CIRCUIT-BOARD MOUNTING USING DOUBLE-SIDED ADHESIVE TAPE

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ABSTRACT

In this paper, a method of using double-sided adhesive tape when mounting microwave circuit-boards is discussed. In particular, one type of adhesive tape with good features is described. The tape-mounting is simple and fast to use and it is cheap. The tape that was used is soft and it can handle both high and low temperatures. These two features make the tape useful in places where parts with different thermal expansion coefficients are mounted together. The tape will absorb the shear forces that could otherwise damage for example substrates made of brittle materials like Aluminium-oxide. When substrates are mounted with tape, a cavity is created under the substrate. The cavity may have potential resonating frequencies within the frequency band of interest. If a bond wire transition between different substrates is used, the cavity resonance may lead to undesirable reflections. The problem can be addressed in different ways. Two methods will be briefly discussed in this paper: coplanar wave-guide-transitions and a "phase-cancelling" technique. Results from simulations and prototype card measurements are presented. The primary frequency range is the X-band (8-12 GHz).

INTRODUCTION

The adhesive tape used in simulations and prototype cards is 3M #9473. The tape is based on acrylic, it has a thickness of 0.25mm and a dielectric constant of $\varepsilon \approx 2.6$ (10GHz). The tape has a specified softening point at 79°C. The softness of the tape allows movement between the circuit-board and the surface on which it is mounted. It is thereby useful in places where thermal expansion and contraction of different parts exist. Differences in thermal expansion of the circuit-board and the mounting surface will be handled by the tape. Damage to brittle substrate materials can be prevented. In figure 1, a schematic side-view of two tape-mounted circuit-boards is shown. Only the bond wire connection between the boards is shown. On the left side of the leftmost circuit board, the edge of the board is soldered to the metallic mounting-surface (providing proper grounding for the coaxial contact). The remaining part of the board is attached using double-sided adhesive tape that has been placed in a milled-down area on the mounting surface. The lower ground plane on the rightmost board is not connected to the ground plane on the leftmost board. The connection between the two boards is made on the upper side of the boards, using bond-wires. To allow for thermal expansion, the two boards are mounted with a small gap between them.

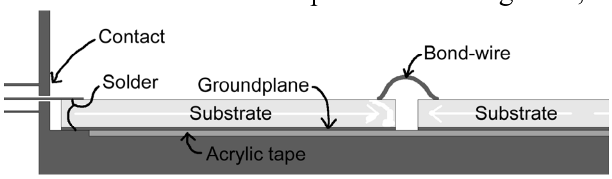

Figure 1 - Schematic side-view of two tape-mounted substrates

CAVITY-RESONANCE

A thin cavity between the bottom ground-plane of the substrate and the mounting-surface may be formed using different mounting methods (this method included). In this case, the cavity is formed by the acrylic-tape.
At the bond wire connection, a small part of the microwaves will leak down through the gap between the cards and into the cavity. In the cavity, the microwaves are reflected at the edges of the cavity, forming a standing wave. When resonating, a strong electric field in the cavity and between the connected circuit-boards is created. The field will interfere with the transferred signal, causing mismatch and reflection of the signal.

