LTCC-MLC Balun for WLAN/Bluetooth

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Abstract- A low temperature co-fired ceramic (LTCC) multi-layer ceramic balun is presented in this paper. This balun is designed in the ISM band for WLAN or bluetooth use. It uses multi-layer structure, meander lines, and multi-section coupled-lines with various coupling coefficients. The characteristics of phase balance and amplitude balance are extremely excellent because of its symmetric structure and a transmission line trimming section. Measured results of the LTCC-MLC balun match well with the computer simulation.

INTRODUCTION

The Marchand balun [1] is a microwave balun and is important in realizing balanced mixers, amplifiers, multipliers, and phase shifters. Through the use of multiple quarter-wave sections, it is theoretically possible to achieve a Chebyshev response up to six-octave bandwidth [2], [3]. Fig.1 shows a Marchand balun [4].

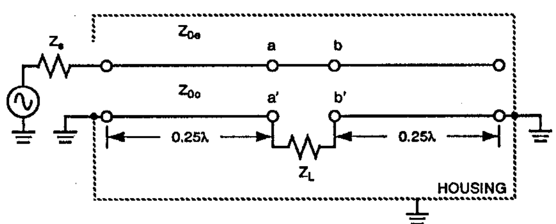


Fig.1 Marchand balun

The multi-layer ceramic technology seems to be the best solution to realize chip type elements [5]-[6]. However, to the time of this writing, only a few published literatures, for example [7], describe the laminated balun. Unfortunately, the balun in [7] shows very narrow operating bandwidth. Besides, the circuit design in [7] needs precisely control of fabricating process.

This paper presents the new design method of chip type balun with multi-layer structure. The balun shows broader bandwidth, better phase balanceing, and looser processing control. The length of a coupled strip-line can be shortened by using various impedance ratio of multi-section coupled-line. For tuning out the imaginary part of the balanced output ports, a trimming transmission line section is introduced. The design and performance of the fabricated LTCC-MLC balun show excellent performance.

DESIGN PROCEDURE

Shown in Fig.2 is the equivalent circuit of LTCC-MLC balun. It comprises of multi-section coupled transmission lines and a transmission line section (not introduce in this paper).

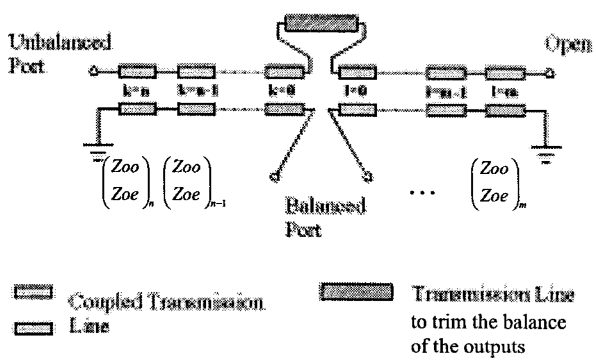


Fig.2 The equivalent circuit of LTCC-MLC

balun

There are three steps to construct the LTCC-MLC balun: multi-section coupled-lines, multi-layer structure, and meander lines.

In this multi-layer chip type balun, the method of different layer thickness to miniaturize the total length of the multi-section coupled transmission line is very useful.

Fig.3 shows different layer thickness of a multi-section coupled transmission line. The coupled-line width is limited by the chip size and the processes. Properly control the layer thickness, the multi-section coupled-line can has an effect of shrinkage like a stepped-impedance resonance.

