

Propagation Delays in Serpentine Traces

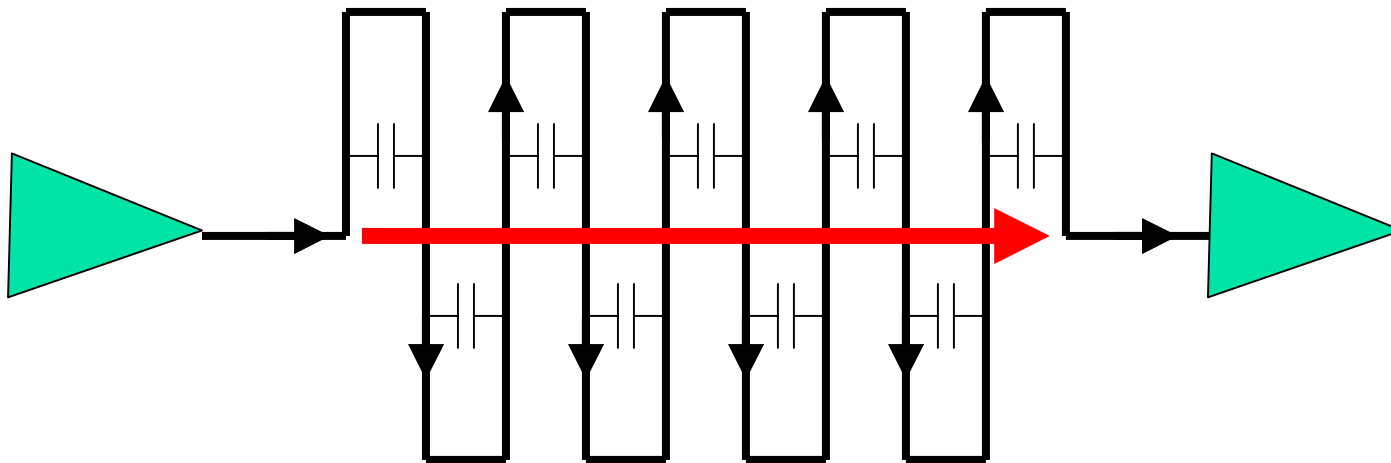
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What is a serpentine trace ?





Why serpentine ?

