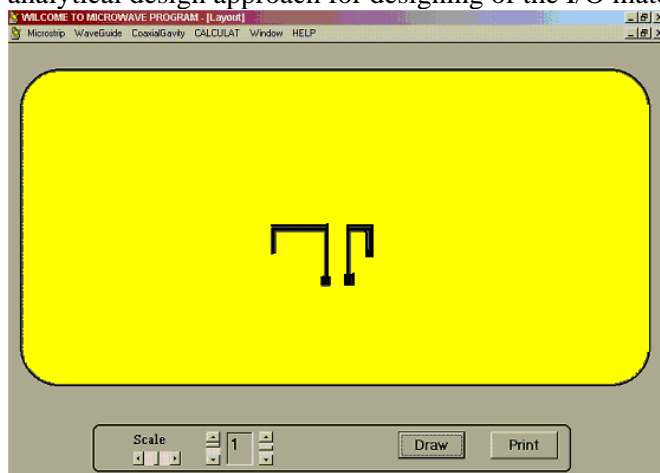Fig. 4: The analytical design approach for designing of the I/O matching circuit

Fig. 5: The layout of the designed microstrip amplifier

2.1.2 Microstrip Oscillators

The program performs all the required calculations needed for transistor stability in addition with performing analytical and graphical design approaches for the terminating and load matching circuits [7, 9-13]. The design entries of the program are S parameters of the active element, the designed frequency, and the substrate parameters. Figures 6 and 7 show the program entry and the program features for microstrip oscillator design.
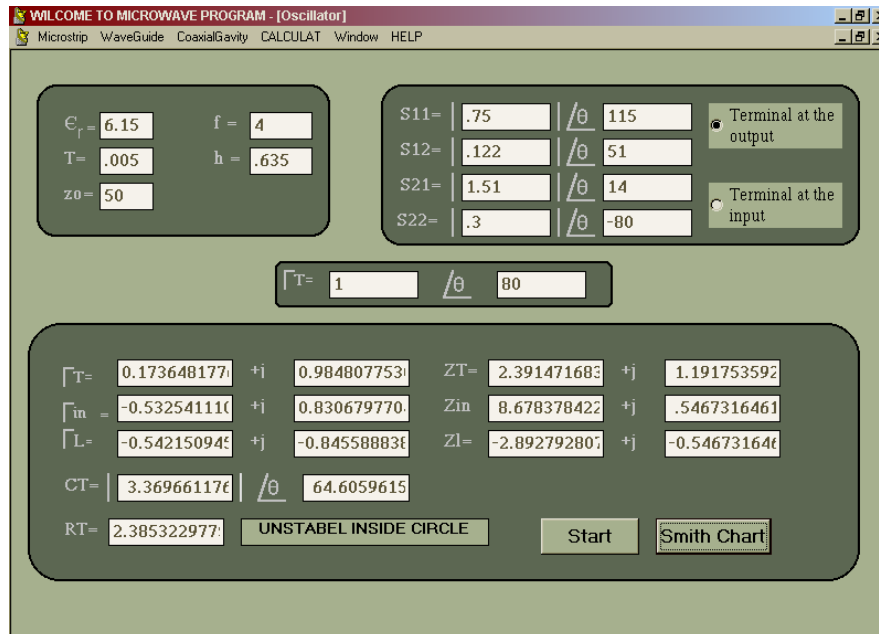