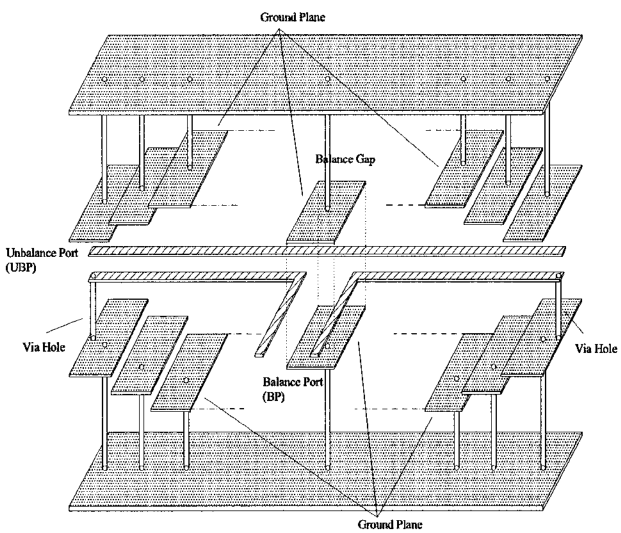


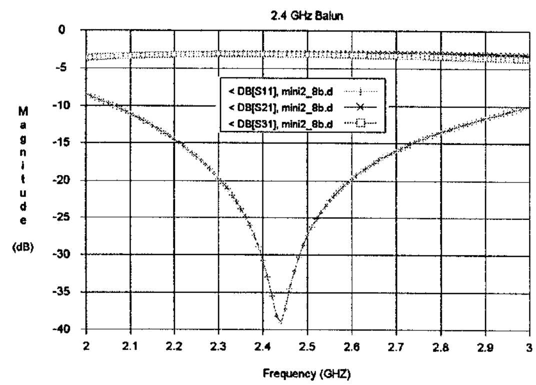
Fig.3 The couple transmission line with different layer thickness

Because the structure of this balun is symmetric, it can be separated into two parts and can be folded to upper (or lower) layer. Finally, two coupled center strips can be meandered to shrink the balun further.

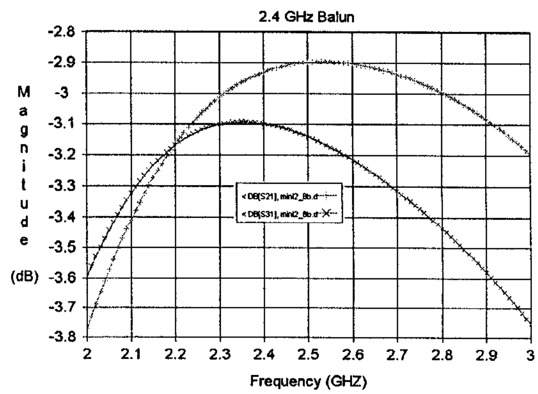
DESIGN AND SIMULATION

In the realization of chip balun, it comprises the methods of different layer thickness, multilayer structure, and meander line. The chip type balun is designed to operate in the frequency range of 2.24-2.64GHz. Unbalanced input impedance and balanced output impedance were 50Ω. The proposed multilayer chip type balun has been investigated using a full-wave electro-magnetic (EM) simulator [8].

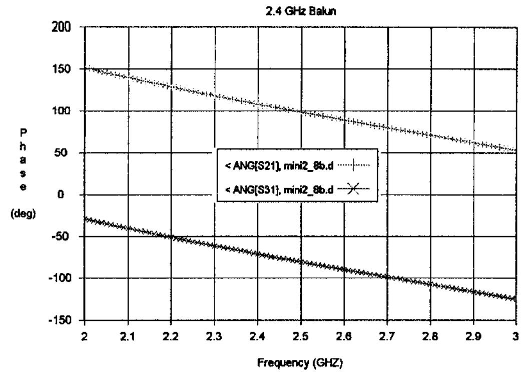
The simulated results are shown in Fig.4. The insertion loss and the return loss are less than −0.8dB and −17dB respectively in operating frequency range as shown in Fig.4(a). The amplitude and phase imbalance between balanced output are within 0.32dB and 0.9° respectively over the operating frequency range as shown in Fig.4(b)-(c).



(a) The simulated insertion loss and return loss



(b) The simulate balanced output amplitude characteristics



(c) The simulate balanced output phase characteristics

Fig.4 The simulated results of designed chip type balun

EXPERIMENT RESULTS

Fig.5 shows the fabricated LTCC-MLC balun. The designed chip type balun is fabricated with multi-layer configuration using 90um-thick ceramic sheets (εr=7.8) and 10um-thick Ag metal pattern. The overall size of the balun is 3.2mm x 1.6mm x 0.8mm.

