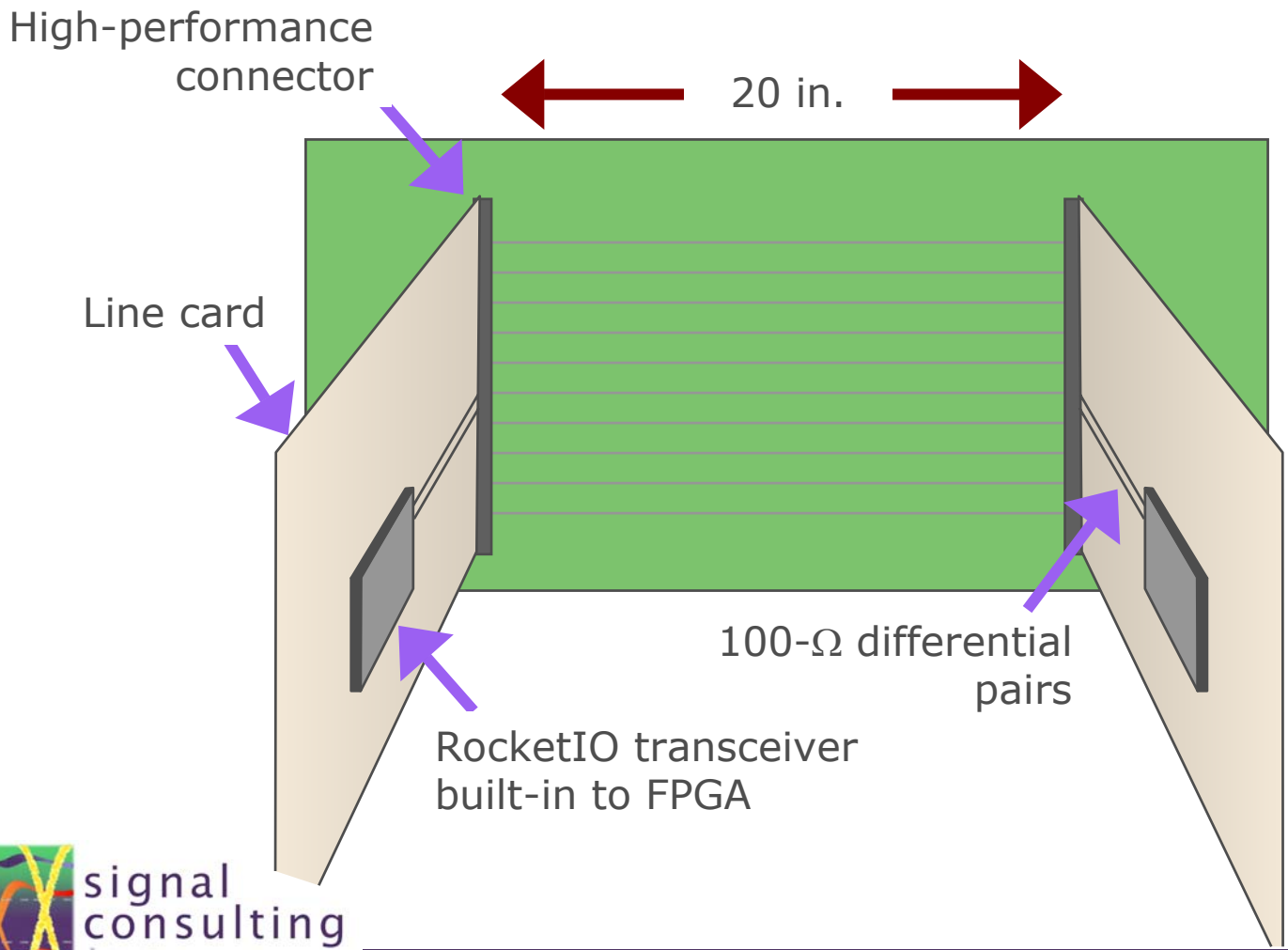
Backplane Link



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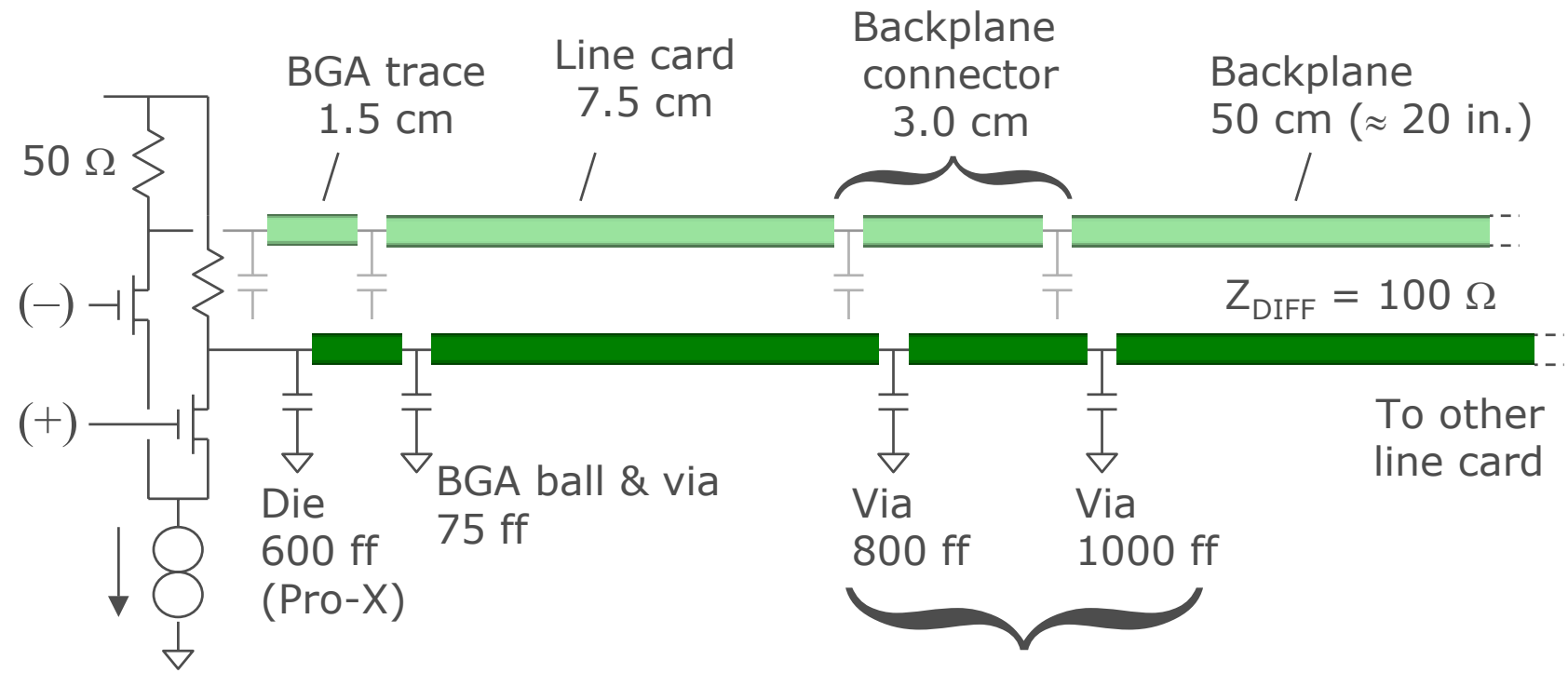