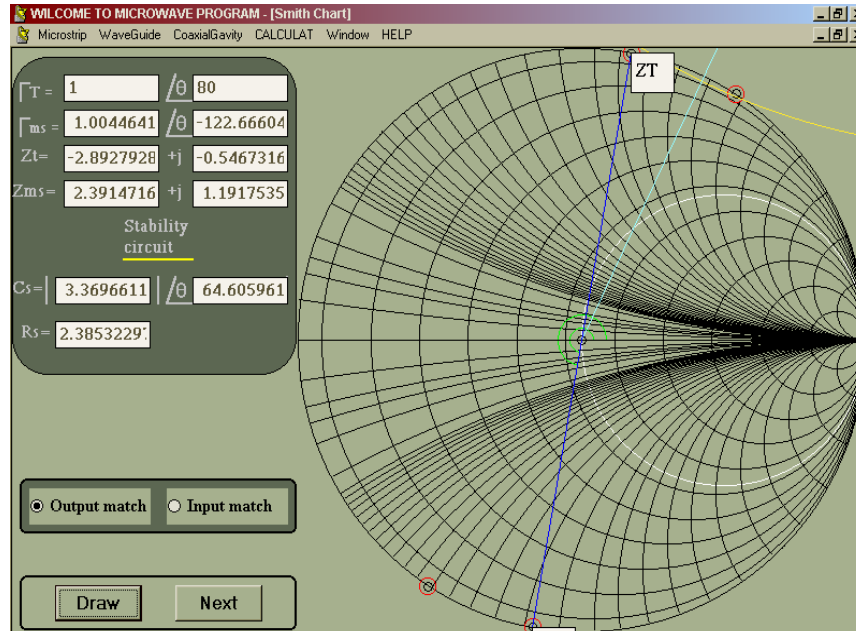Fig. 6: The program entry and the basic calculations for microstrip oscillator design

Fig. 7: The graphical design approach for designing of the terminating circuit

2.1.3 Microstrip antennas

The program is used for the design microstrip rectangular patch antenna array with TL and coaxial feeding. Figures 8 and 9 show the program entry and the program features for MPA design

2.1.4 Microstrip couplers

MSDES_WIN program is applicable for microstrip coupler design, especially for branch and rate-race couplers design. Figures 10 and 11 show the program entry and the program features for microstrip coupler design [16-23].

Fig. 8: The program entry, configuration and the basic calculations for single element MPA design
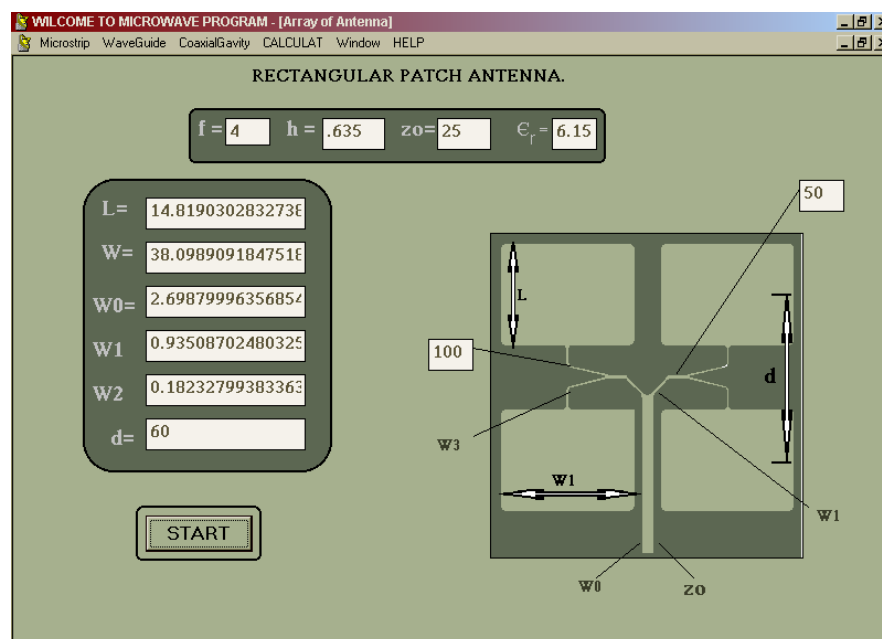

Fig. 9: The program entry, configuration and the basic calculations for 4-elements MPA design

2.1.5 Microstrip Mixer

The program performs the design of singly balanced diode mixer. The diode equivalent circuit and the substrate parameters are the entry of the mixer design [14-16].

