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Absence of Insertion Loss Anti-Resonance In Shielded Pairs Having High Skew

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Background

Allegedly, within-pair skew causes resonances (actually anti-resonances) to be present in measured insertion loss. Skew related resonances are calculated using the following equation:

$$\text{Freq} = \frac{1+2\text{n}}{2(\text{Skew})} \quad \text{for n} = 0,1,....$$

Several cable samples were examined to study these resonances. No resonances were observed when measuring cable. All samples were shielded parallel pairs.

Presented data confirms the equation, but only when launch skew exists. Launch skew is a condition where the drive signals are mismatched in time. If one wire of the pair is driven before the other wire, then a launch skew condition exists.

Finally, a curious effect is noted, where insertion loss degradation of high-skew pairs appears to stabilize at high frequencies.

Acknowledgement

Dean Vermeersch, Tyco Electronics, provided valuable insight concerning launch skew.

The samples

Three samples were measured:

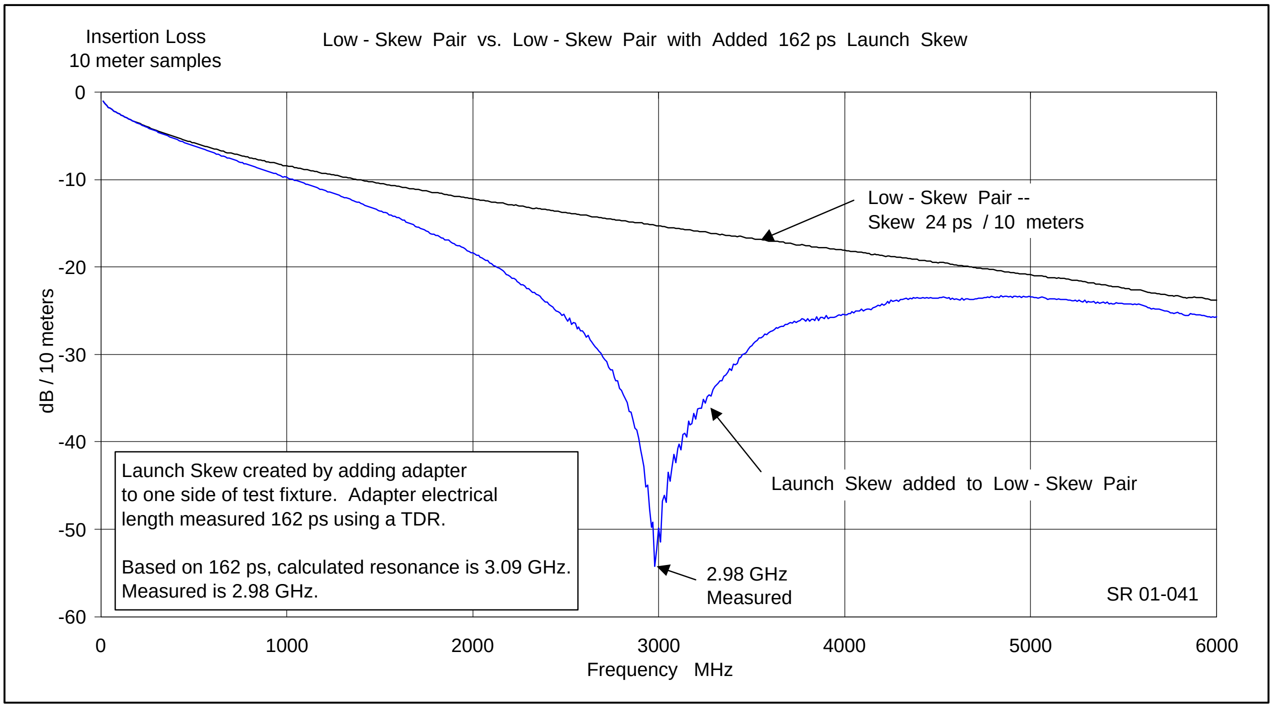
1) An single shielded parallel pair having low within-pair skew.

