Impedance Matching of a Loaded Microstrip Transmission Line Using a Double Parasitic Element

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Abstract

Impedance matching of a loaded microstrip transmission line is performed by using only parasitic elements. By the term "parasitic" matching element we mean that there is no physical or electrical connection between the conductors of the matching elements and the conductors of the main line. We use a double λ/4 parasitic transformer by adding two dielectric bricks above the main line, and another conductive strip above each brick. It is shown that a very good matching performance is achieved by using the double λ/4 parasitic transformer.

1. INTRODUCTION

Impedance matching is needed in most RF and microwave systems [1],[2],[3]. Generally, impedance-matching sub-systems are composed of one of the following techniques: L,T,π, and so forth lumped-element circuits, transmission-line stubs, series of λ/4 transformers, or tapered transmission line sections. In all the matching techniques mentioned above, the conductors of the matching sub-system are physically connected to the conductors of the main circuit. It was shown in [4],[5] that a good matching level can be achieved by using a single λ/4 parasitic transformer. In this work, we propose a double λ/4 transformer in order to match a loaded microstrip transmission line. The idea is to create two λ/4 transformers based on the standard microstrip transmission line, with another dielectric bricks and a conductive strip above them. The characteristic impedances of the λ/4 parasitic elements (Z_{p1}, Z_{p2}) are lower than the characteristic impedance of the microstrip line (Z_0). Z_{p1} and Z_{p2} can be controlled by the thickness and width of the dielectric bricks, their dielectric constant and the width and thickness of the upper conducting strips. We use for our research a standard 1:2 microstrip splitter as a test case, in order to compare between the matching performance of our parasitic double λ/4 transformer and the standard double λ/4 microstrip transformer. Three different configurations have been simulated and measured: the unmatched splitter, the splitter matched by two λ/4 Chebyshev microstrip transformer sections, and the splitter matched by two λ/4 parasitic transformers. The simulation was performed using CST - Microwave Studio software.

The structure of the paper is as follows: section 2 describes the geometry of the new matching device, compared to the geometry of the two λ/4 Chebyshev microstrip transformer sections. In section 3 we present the simulation results, and section 4 describes the measured scattering parameters. Finally, section 5 contains discussions and conclusions.

2. GEOMETRY

In figure 1.a we see an upper view of the unmatched 1:2 microstrip splitter, figure 1.b shows an upper view of the splitter matched by a standard two λ/4 microstrip line sections, and figure 1.c presents the splitter matched by our two λ/4 sections containing the parasitic bricks. The width of the upper conductor of the standard microstrip line is W_1 = 2.95 mm, and the thickness of the dielectric material, FR4 with $\varepsilon_r \approx 4.7$, is h = 1.6 mm. The first parasitic element is made of an FR4 dielectric layer of thickness h and width W_3 = 44 mm, having a W_2 = 24 mm width conducting strip on it. The second parasitic element is also made of FR4 dielectric layer having width W_5 = 33 mm, and a W_4 = 13 mm width conducting strip on it. The thickness of all the consucting strips is about 17 μm. The geometrical and electrical parameters of the new transmission lines related to the parasitic transformers are chosen such that their characteristic impedances will have the values Z_{p1} = 30.5 Ω and Z_{p2} = 41 Ω, in order to create a Chebyshev two section transformer.

