Design and Simulation of Multilayer Microstrip to Stripline Transition on LTCC for 20GHz Frequency Range Application

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Abstract— This paper shows design and simulation of multilayer ceramic technology that is used for the system in package (SiP) module packaging of different MMIC, MEMS and MOEMS and operates from d.c to 20 GHz frequency range. This paper describe about miniaturized Microstrip line to Stripline transition on to the layers of LTCC. This paper also describe about the proper utilization of vertical interconnection access (via) in Stripline design. The entire design of LTCC and the transmission line transition is simulated on High Frequency Simulated Structure (HFSS) software that is a 3-dimensional model EM simulator. The measured isolation and measured insertion loss is better than -0.045 dB at 12 GHz and -0.035 dB at 8 GHz. The return loss is better than -23 dB up to 12 GHz and -24.1 dB at 8 GHz.

Key words: LTCC, Multilayer Ceramic Substrate, Microstrip To Stripline Transition

I. INTRODUCTION

Low Temperature co-fired ceramic (LTCC) is a multilayer glass ceramic substrate that is hard, corrosion resistance and brittle. The enormous advantage of multilayer LTCC is the uses of Meta-material thermal via and a conductor strip in inner layer to realize short circuit. The use of thermal via is used to improve the thermal conductivity of LTCC. The different embedded, integrated, printed, multilayer passive component can be integrated onto the LTCC. LTCC have a high density packaging as at microwave and millimeter wave packages are miniaturized, behind that line pattering and small via diameter are required for high frequency design. Moreover the bare MMIC, RF MEMS, RF MOEMS and other discrete component will be mounted onto the surface of LTCC substrate and sealed [1]. In this work we had design and simulate the multilayer Microstrip line to Stripline transition onto the LTCC layer and the height of transmission line substrate is 3 tapes of 10mil each i.e. 30mil with +/-25% sinkage in x,y,z direction and we had used LTCC green tape material as an Ferro substrate with dielectric constant (E_r) of 5.9 for 50Ω line. The transmission line is made of gold material that having an relative dielectric constant (E_r) of 1. LTCC is an multilayer structure that is made by sandwichng an LTCC substrate between the two meta-material layers and to connect the the layers of meta-material than thermal via is used and it is an conducting material.

II. DESIGN AND CALCULATIONS

The general importance of making line transition is to package and sealing the device to get a near hermetic environment. While dealing with the transmission line transition the connection of the two different lines at high frequency it having a negative effect on the corresponding circuit or a design in terms of loss. And the major challenge of the transition is to match the characteristics impedance of two different lines width and to transfer a field with low losses. To realize a multilayer Stripline from a Microstrip line, it needs to add a substrate and an upper ground plane. Also to connect an upper ground plane to the lower ground plane for the hermeticity it needs to connect by using the staggering of via, staggering of via in an individual layers are arranged such that the desired pattern is form and achieve an proper hermeticity layer wise respectively. The distance for the connection of both the ground plane is selected such that center of via to Stripline edges distance (S) is taken as 3 to 5 times the width of the Stripline or taken as λ/4 for the separation and is as shown in figure 1. Also if the separation distance is greater than λ/4 than higher order modes can propagate [2]. This paper describes about the multilayer transmission line transitions. As design is concern, the multilayer Microstrip to Stripline transitions having a same height of dielectric substrate for the transition and also need to match the characteristics impedance so that proper electric field can transfer. The design of multilayer Microstrip line to Stripline transition at both the ends of package is as shown in figure 2. We had use three layers of substrate and that is sandwiched by a metallization layer. For the connection between two layers of a metallization we had use short circuit via so that it acts as a ground. The entire flexural strength of LTCC is 540 MPa. After forming an LTCC the Microstrip to Stripline transition pattern is design onto the surface of the LTCC. The catch pad area for via design used is 0.5mm. In this work the entire area used for the entire design is 7mm x 14mm x 1.77mm with the inner pattern of via inside the layer of substrate. The height of LTCC substrate is calculated accordingly to the frequency range application and is calculated from equation (1). The line width of Microstrip line and Stripline is calculated from the equation (2) and equation (3).

$$h = \frac{0.05Vo}{f\sqrt{Er}} \qquad (1)$$

Where, V_o = velocity of light, h=height of Substrate, f=operating frequency

Also for Microstrip line,

$$\frac{W}{d} = \frac{8e^{A}}{e^{2A}-2} \qquad (2)$$

Where, A is an arbitrary constant, w is width of Line, d is height of Substrate

$$A = \frac{Zo}{60}\frac{\sqrt{Er}+1}{2} + \frac{Er-1}{Er+1}\left(0.23 + \frac{0.11}{Er}\right)$$