- Layout constraints
- To adjust clock skew
- Equal length traces



Issues in serpentine traces

- Changes in propagation delay
- Signal distortion due to cross talk

Reason: coupling between the
serpentine legs



Problem Statement

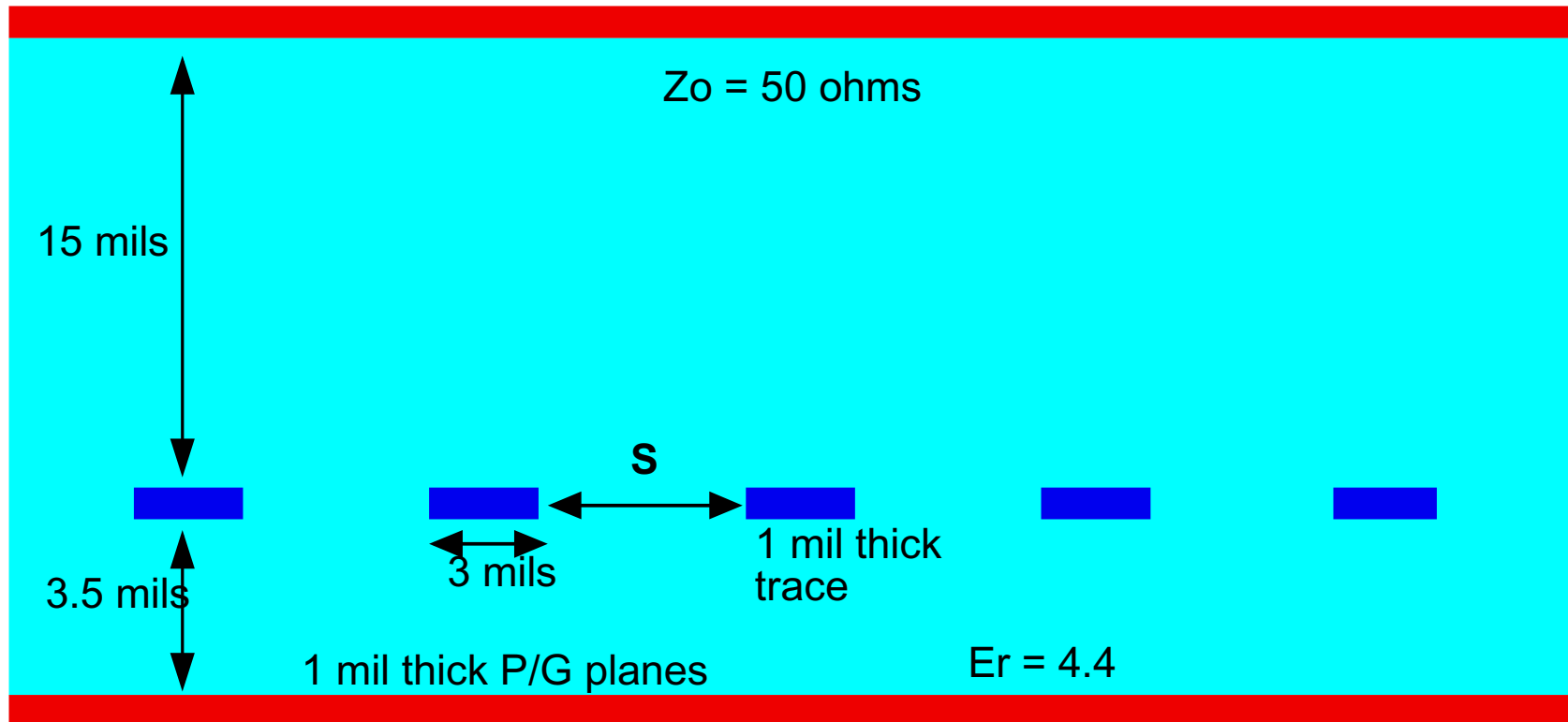
Specifications:

- 3/15 mils asymmetric stack-up
- 3 inch long and 3 mil wide trace
- Rise time 100ps
- Frequency 1-5GHz

Find an optimum serpentine layout ?