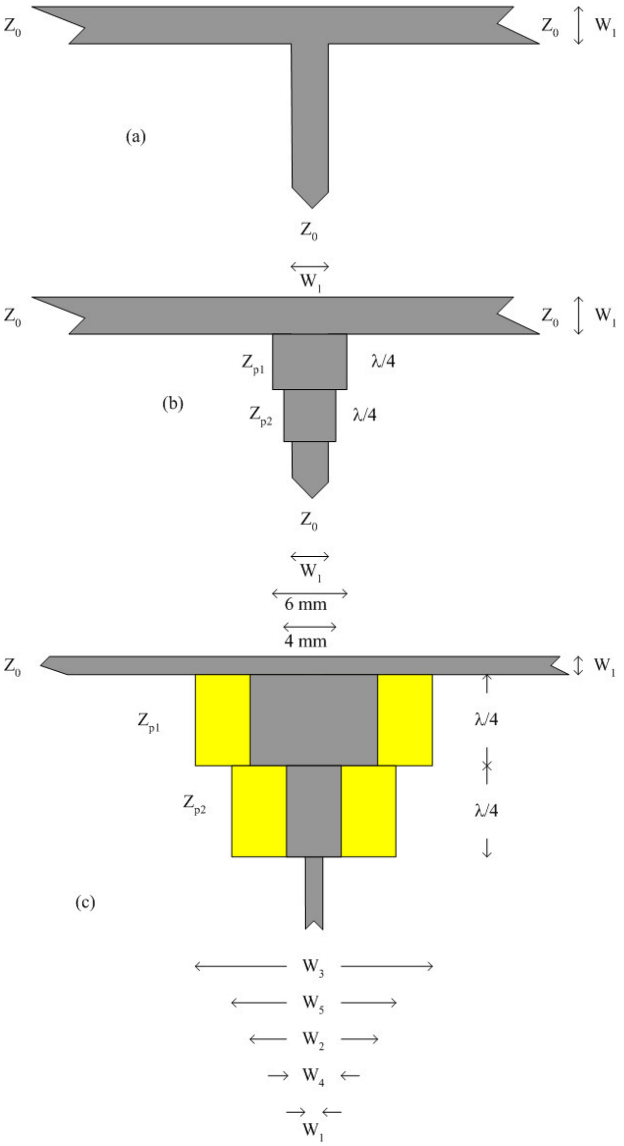
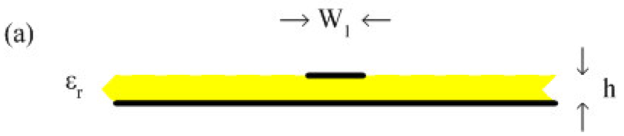


Fig. 1: Upper view of (a) the unmatched 1:2 microstrip splitter, W_1 = 2.95 mm on 1.6 mm thick FR4 with $\varepsilon_r \approx 4.7$, for Z_0 = 50 Ω. (b) The splitter matched by two λ/4 microstrip sections, for which Z_{p1} = 30.5 Ω, Z_{p2} = 41 Ω.(c) The splitter matched by two λ/4 sections, where another FR4 layer is placed on the main line, and another thin conducting plate is placed above it, for each section.

Figure 2.a shows the side view of the standard microstrip transmission line, figures 2.b and 2.c show the side view of the new transmission lines λ/4 sections used for the matching, where the transformer closer to the junction is shown in fig. 2.b



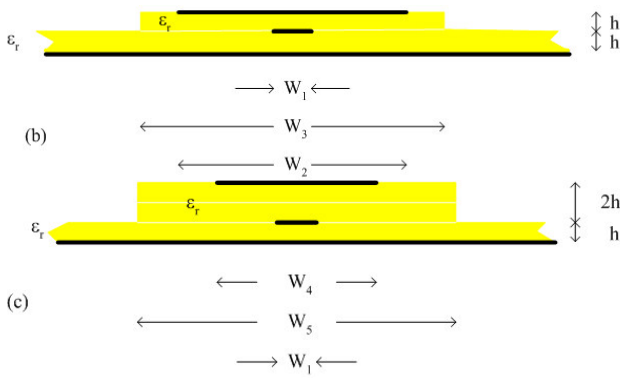
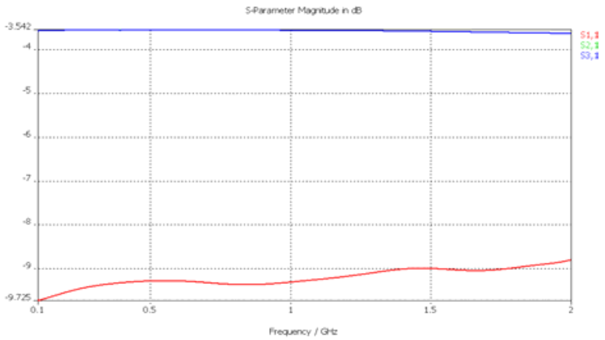