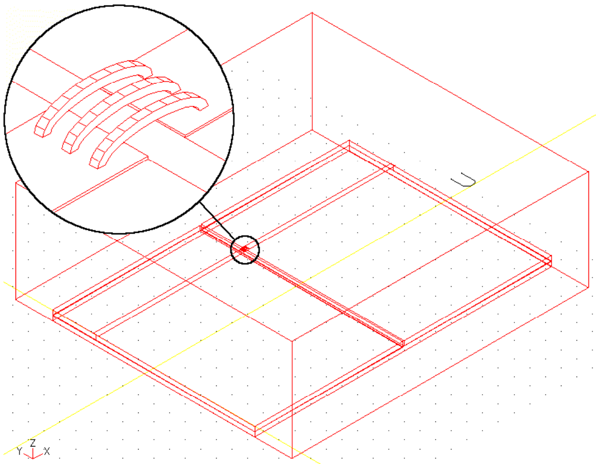

Figure 2 - Microstrip transition

When simulating the construction in figure 2, with the two circuit-boards (10 mil Aluminium-oxide substrates), the problem can be visualised. The microstrip lines (50 ohm impedance) starting at the southwest and northeast side in figure 2, constitutes port 1 and 2 respectively.
Curve A (blue) in figure 3 shows the magnitude of the transfer parameter S_{21} in log-scale and the reflection of the signal at 10 GHz can be seen (approximately zero radiation and other losses).

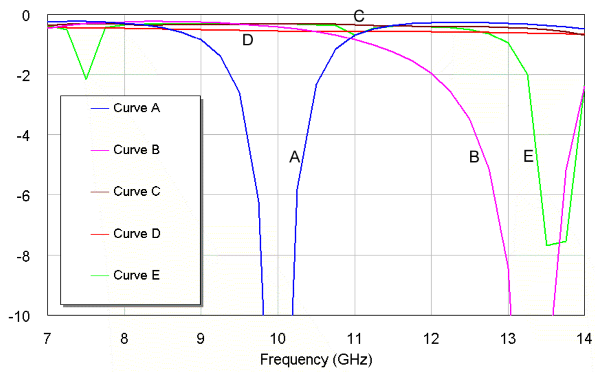

Figure 3 - Transfer parameter S_{21} for different constructions

The dip corresponds to a resonance in the cavity, shown in figure 4. In figure 4, the construction in figure 2 is seen from above. The magnitude of the electric field inside the cavity is plotted. Yellow and red is stronger, green and blue is weaker.
In this case, the cavity acts like a rectangular wave-guide (the width is well above cutoff for 10GHz) terminated with air in the top and bottom of the picture. The air-termination leads to maximums in the electric field at the edges of the circuit-board. This condition means that all multiples of half-wavelength resonances can exist. The resonance at 10 GHz corresponds to the one-half-wavelength resonance, which is the lowest in frequency in this direction in the cavity. Resonances also exist in the right-left direction in the cavity and in combinations of the two directions. The potential resonating frequencies depend on the dimensions of the substrate. A bigger circuit-board means more potential resonances close to each other. To avoid this resonance-problem, different methods can be used. Perhaps the easiest method is making the circuit-boards narrower, moving the lowest resonance up in frequency, above 12 GHz. The circuit-board, in this case, has to be approximately the most 7.5 mm wide. The result (S_{21}) is shown as curve B (purple) in figure 3.