And for Stripline,

$$\frac{W}{d} = x \qquad (3)$$

Where, A is an arbitrary constant, w is width of Stripline

$$x = \frac{30\pi}{\sqrt{ErZo}} - 0.441^{[3]}$$

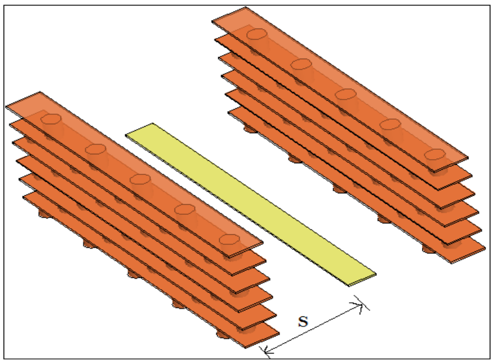

Fig. 1: Staggered Via to stripline distance

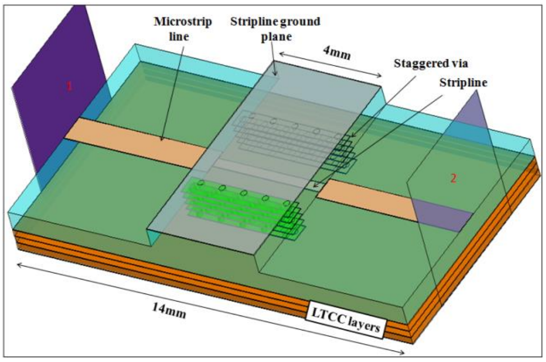

Fig. 2: Microsrip to stripline transiton

The various parameters that are used while designing this package is mentioned in table 1

Parameter	Values
Microstrip Line Width	0.771mm
Stripline Width	0.267mm
Strip to VIA spacing	0.801mm
Line Thickness	0.02mm
Substrate thickness of each layer	0.190mm
Via height	0.190mm
Via radius	0.1mm

Table 1: Dimension used in Line transition

III. SIMULATIONS AND RESULTS

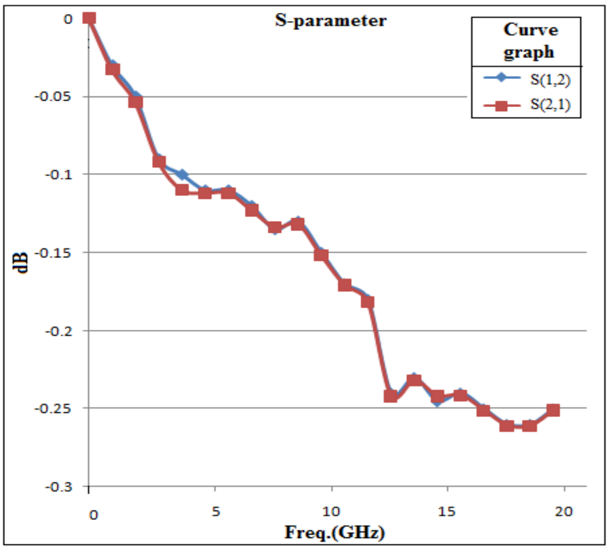

Fig. 3: Insertion loss and isolation loss

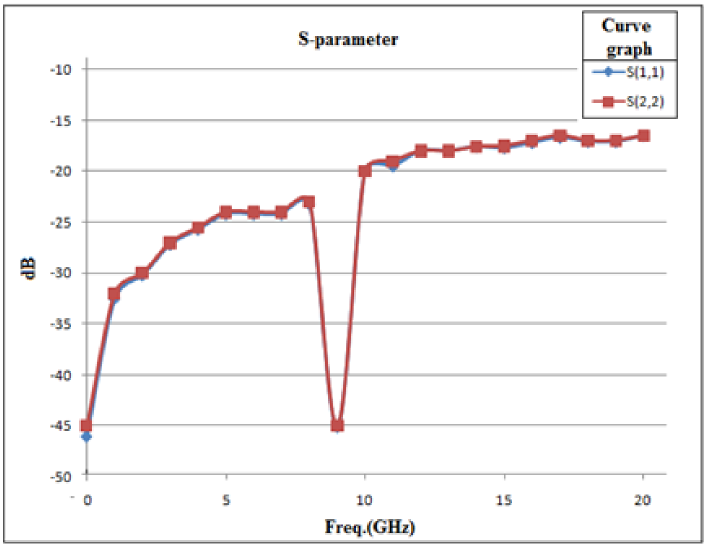

Fig. 4: Forward and reverse return loss

As a result, the 50 Ohm line transition is calculated as per the S-parameter is as shown in Figure 3 and Figure 4. We can say that the measured isolation loss and insertion loss is better than -0.045 dB at 12 GHz and -0.035 dB at 8 GHz. The return loss is better than -23 dB up to 12 GHz and -24.1 dB at 8 GHz. From this result we can say that insertion loss and the isolation loss and the forward and reverse return loss is also same so from it we can say that the impedance of multilayer Microstrip to Stripline transition is properly matched.

IV. Conclusion

In this paper we had design, analysis and simulation of multilayer Microstrip to Stripline transition that drives from D.C to 20GHz. We had showed different s-parameters and the measured isolation and measured insertion loss is better than -0.045 dB at 12 GHz and -0.035 dB at 8 GHz. The return loss is better than -23 dB up to 12 GHz and -24.1 dB at 8 GHz. From this result we can say that the design is reciprocal and resonance free, so that this transition can be used to bond the device and a device is kept under the cavity which is formed due to line transition at both the ends and provides a seal ring and a cap to form a complete enclosed package.

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