The program calculates the diode input impedance and performs a complete design of the diode matching circuits.

Figures 12 through 14 show the program entry and the program features for microstrip singly balanced diode mixer design.

2.2 Rectangular Waveguide Circuit Design

MSDES_WIN is used for amplifier and oscillator design using rectangular waveguides. The tuning of the active element and the post/disc biasing assembly are designed [9,10,12,13]. Figure 15 shows the design entry, configuration, and the basic calculations for the diode tuning and post/disc assembly
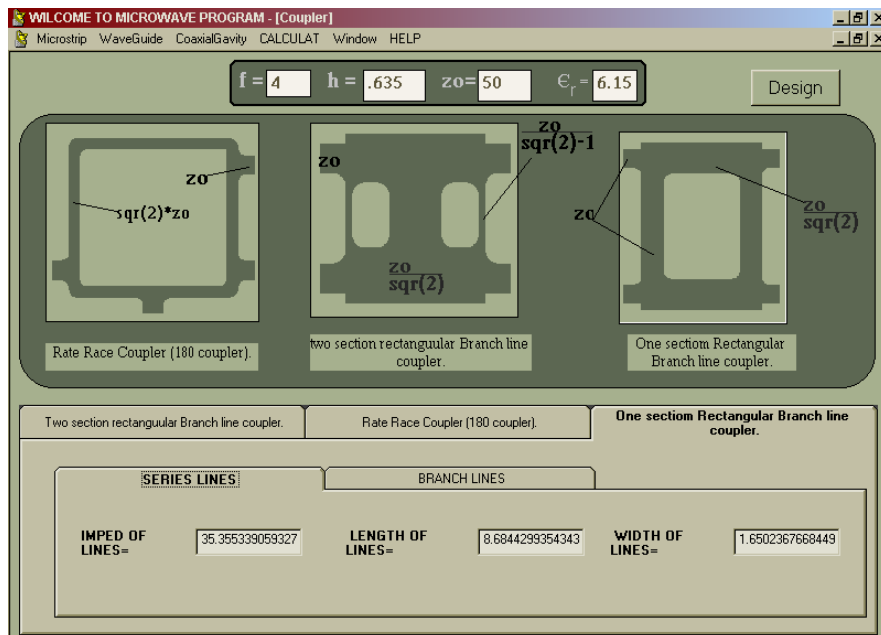
Fig. 10: The program entry, configuration and the basic
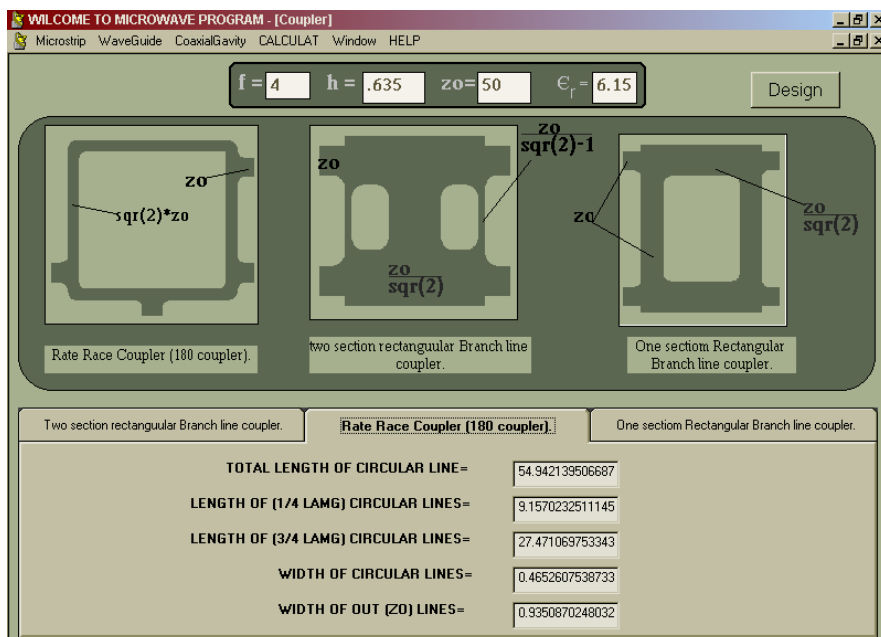calculations for microstrip coupler design

