Avoiding arithmetic errors when calculating impedance on single-ended structures

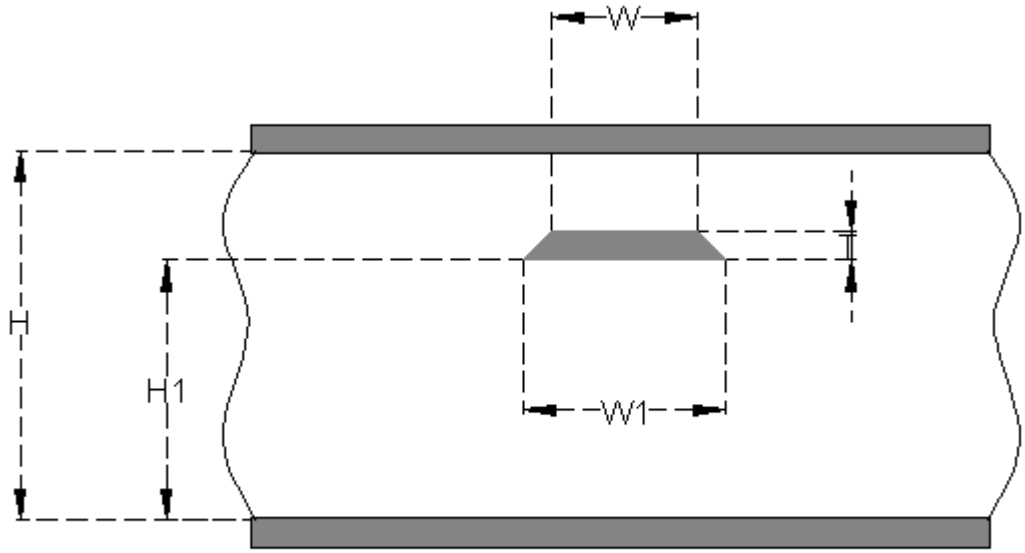
The Si6000 is a powerful tool but care must be taken to avoid arithmetic errors in impedance calculations.

We sometimes get asked by new Si6000 users:

"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!"

The characteristic impedance of a microstrip or stripline structure is derived from the physical dimensions of the structure and its material properties. For the Offset Stripline structure below the Si6000 uses dimensions H, H1, W, W1, T and dielectric constant Er.



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

For these values Zo is calculated as 48.9Ω.

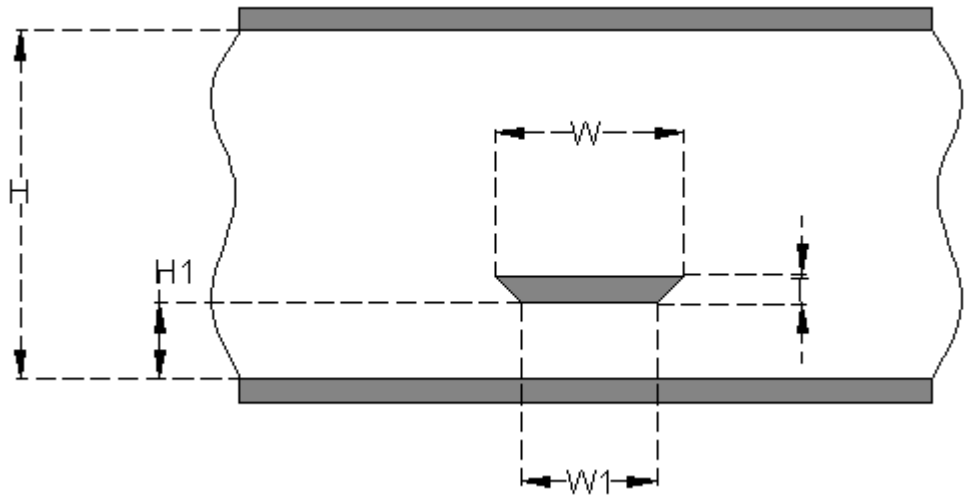
Note that H1 is the distance from the base of the trace to the lower plane and W1 is the width of the base.

Inverting the structure

What happens if we invert the structure? Won't the numbers change? Simply inverting the structure should not change the impedance!

The diagram below shows the structure inverted.

Again, H1 is the distance from the base of the trace to the lower plane and W1 is the width of the base (W1 is associated with H1).



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

For these values the Si6000 again calculates Zo as 48.9Ω.

A common mistake when comparing impedance values between the "normal" and "inverted" structure is to forget the thickness of the trace 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 use the non-inverted values for W and W1. This would result in the following parameters:
H = 15
H1 = 5
W = 4
W1 = 5
T = 1
Er = 4

For these values the Si6000 would calculate Zo as 51.9Ω, 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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