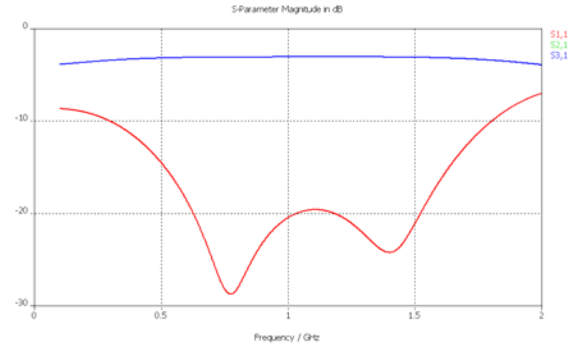
Fig. 2: (a) Side view of the microstrip line. (b) Side view of the parasitic transformer closer to the junction. (c) Side view of the next parasitic transformer.

3. SIMULATION

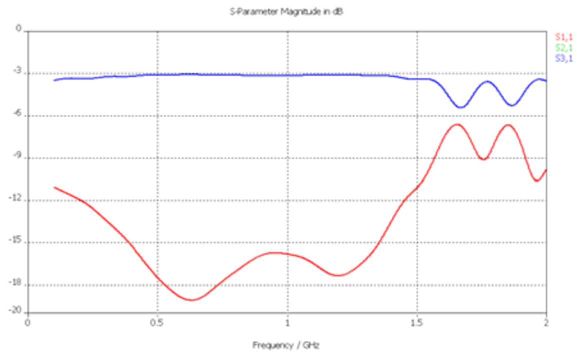
CST - Microwave Studio EM software had been applied to perform some simulations for the various structures, for a center frequency of 1 GHz. Firstly, we have find the needed geometry for the two new transmission lines used for matching, in order to have the relevant characteristic impedances of Z_{p1} = 30.5 Ω and Z_{p2} = 41 Ω. Secondly, we have find the wavelengths at the centre frequency related to these new transmission lines, in order to fix the λ/4 relevant lengths. The final stage was the simulation of the scattering parameters. The quality of the parasitic matching technique had been compared to the matching level of the unmatched splitter and to the splitter matched by a standard Chebyshev double stage λ/4 microstrip transformer. Figure 3.a presents the scattering parameters of the unmatched splitter, in figure 3.b the scattering parameters of the standard Chebyshev double stage λ/4 microstrip transformer are shown, and in figure 3.c we see the scattering parameters of the splitter matched by the two parasitic λ/4 transformers.



(a)



(b)

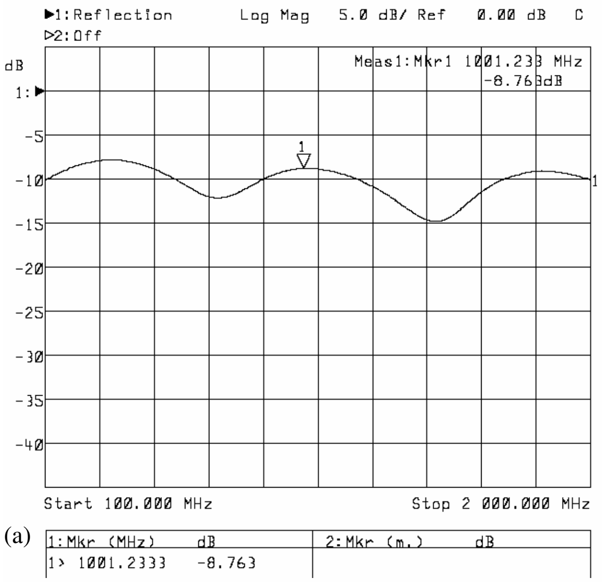


(c)