2) An single shielded parallel pair, “identical” to above, only deliberately designed for very high skew.

3) A round nineteen pair cable, 15 meter length, containing shielded parallel pairs having both very good and very bad skew.

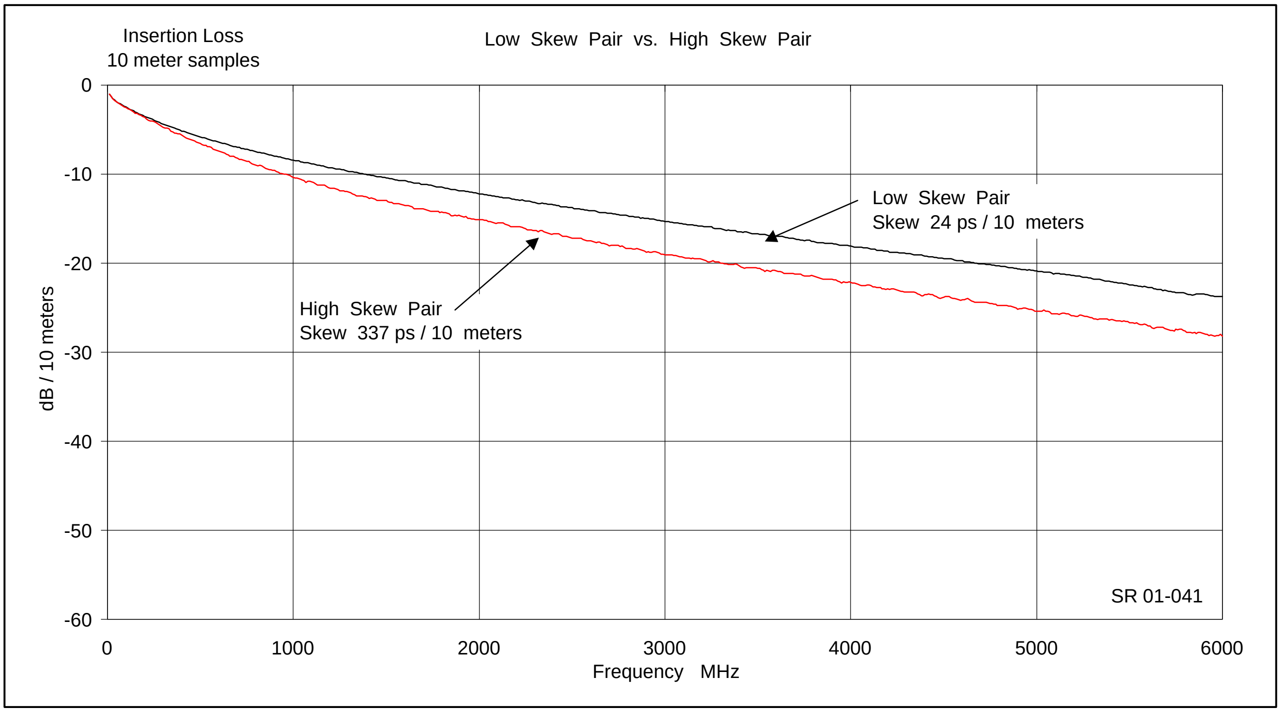
Results, Launch Skew

The figure below demonstrates the effect of launch skew. A low-skew measurement setup was modified by inserting adapters into the signal path going to one wire of the low-skew pair, while the other wire was driven without the adapters. The drive signal therefore had 162 ps launch skew. The equation predicts a resonance at 3.09 GHz (and odd harmonics). The first resonance is confirmed for launch skew.