Simulation Setup

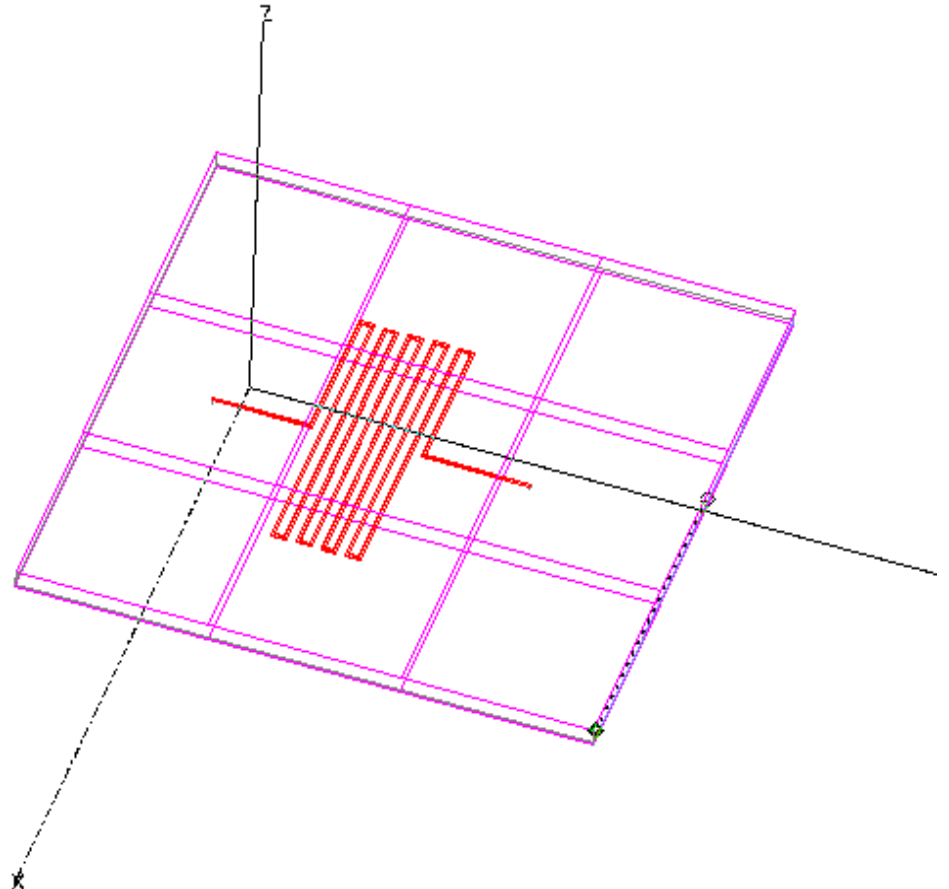
Asymmetric stack-up





Simulation Software

- Ansoft Maxwell Tools
 - HFSS
 - Maxwell SPICE



Strip line layout rules

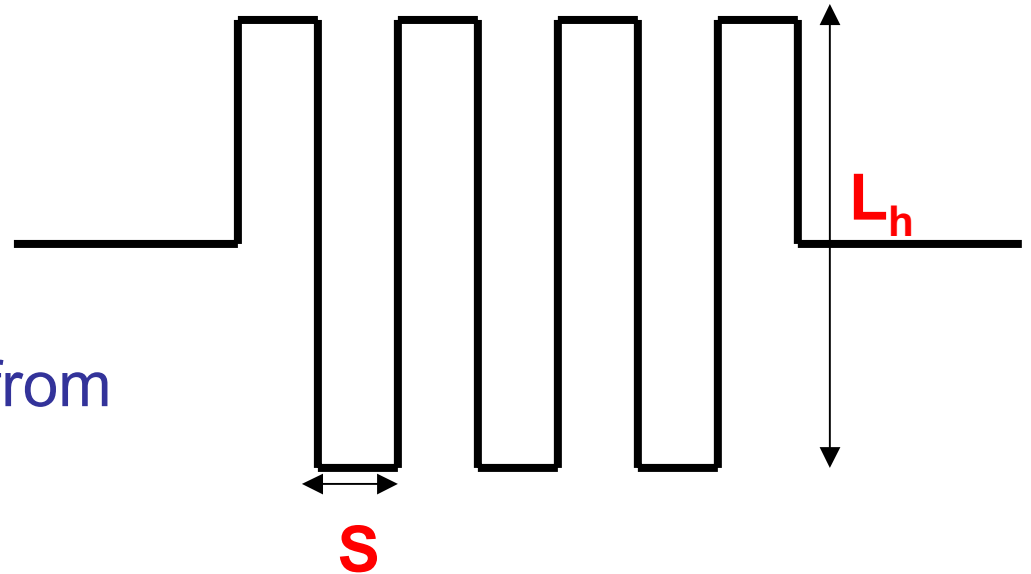
General Recommendations:

1. $S=3 \times$ “height of the trace from ref ground plane” [1]