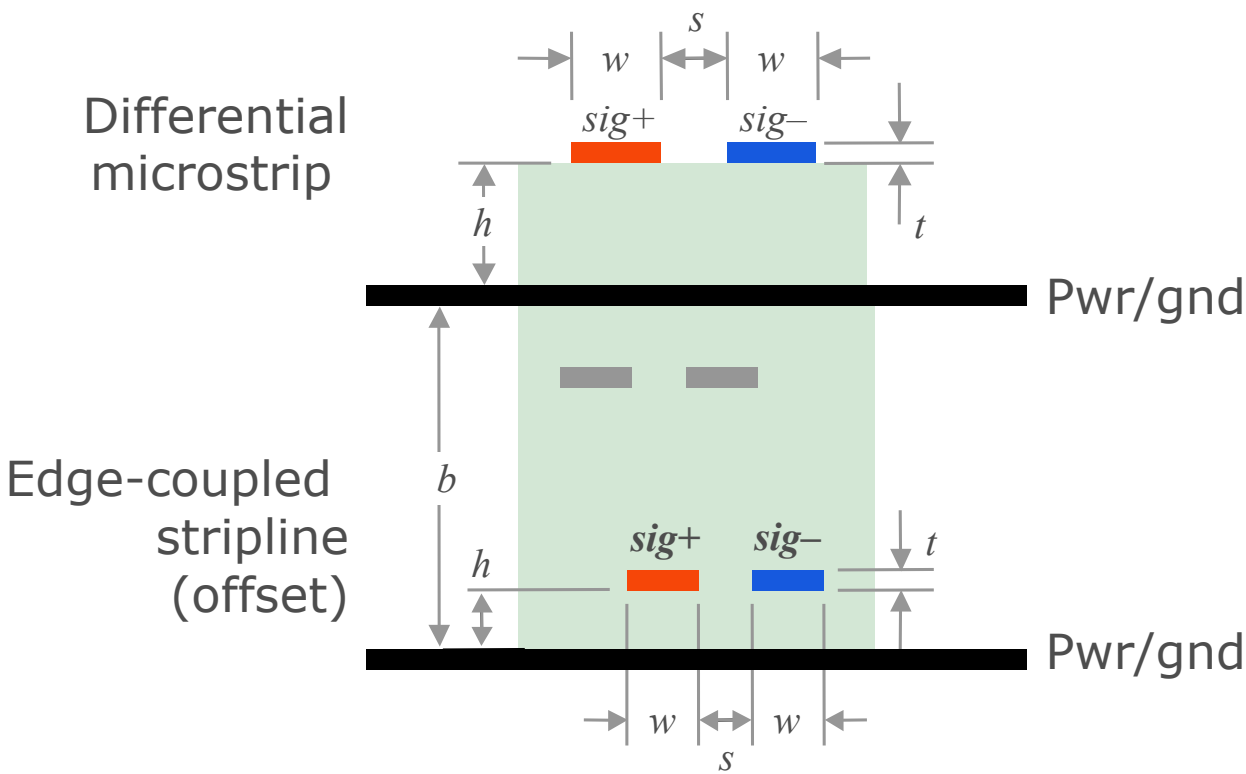
Electrical Model



Edge-Coupled Pair



Differential pcb traces can be arranged in many different ways.