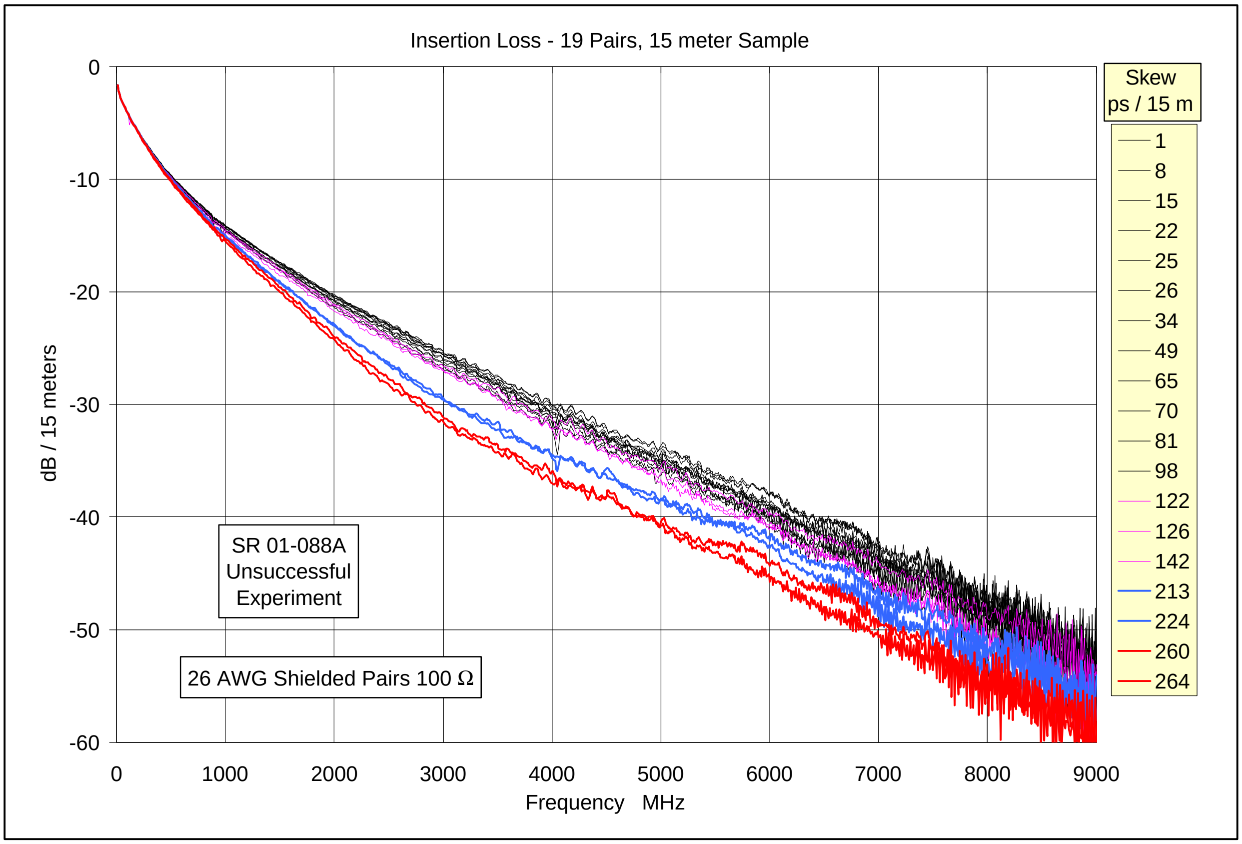
Results, Low-Skew Pair and High-Skew Pair

If within-pair skew caused resonances, the high-skew pair would have shown a resonance at about 1.48 GHz, based on the above equation. There is no evidence of such.



Results, 19 Pair Cable

If within-pair skew caused resonances, the pair having 264 ps skew would have shown a resonance at about 1.89 GHz. Lower skew pairs would have higher frequency resonances. Again, none are present.