2. L_h must be reasonable [2]

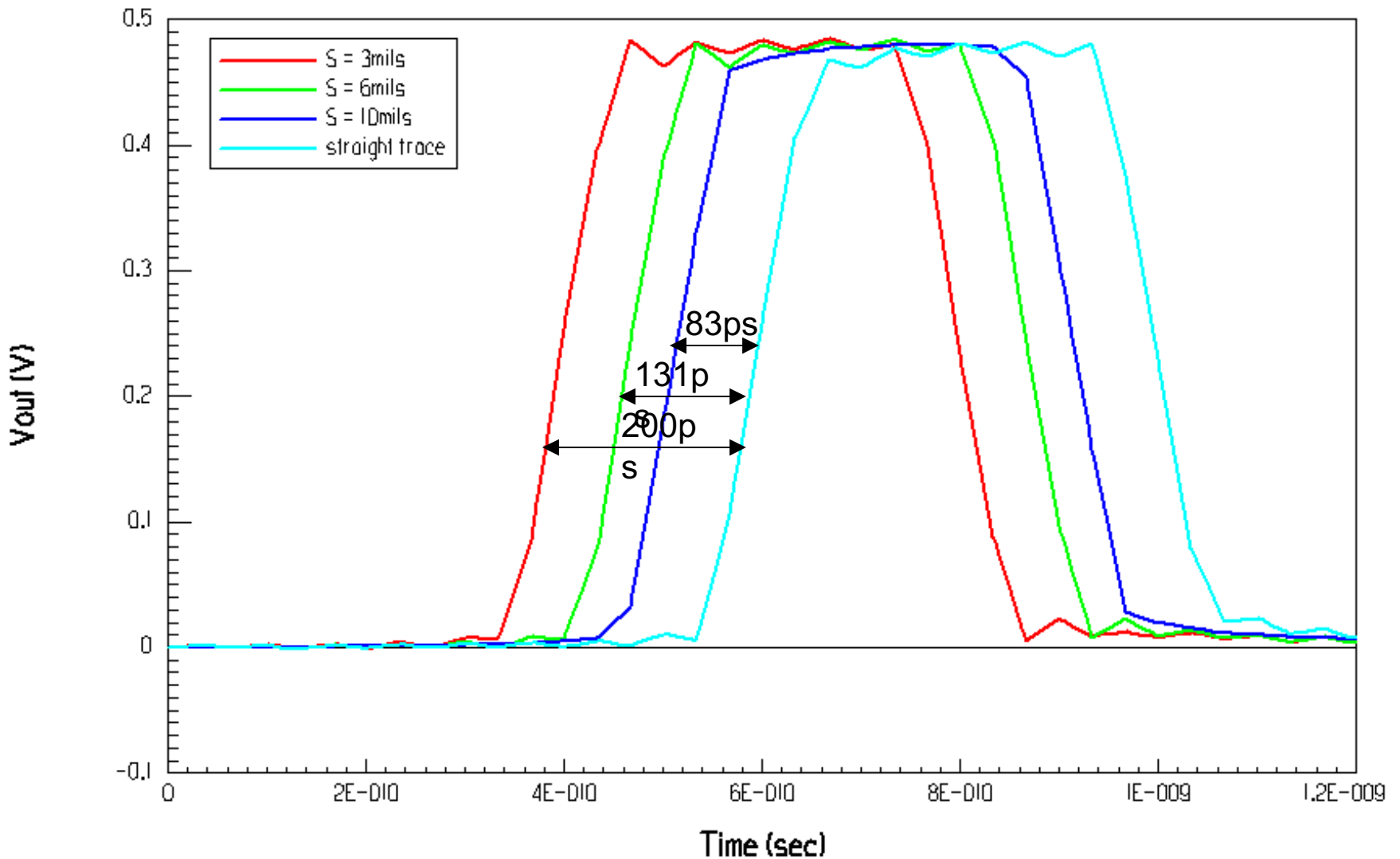
Time of $2 \times (L_h + S) \ll 1/3 Tr$ --> Advanced timing