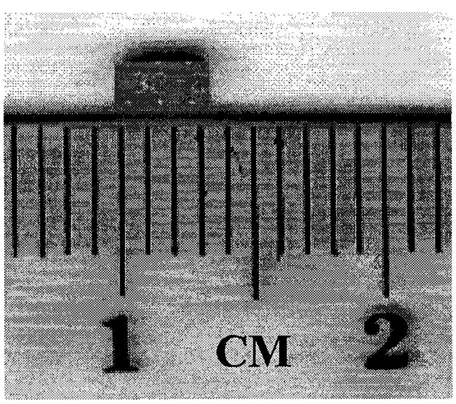
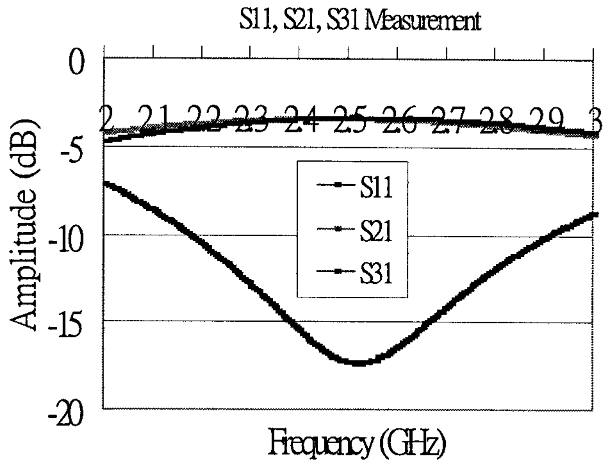
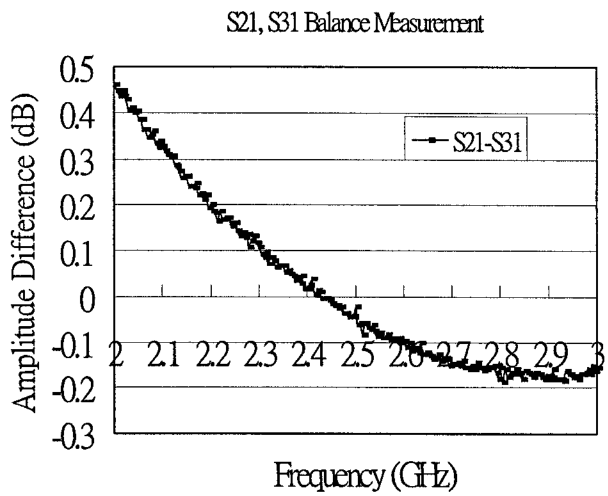


Fig.5 The fabricated chip type balun

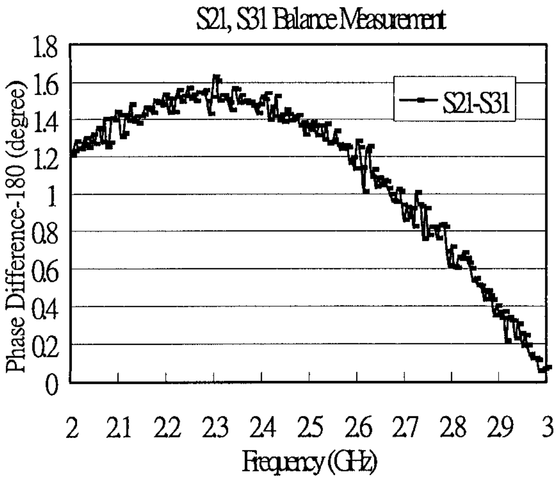
The measured results are shown in Fig.6. The insertion loss and return loss are less than –0.8dB and –12dB respectively over the operating frequency band as shown in Fig.6(a). Fig.6(b) shows the measured amplitude difference and Fig.6(c) shows the phase difference between balanced output. The amplitude and phase imbalances are within 0.15dB and 1.6° respectively over the operating frequency range.



(a) The measured insertion loss and return loss



(b) The measured amplitude difference



(c) The measured phase difference

Fig.6 The measured result of fabricated chip type balun

CONCLUSIONS

The novel LTCC-MLC balun has been developed. The design method and the equivalent circuit of this balun have been given. The design procedures are simple. The size of this balun is compact, and measured performance is excellent. This balun has been designed with the operating frequency range of 2.24-2.64GHz. Unbalanced input impedance and balanced output impedance are 50Ω. The designed chip type balun has been fabricated with multilayer configuration. The insertion loss and return loss are less –0.8dB and –12dB respectively over the operating frequency band. The measured amplitude and phase imbalances between balanced output were within 0.15dB and 1.6° respectively over the operating frequency range. The simulated and measured results show the validity of the proposed design method and the equivalent circuit of the balun.

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