Kovar Walls and Impedance Matching

Michael Baumer

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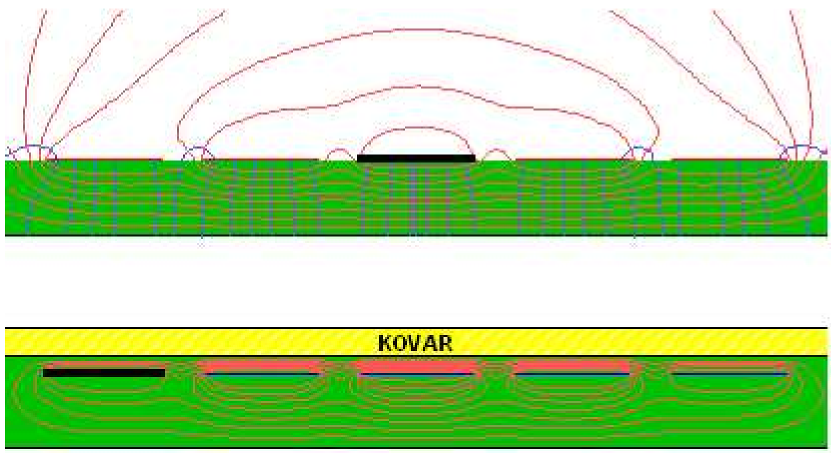
1 Introduction

For an Option E readout scheme, the anode signal strips will carry the signal through the side wall of the detector to the sampling chip and other electronics. When the signal goes through the wall, the geometry of the waveguide changes because of the additional material above the signal strips. For a dielectric wall, such as borosilicate, the impedance discontinuity induced is only a few ohms, because most of the field is contained between the strips and the ground plane and therefore unaffected by the additional dielectric above. For a kovar wall sealed with frit, however, the impedance mismatch is much greater because of strong coupling between the signal strips and the metal wall above (see figure).

The geometry of the situation is the same as the anode card itself, with a .5mm (.02 inch) layer of frit above the signal traces, followed by a kovar wall. The permittivity of the frit is assumed to be the same as the glass itself, which is likely not true. Even so, the results of these simulations are still valuable, as the small distance between the strips and the kovar ensures strong coupling regardless of the frit's exact permittivity. Anyone who knows about this might mention it at the meeting.



This figure compares the normal anode field geometry with the new geometry induced by kovar walls. The density of red potential lines indicates the strength of the coupling.