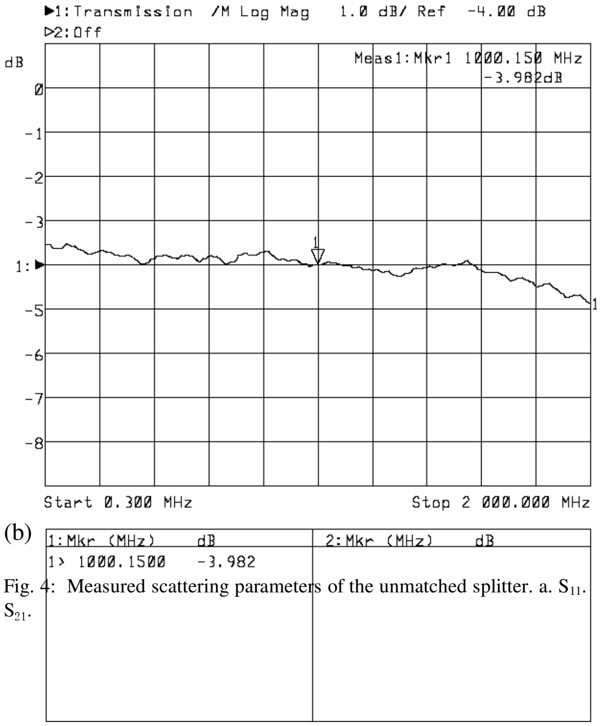
Fig. 3: Simulated scattering parameters (a) The unmatched splitter. (b) The splitter matched by the double quarter wave microstrip transformer. (c) The splitter matched by the parasitic transformer.

4. MEASUERMENTS

The measured scattering parameters of the unmatched splitter are shown in figure 4, the scattering parameters of the splitter matched by a standard Chebyshev double stage λ/4 microstrip transformer are presented in figure 5, and the scattering parameters of the splitter matched by the two λ/4 parasitic transformers are shown in figure 6, respectively. The measurements have been performed by the HP-8714B Network Analyzer. As the parasitic bricks can be freely moved, one can creates different levels of matching inside the relevant frequency band, according to the need of the engineer. Figure 7 presents a high level, narrowband matching around 1 GHz, simply by moving a little bit the parasitic bricks.



(a)



(b)

Fig. 4: Measured scattering parameters of the unmatched splitter. a. S_{11}. b. S_{21}.

(a)

(b)

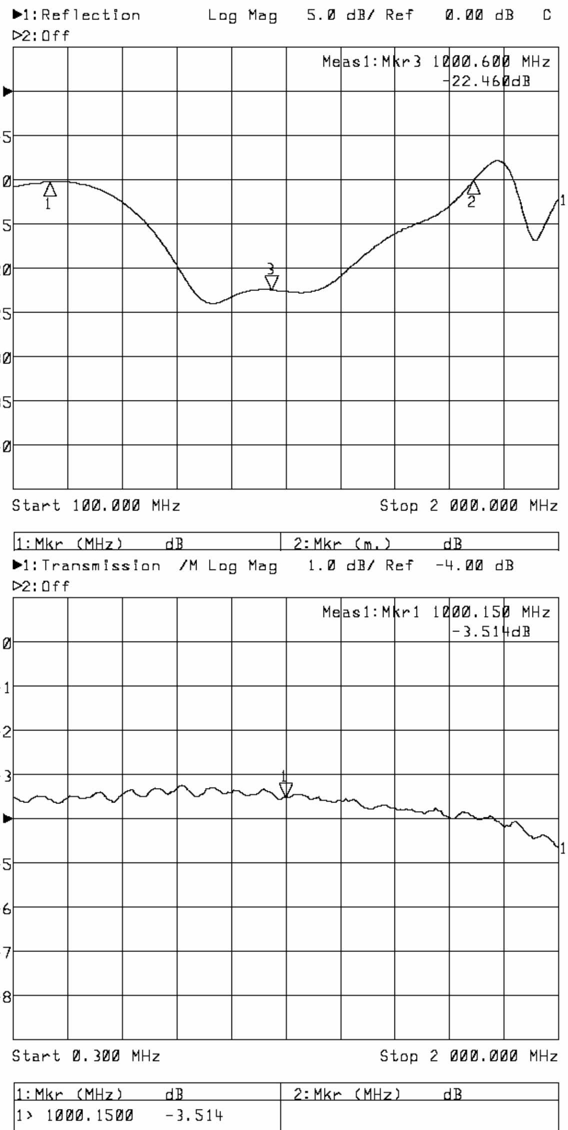


Fig. 5: Measured scattering parameters of the splitter matched by a double quarter wave microstrip transformer.. a. S_{11}. b. S_{21}.

