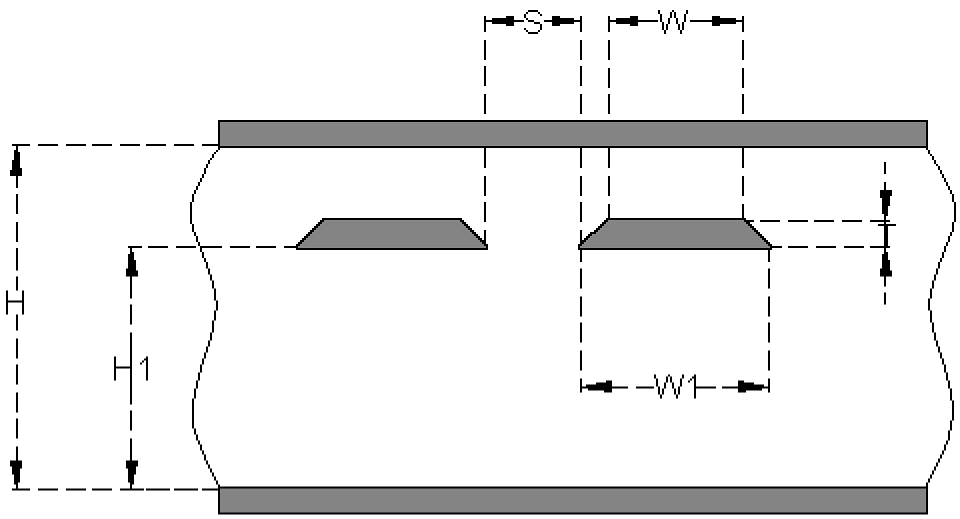
Avoiding arithmetic errors when calculating impedance on differential structures

The Si6000 is a powerful tool but care must be taken to avoid arithmetic errors in impedance calculations.

Questions asked by new Si6000 users include:
"When the Si6000 calculates impedance does it only reference the nearest plane?"
"Why does the impedance value change if I invert the structure? I should get the same impedance value whichever way I view the structure!"

AP160 addressed these questions for a single ended structure. This application note discusses a commonly used differential structure, the edge-coupled offset stripline.

The characteristic impedance of a microstrip or stripline structure is derived from the physical dimensions of the structure and its material properties. For the edge-coupled offset stripline structure below the Si6000 uses dimensions H, H1, W, W1, S, T and dielectric constant Er as shown in the diagrams below.



Let's assume the parameters are as follows:
H = 15
H1 = 10
W = 5
W1 = 6
S = 4
T = 1
Er = 4

For these values Zo is calculated as 75.0Ω.

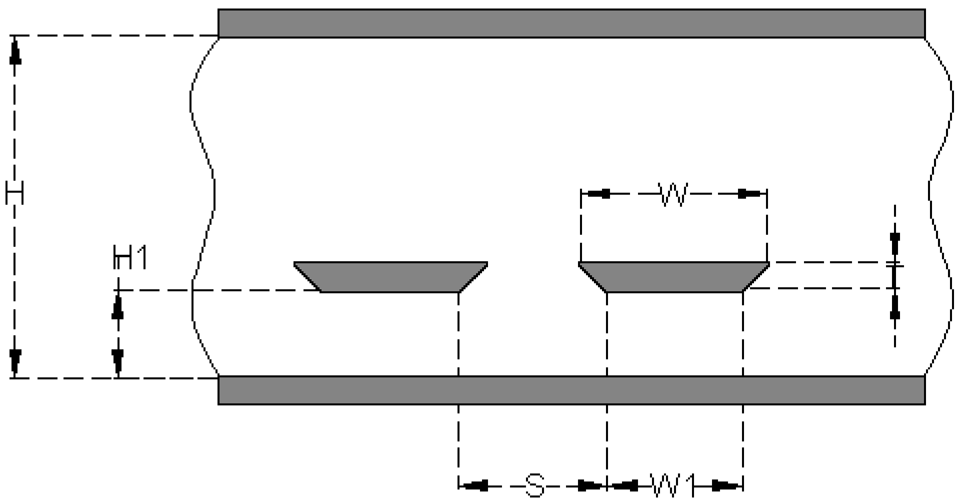
Note that H1 is the distance from the base of the traces to the lower plane, W1 is the trace width of each base and S is the separation between the traces in the same plane as W1.

Inverting the structure

What happens if we invert the structure? The dimension numbers used in the calculations change, but the Si6000 should still correctly calculate the impedance.

The diagram below shows the structure inverted.

As in the above example, H1 is the distance from the base of the trace to the lower plane, W1 is the width of each base (W1 is associated with H1) and S is the separation between the traces in the same plane as W1.



Now the parameters are as follows:
H = 15
H1 = 4
W = 6
W1 = 5
S = 5
T = 1
Er = 4

For these values the Si6000 calculates Zo as 75.0Ω.

New Si6000 users sometimes forget to take into account the thickness of the trace when comparing impedance values between the "normal" and "inverted" structure and calculate the inverted H1 as (H – the non-inverted H1) (= 15 – 10) = 5. The true value for this structure is (H – the non-inverted H1 – T) (15 – 10 – 1) = 4. (The Si6000 field solver includes the trace thickness in its calculations.)

It's also easy to forget to associate W1 with H1 and S and use the non-inverted values for W, W1 and S.

This would result in the following erroneous parameters:
H = 15
H1 = 5
W = 5
W1 = 6
S = 4
T = 1
Er = 4

For these values the Si6000 would calculate Zo as 78.3Ω, clearly different from the non-inverted value.

So the answer to the first question "When the Si6000 calculates impedance does it only reference the nearest plane?" is that the Si6000 takes *every* surface into account when calculating impedance. You can use either plane as reference — just be sure to use the finished dimensions in your calculations (the actual trace dimensions *after* processing).

Similarly, the impedance value does not change if the structure is inverted but you have to take care to use the correct numbers. You get the same impedance value whichever way you view the structure.

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