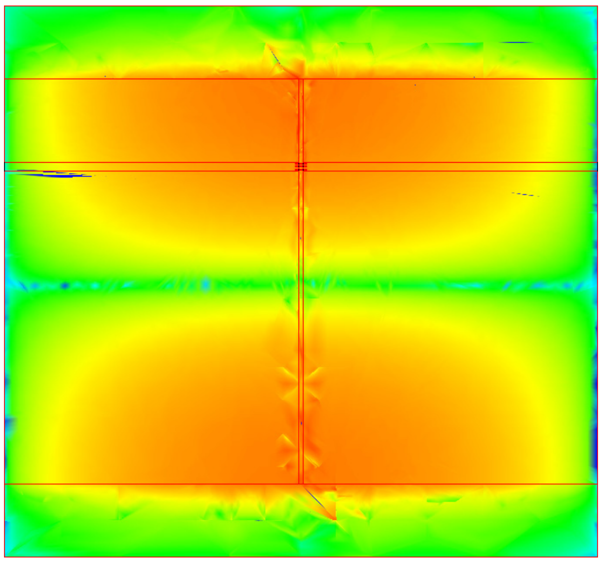

Figure 4 - Magnitude of the electric field inside the cavity

PHASE-CANCELLING TECHNIQUE

In this method, the signal is divided using a T-splitter and then transferred over two transitions at different places on the boards (see figure 5). The placement of the transitions is symmetrical with respect to the centreline of the boards. This will cancel out asymmetrical resonances, i.e. resonances where the number of wavelengths in the cavity is $1 \cdot \frac{1}{2}$, $3 \cdot \frac{1}{2}$, $5 \cdot \frac{1}{2}$ etc. The result (S_{21}) can be seen as curve C (brown) in figure 3.
Using one transition (as in figure 2) can also be done if placed at a minimum in the resonating field, reducing the induction to the cavity.

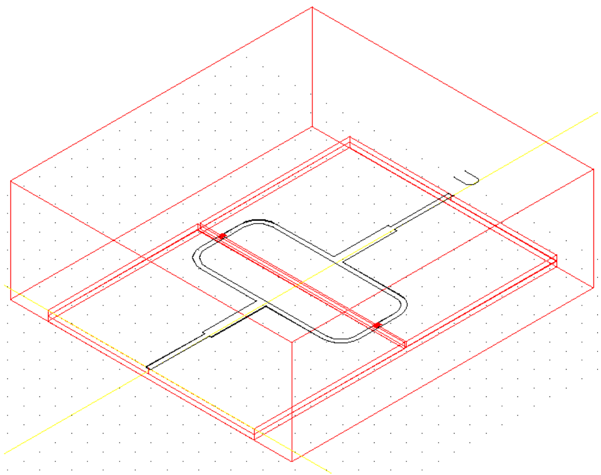

Figure 5 - Double microstrip transition

COPLANAR TECHNIQUE

The idea is to reduce the signal transferred to the cavity, using a coplanar wave-guide (including lower ground-plane). The coplanar waveguide reduces the electric field between the microstrip line and the lower ground-plane. Instead, the bigger portion of the electric field is rotated 90° and strengthened between the microstrip line and the side-ground-planes. In figure 6 this technique is shown.
The dimensions of the coplanar wave-guide are chosen in order to minimize the electric field between the microstrip line and the lower ground-plane. This leads to a narrow microstrip line and a small gap between the microstrip line and the side-ground-planes. The impedance is 50 ohm.
Comparison of impedance with or without the lower ground-plane can be done, in order to measure the importance of the lower ground plane.

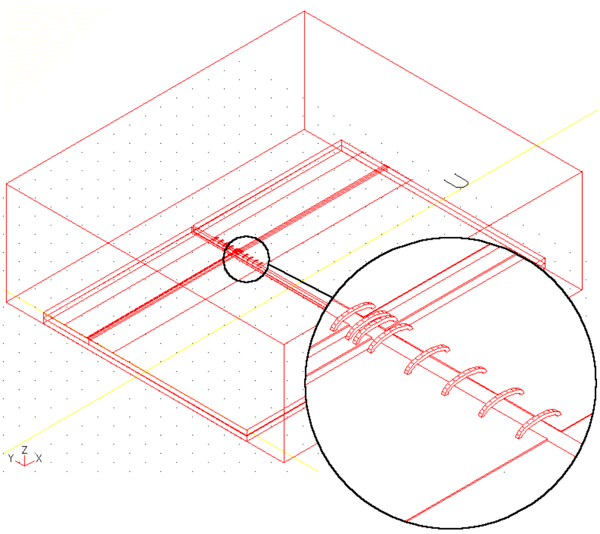

Figure 6 - Coplanar transition

The result of this technique is shown as curve D (orange) in figure 3. In figure 7, a construction using this technique is shown. The smooth transition from microstrip waveguide to coplanar waveguide is made with a constant impedance of 50 ohm. The finite length side-ground-planes will introduce new resonance problems. They act as short lengths of microstrip lines, with standing waves as a result. The problem can be addressed, choosing the right length for the side-ground-