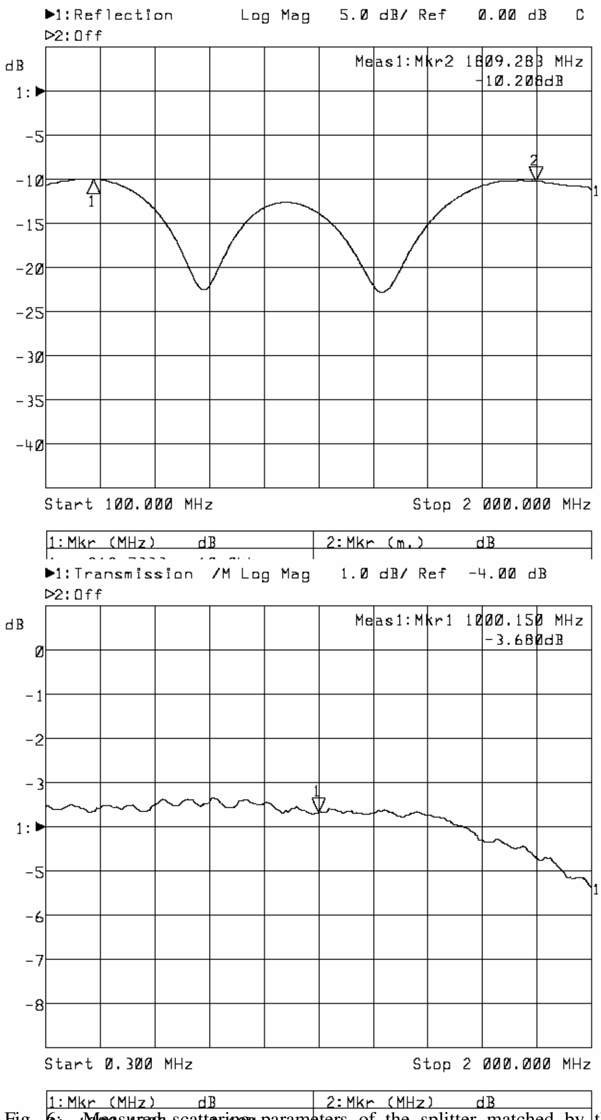


Fig. 6: Measured scattering parameters of the splitter matched by the parasitic transformer.. a. S_{11}. b. S_{21}.

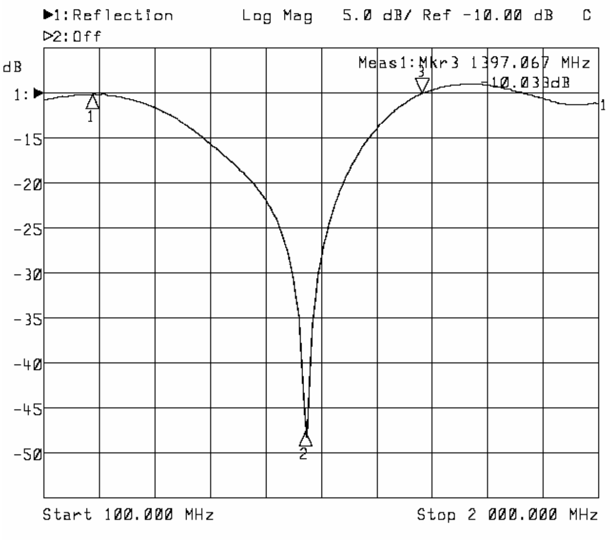


Fig. 7: Measured scattering parameters of the splitter matched by the parasitic transformer after moving a little bit the parasitic bricks.

5. CONCLUSIONS

It has shown that a very good matching level was obtained using the parasitic double λ/4 transformer. Though the quality of the reflection coefficient of the parasitic transformer is a bit less then that of the standard microstrip transformer, its bandwidth is bigger. The main advantage of the presented method is that one can creates different levels of matching, a wideband matching or a very narrowband matching, according to the needs of the designer. Tuning of the matching level is obtained by moving the parasitic elements on the microstrip line. When the desired matching level is obtained, the parasitic elements can be permanently connected to the main line by dielectric screws. This method is especially suitable for matching improvement, after the circuit has been made, without damaging the circuit.

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