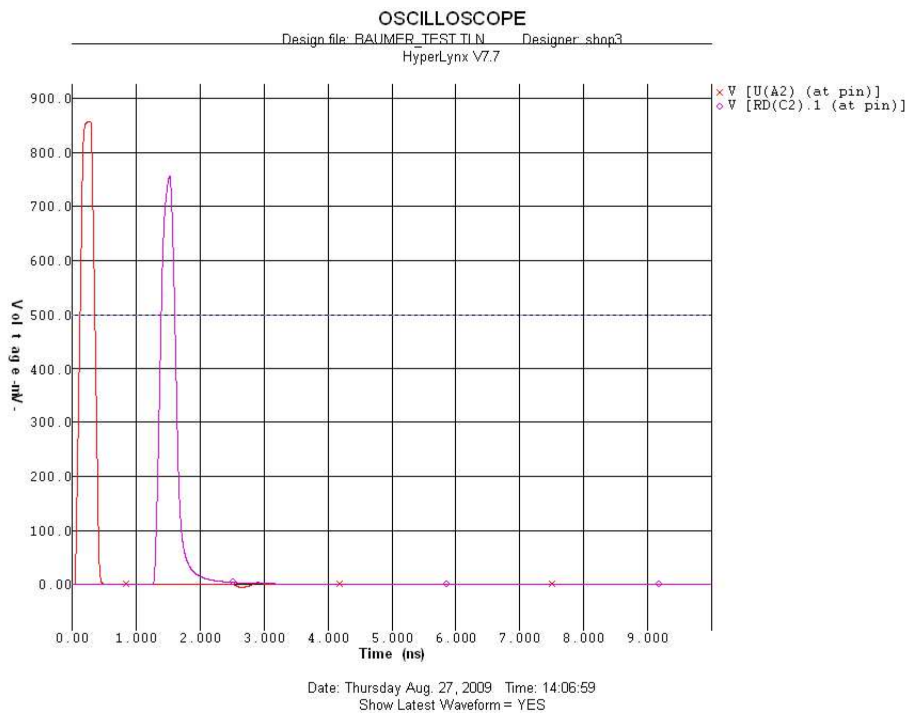
A signal processing rule of thumb indicates that an impedance discontinuity (a quick departure from 50 Ω followed by a quick return back to 50 Ω) is usually acceptable if its length in inches is less than its risetime in nanoseconds. This makes sense because for a small discontinuity, the reflection at the first boundary (which in our case has the same orientation) can be more closely canceled by the reflection from the second boundary (opposite orientation, but same magnitude of discontinuity). By this rule, at our target bandwidth of 3.5GHz, discontinuities shorter than .1 inch might be acceptable. Henry proposed a .02 inch (.5mm) thick kovar wall, sealed to the anode plane by .02 inches (.5mm) of frit. I used Hyperlynx to simulate the propagation of a pulse through 8 inches of our anode microstrip lines ($\approx 50\Omega$), a thin Kovar wall ($Z_0 \approx 16\Omega$), and terminated on 50 Ω.

2 Simulation

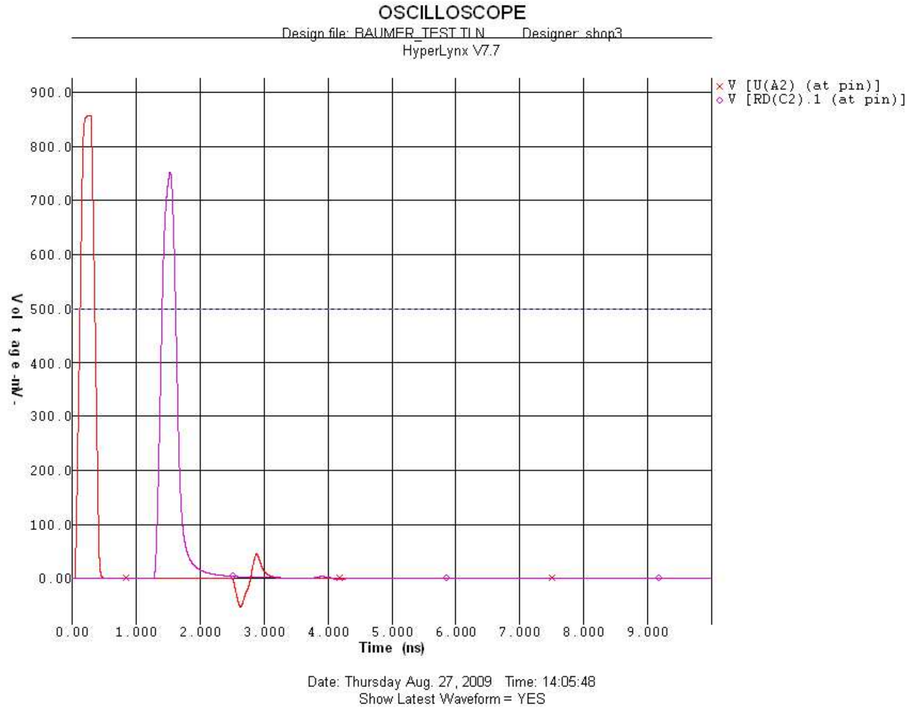
To isolate the effects of the kovar wall on the signal, I first removed all but one signal trace to remove cross-talk effects and slightly adjusted the value of the terminating resistor to achieve an exact match between the anode card and the terminating resistor. Therefore, we can say that all observed reflections are due to the mismatch caused by the kovar walls. The following chart indicates the amount of reflection observed at the input relative to the original input (3.5GHz pulse):