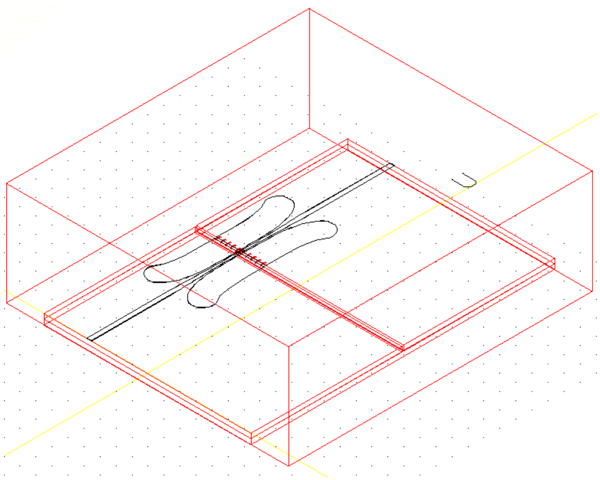

Figure 7 - Coplanar transition

planes, moving the resonances out of the frequency-band of interest.
In curve E (green) in figure 3, the result (S_{21}) is shown. The dips at 7.5 and 13.75 GHz are resonances in the finite ground-planes.
A different solution to the side-ground-plane-resonance-problem, is to place resistors inside the ground-planes. A photograph of a construction using this technique is shown in figure 8. It uses surface mounted resistors at 24 ohms, to absorb the wave transferred through the ground-plane. The measured and simulated result is shown in figure 9.
One should note that the construction in figure 8 was placed at much bigger circuit-boards compared with the previous constructions. The big cards had many potential resonating frequencies. It seems like this solution could be interesting for broadband applications.

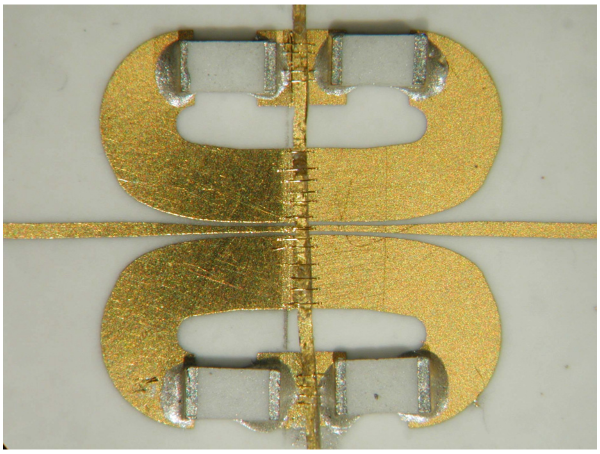

Figure 8 - Photograph of a prototype card

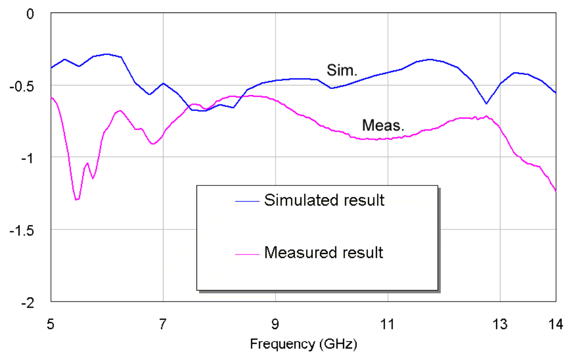

Figure 9 - Transfer parameter S_{21}

CONCLUSION

Tape-mounting can and has been used with success. It provides an easy and fast way of mounting circuit-boards. There seem to be several ways of avoiding cavity resonances.

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REFERENCES

[1] Björn Petersson, "Design av mikrovågsövergångar" LITH-ISY-EX-3334-2003, Department of electrical engineering, Linköping university (2003)

[2] Rainee N. Simmons, "Coplanar waveguide circuits, components, and systems", Wiley-interscience (2001)