Fig. 11: The configuration and the basic calculation
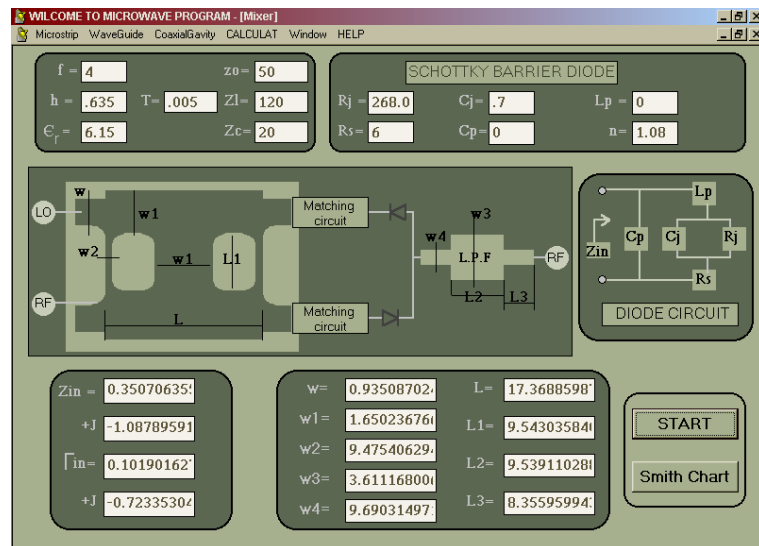for microstrip coupler design

Fig. 12: The design entry, configuration and the basic calculations
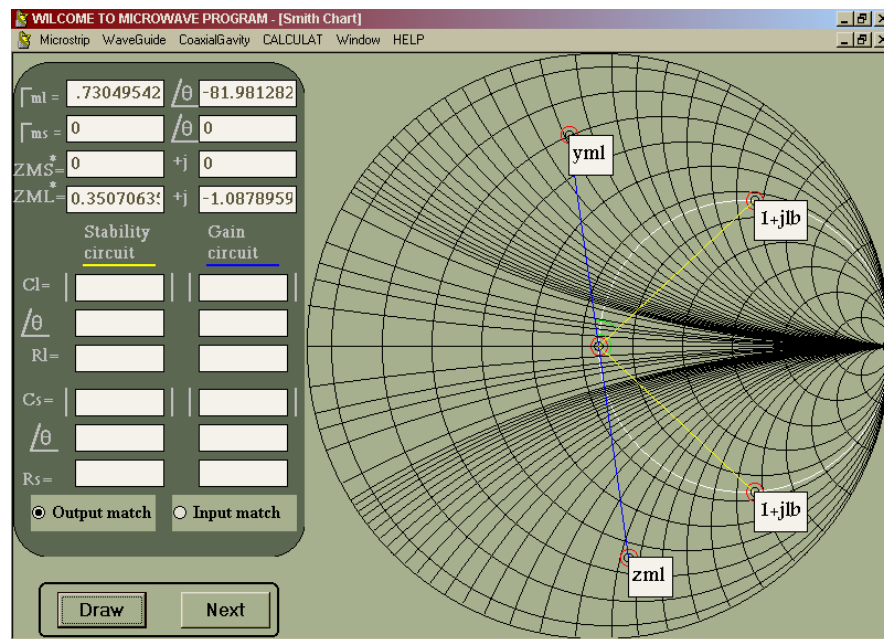for microstrip singly balance diode mixer design

