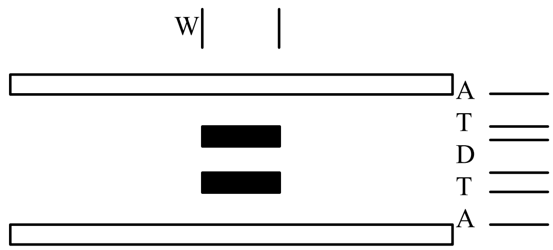
To: X3T10 Membership X3T10/96-261
From: Dean Wallace
Subject: Universal Backplane
Date: 11/4/96

The goal is to define a backplane that has the same ratio between differential and single ended impedance as cables (30% to 40% range, sometimes more with the differential impedance being higher).

The differential configuration is below;

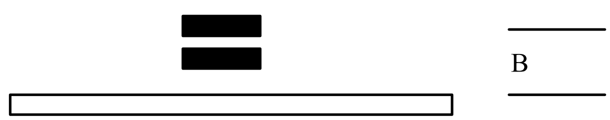


W is the width of the conductor.
T is the thickness of the conductor.
A is the distance from the conductor to the ground/power planes.
D is the conductor separation.

The spacing A is on the order of D but D<A for complete shielding. The conductors cannot be offset from each other or the impedance in the single ended mode will be much too high. The impedance of the above configuration is;

$$Z=\left(80\left[1-\left(\frac{A}{4(A+D+T)}\right)\right]\ln\left\{\frac{1.9(2A+T)}{0.8W+T}\right\}\right)/(Er)^{1/2}$$

For the single ended measurement I assumed the top conductor was grounded.



B is the separation between the top and bottom ground plane. The impedance of this configuration is;

$$Z=\left(60\ln\left\{\frac{4B}{0.67\pi W(0.8+T/W)}\right\}\right)/(Er)^{1/2}$$

The ratio of the differential impedance to the single ended impedance is;

$$\frac{Zdiff}{Zse} = \frac{1.33\left[1-\left(\frac{A}{4(A+D+T)}\right)\right]\ln\left\{\frac{1.9(2A+T)}{0.8W+T}\right\}}{\ln\left\{\frac{4(A+D+T)}{0.67\pi W(0.8+T/W)}\right\}}$$

If the spacing between the conductors is 1/2 of the spacing from the bottom conductor to the ground plane the differential impedance should be about 35% higher than the single ended impedance. The simulations that we did seem to agree with this pretty well. The simulations were done with the following parameters;

T= 0.006”
W=0.015”
A=0.02”
D=0.02”
Er=4.5

The results were;

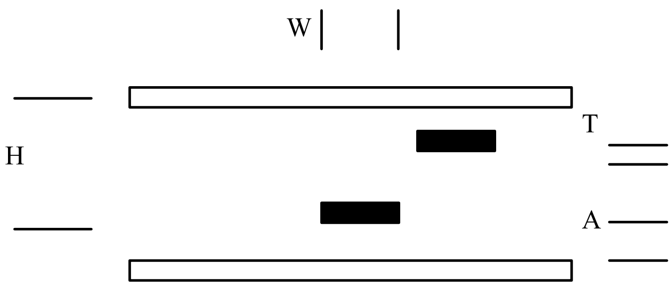
Zse = 42 ohms (A=D)
Zdiff=50.3 ohms
Zse=54 ohms (if the conductors are offset)

The ratio in this configuration is approximately 29%.

The accuracy of the results are affected by the size and location of the top conductor which becomes the ground plane. In the simulations the effective capacitance is about 40% lower in the differential mode and the inductance increased by about 25% due to the increased mutual inductance between the leads. This seems to correspond quite well with the cable environment.

If off-centered leads are required the equations become;

Z=(2F1F2)/(F1+F2)
F1= 60/(Er)^1/2 (ln(8A/(0.67pi*W(0.8+T/W)))
F2= 60/(Er)^1/2(ln(8H/(0.67pi*W(0.8+T/W)))



In this case the correlation between the single ended and differential impedances seems to be more difficult because you only get partial shielding and must trade off separation which also reduces impedance.

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