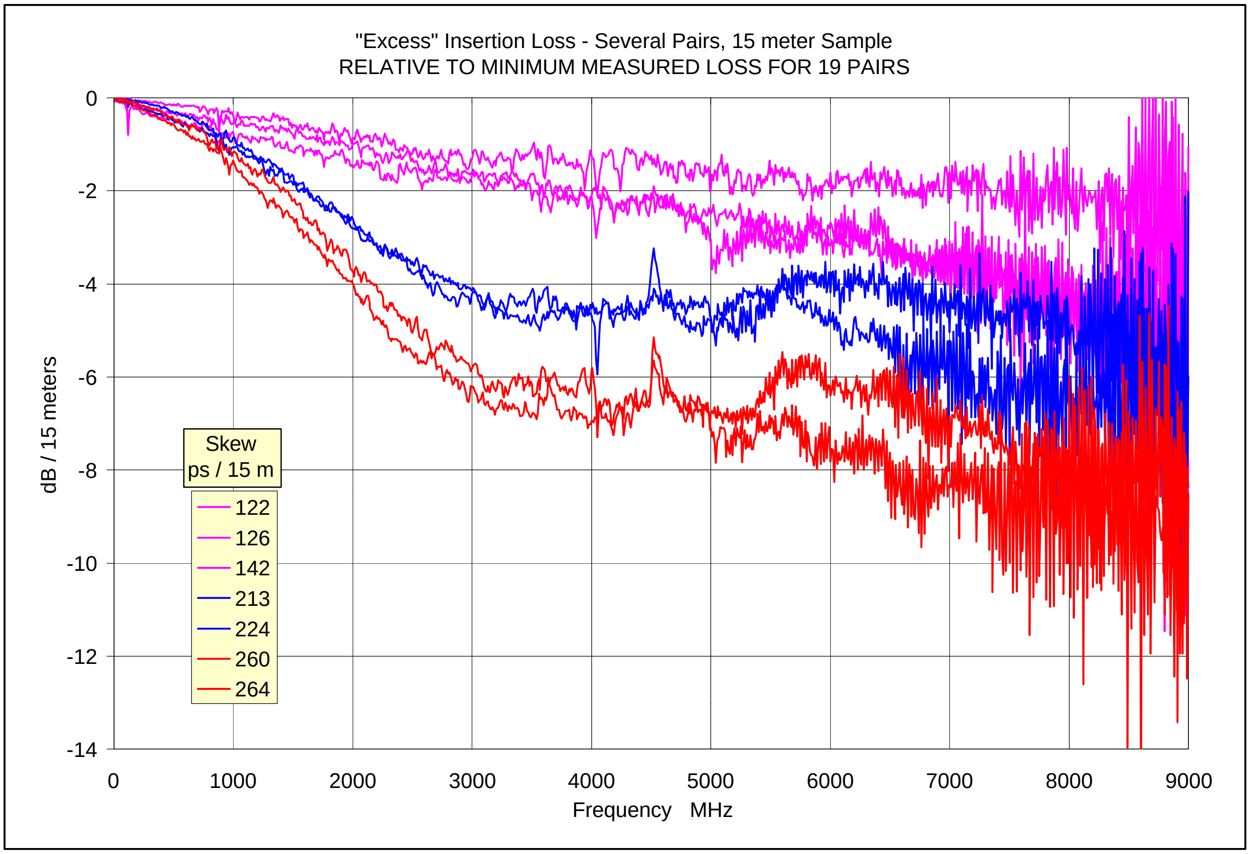
Curious Effect

The previous figure shows insertion loss for high-skew pairs rapidly diverging from loss of low-skew pairs up to about 3 GHz. But, at frequencies higher than 3 GHz the difference in loss diverges much less rapidly.

The following figure shows loss of the seven worst pairs with respect to the lowest loss seen in the entire 19 pair data-set. Excess loss is calculated as follows:

Excess Loss = (Measured loss of a pair) – (Minimum measured loss from entire data set)

The four highest skew pairs show rapidly increasing loss to 3 GHz. At higher frequencies the excess loss becomes almost “flat”.