Fig. 13: The graphical design approach
for the diode matching circuit
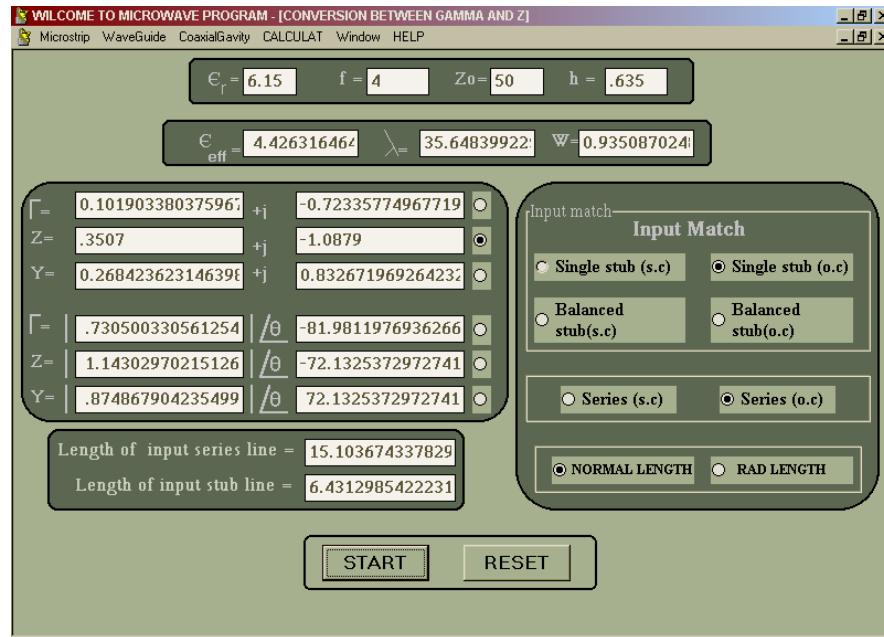
Fig. 14: The analytical design approach
for the diode matching circuit

Fig. 15: The design entry, configuration, and the basic
calculations of the diode tuning and post/disc assembly

2.3 Coaxial Circuit Design

MSDES_WIN is used for amplifier and oscillator design with coaxial waveguide as a guide media. The tuning of the active element and the post and disc biasing assembly are designed [9,10,12,13].