Wall Thickness	% reflected
$\leq .4mm$	negligible reflection
.5mm	3%
.6mm	3.9%
.7mm	4.4%
.8mm	5%
.9mm	5.6%
1mm	6.1%

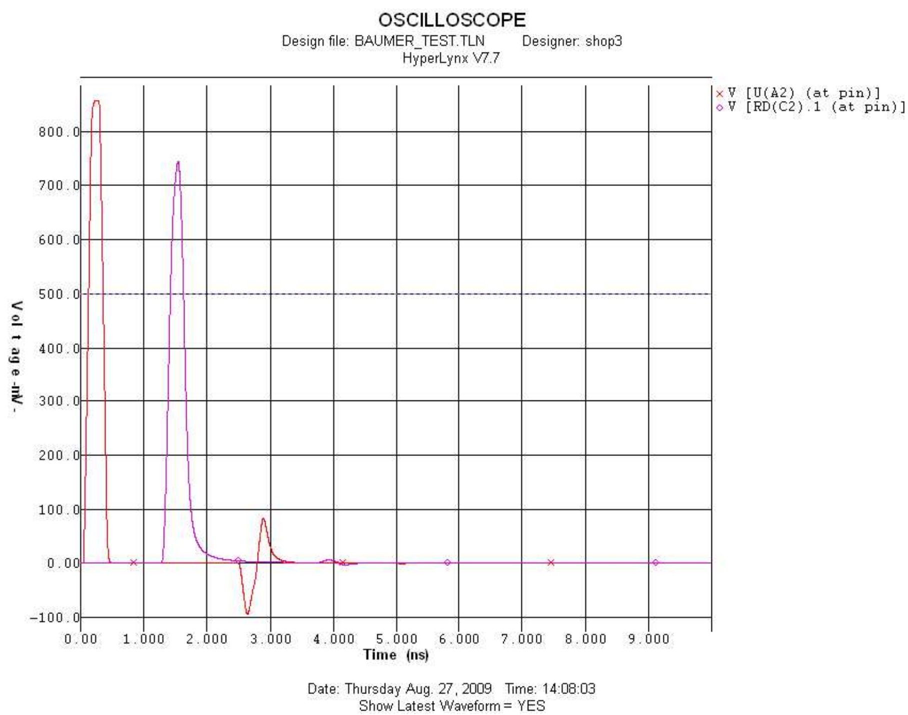
The following simulated scope images illustrate the reflections:



This is the response of the anode card by itself on a matched terminating resistor. Red is the input ($\tau \approx 100ps$) and purple is the output.



This is the response of the line with a 1mm thick kovar wall.



This is the response with a 2mm thick kovar wall.

3 Conclusion

From a signal integrity perspective, a dielectric wall would seem like the obvious choice, as it introduces an impedance discontinuity of only a few ohms. However, to maintain structural integrity according to Rich's diagrams, a dielectric wall would have to be thicker than one made of kovar ($\approx 2.5mm$ rather than $\approx .5mm$). This added thickness would make it less likely to have the first and second reflections cancel, as they do for a thin kovar wall, but would cause a smaller overall impedance discontinuity resulting in greater transmission of the signal. The kovar walls may cause the first and second reflections to cancel, but this effect depends on the bandwidth of the signal and still results in less transmission through the wall. Overall, both dielectric and thin kovar walls appear acceptable from a signal integrity perspective. There is no way to achieve perfect continuity, so we are satisfied in choosing any situation that results in both signal and structural integrity. Because limiting the kovar thickness can give us similar signal integrity to a dielectric wall, the eventual choice will depend mostly on mechanical concerns, like frit-kovar sealing and the minimum thickness of kovar needed for the wall.