Below, the best pair and the worst pair from the above figure (122 and 264 ps skew) are examined from a phase-shift perspective. Assuming the excess loss is caused exclusively by skew induced phase shift, that shift can be calculated as follows:

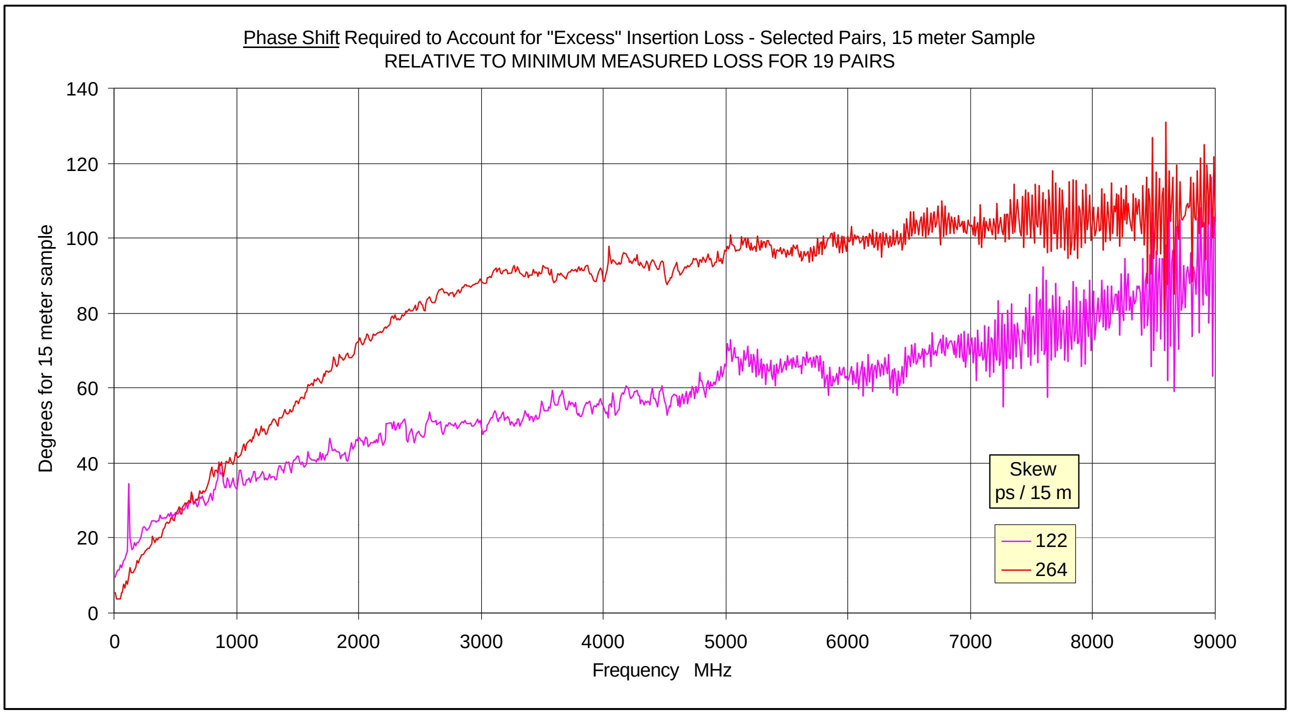
Output signals (volts): Vpos = 0.5 Vneg = -0.5 (cosθ) θ = phase shift

Differential output: Vdiff = Vpos – Vneg = (0.5 – (-0.5(cosθ)) = 0.5 (1+cosθ)

Differential input (θ = 0): Vin = 0.5 (1+cos0) = 0.5 (1+1) = 1

Excess Loss: $$dB = 20\log\left(\frac{V_{OUT}}{V_{IN}}\right) = 20\log\left(\frac{0.5\,(1+\cos(q))}{1}\right)$$

then $$q = \operatorname{acos}\left(2\,(10^{\frac{dB}{20}} - 1)\right)$$



The phase shift of the worst pair (264 ps / 15 meters) rises rapidly to 3 GHz, then rises very slowly between 3 GHz and 9 GHz. The author would not have predicted this result.

Comments

1. The author used Ansoft's 2D electromagnetic simulator to model a high-skew pair and a low-skew pair. The modeled attenuation of the low-skew pair adequately matched previously shown data. The modeled attenuation of the high-skew pair was much lower than measured data. Perhaps 3D simulation might be more accurate.
2. Only shielded parallel pairs were measured. Other types of pairs might conceivably show skew related resonances, although this seems unlikely.