Figure 16 shows the design entry, configuration, and the basic calculations of the diode tuning and post and disc assembly for coaxial amplifier design.
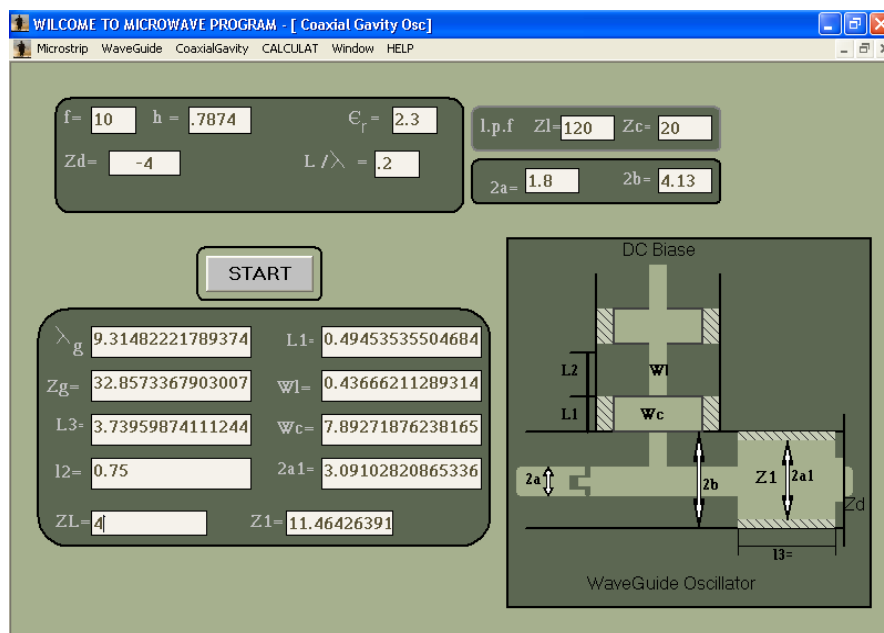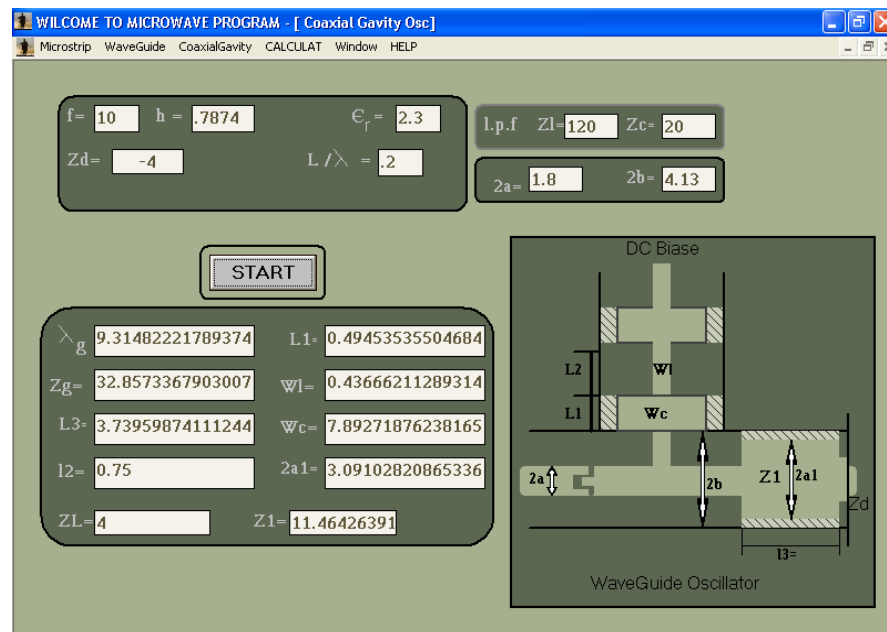
Fig. 16: The design entry, configuration, and the basic calculations of the diode tuning and post/disc assembly for coaxial waveguide amplifier design

3 Program Advantages

Comparing with the other packages used for microwave circuit design, the developed program has the following features and advantages

o It is an easy to use windows user oriented program
o It give approximate layout of the deigned microchip amplifier, oscillator or mixer
o It perform the matching circuit graphically with the aide of the smith and analytically with an accurate length in mm
o It is used not only for microstrip circuit design but also for waveguide and coaxial circuit design
o It can shows different windows at the same time

4 Program Applications

The new program has many applications especially for the design of microstrip receiver module[24] and HMIC-SOP (System On Package) module [25]. It can be used also for waveguide applications such as the design of rectangular waveguide oscillators and amplifiers with post and disc assembly used for the tuning of the active element (IMPATT or Gunn diode). For coaxial applications, it is used for the design of coaxial amplifiers and oscillators with the design of the tuning circuit of the active element.

5 Conclusion

This paper illustrates the general description of a comprehensive visual windows user-oriented program called MSDES_WIN for microstrip, rectangular waveguide and coaxial cavity circuit design. The program is used for the design of microwave active circuits such as amplifiers, oscillators, and mixers with microstrip or waveguide media. The program is used also for passive microwave circuit design such as rectangular one/two section branch-line couplers, and ring couplers. The program can also be used for stability change from unconditional stability to potential unstability and vice versa by connecting a series feedback stub with a certain length or connecting a cascaded resistor to the transistor terminals. The matching circuit obtained by the program is accurately calculated without using Smith chart either by using stub lines with different values of characteristic impedances. The program draws the smith chart for design parameters (input/output matching circuits stability circles and gain circles). The developed program has many applications such as the design of microstrip HMIC receivers and SOP-HMIC modules. It can be used also for the design of coaxial and rectangular waveguide applications. As a future work the program will be modified for circuit optimization using some of the circuit optimization techniques such as GA.

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