Time of $2 \times (L_h + S) \gg 1/3 Tr$ --> Distorted Signal



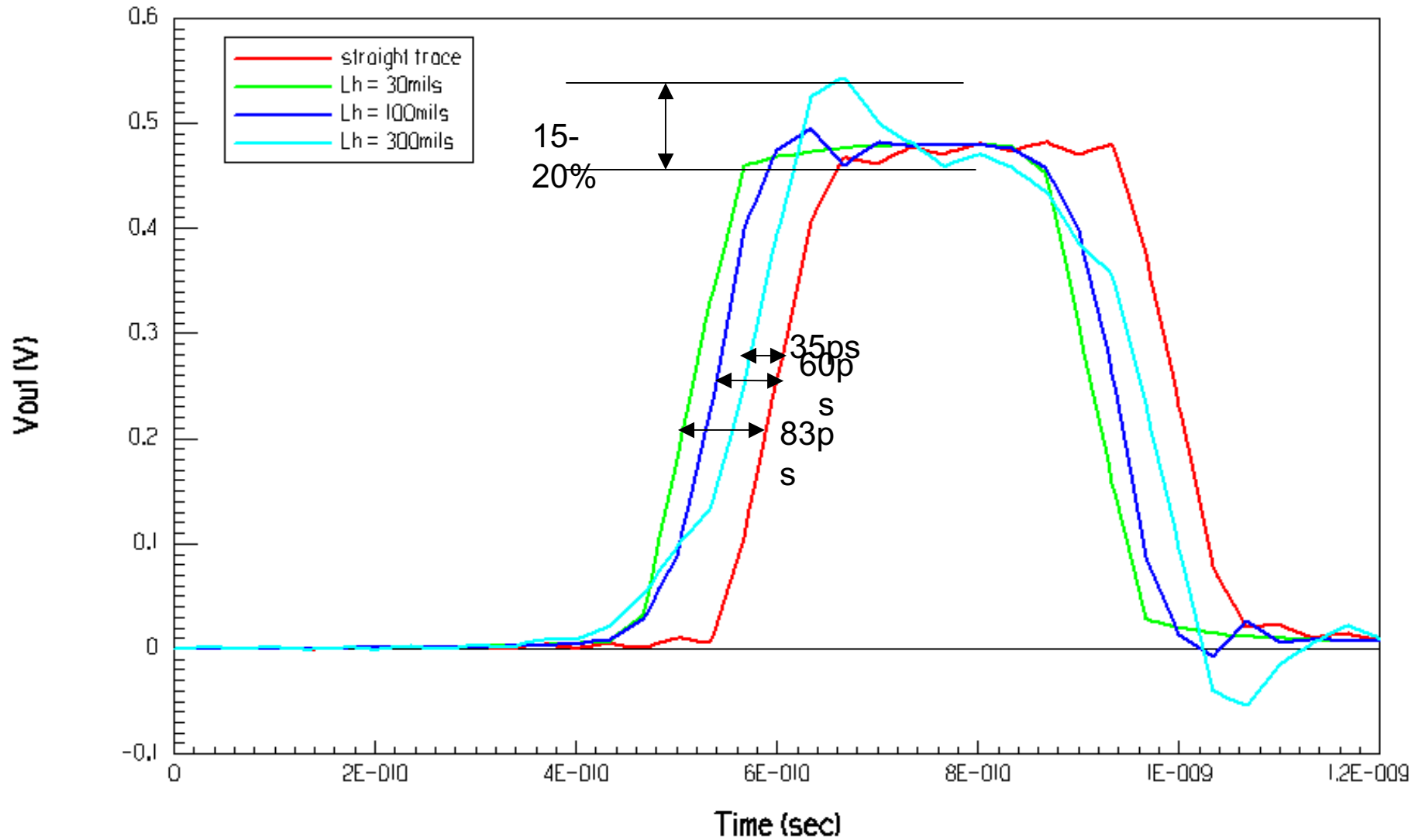
Varying the gap (S)

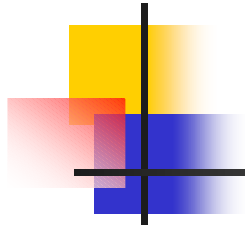
Vout given 0.5V pulsed input



Varying the leg length (L_h)

Vout given 0.5V pulsed input





Pick the best case

f = 5 GHz l = 3 inch		L _h = 30mils			S = 10mils	
		Ideal case	S=3mils	S=6mils	S=10mils	L _h =100mils
w = 3mils						
p.d. (ps)	551	351	420	468	491	516
ps/inch	184	117	140	156	164	172
Xtalk	N/A	< 5%	< 5%	< 5%	5 – 10%	15 – 20%



Conclusions

- $S < 10$ mils: signal propagates too fast.
- $L_h = 300$ mils: poor signal quality.

$L_h = 100$ mils and $S = 10$ mils is a good compromise which is 20 ps/inch faster than the equal length straight trace.



References

- [1] “High Speed Digital System Design”
Hall, Hall, McCall
- [2] “Serpentine Delays” *Howard Johnson*,
article published in EDN Magazine, Feb
2001