100-ohm edge-coupled stripline configurations

b	*h*	*w*	*s*	R_{skin}	Z_0	α_r (dB/in. @1GHz)
10	3	3	40	3.501	99.03	0.1522
10	4	3	7	3.235	100.4	0.1389
10	5	3	7	3.218	101.2	0.1371
10	5	4	40	2.76	94.59	0.1258
14	4	3	5.5	3.191	101	0.1361
14	4	4	12	2.738	100.3	0.1177
14	5	3	4.5	3.136	100.1	0.135
14	5	4	7.5	2.599	100.5	0.1116
14	5	5	40	2.329	99.51	0.1011
14	7	3	4.5	3.112	101.8	0.1317
14	7	4	6.5	2.556	100.6	0.1096
14	7	5	13	2.236	100.9	0.09574
14	7	6	40	2.006	94.98	0.09126

b	*h*	*w*	*s*	R_{skin}	Z_0	α_r (dB/in. @1GHz)
20	5	3	4.4	3.141	101	0.134
20	5	4	6.5	2.592	100.7	0.1111
20	5	5	11	2.271	100.6	0.09746
20	5	6	40	2.087	98.41	0.0916
20	7	3	3.9	3.132	101.1	0.1336
20	7	4	5.2	2.547	100.9	0.1089
20	7	5	7	2.165	100.7	0.0929
20	7	6	10	1.908	100.3	0.08218
20	7	7	19	1.75	100.7	0.0751
20	7	8	40	1.613	96.34	0.07242
20	10	3	3.7	3.143	100.6	0.1347
20	10	4	5	2.54	101.6	0.1079
20	10	5	6.5	2.148	101.4	0.0915
20	10	6	8.5	1.876	100.7	0.08054
20	10	7	12	1.682	100.5	0.07236
20	10	8	25	1.562	100.3	0.06735

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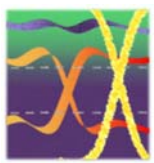
***t*=1/2-oz Cu for all combinations. All dimensions in mils.**

b	h	w	s	R_{skin}	Z_0	α_r (dB/in. @1GHz)
30	5	3	4.3	3.147	100.7	0.1347
30	5	4	6.3	2.595	100.7	0.1112
30	5	5	10	2.268	100.7	0.09729
30	5	6	22	2.087	100.2	0.08996
30	6	3	4	3.139	101	0.1339
30	6	4	5.4	2.564	100.7	0.1099
30	6	5	7.5	2.195	100.7	0.09415
30	6	6	11.2	1.955	100.6	0.08399
30	6	7	20	1.81	100.4	0.07795
30	7	3	3.8	3.144	100.9	0.1343
30	7	4	5	2.557	100.9	0.1094
30	7	4.5	5.7	2.347	100.7	0.1006
30	7	5	6.5	2.172	100.6	0.09323
30	7	6	8.8	1.907	100.7	0.08188
30	7	7	12.5	1.727	100.8	0.07411
30	7	8	21	1.604	100.5	0.06903
30	8	3	3.7	3.15	101	0.1344
30	8	4	4.7	2.562	100.6	0.1099
30	8	5	6	2.167	100.7	0.09296
30	8	6	7.7	1.89	100.6	0.08123
30	8	7	10.2	1.692	100.9	0.07251
30	8	8	14	1.545	100.6	0.06647

b	h	w	s	R_{skin}	Z_0	α_r (dB/in. @1GHz)
30	8	9	23	1.446	100.5	0.06229
30	8	10	40	1.362	97.8	0.06029
30	10	3	3.6	3.159	101.2	0.1345
30	10	4	4.5	2.568	101	0.1098
30	10	5	5.5	2.17	100.7	0.09311
30	10	6	6.8	1.888	100.7	0.08102
30	10	7	8.4	1.672	100.9	0.07163
30	10	8	10.5	1.507	100.8	0.06471
30	10	9	13.5	1.381	100.6	0.05944
30	10	10	19	1.287	100.6	0.05539
30	10	11	34	1.222	100.2	0.05284
30	10	12	40	1.15	96.42	0.05163
30	15	3	3.5	3.171	101	0.1354
30	15	4	4.3	2.581	100.7	0.1107
30	15	5	5.3	2.175	101.2	0.0928
30	15	6	6.3	1.889	100.9	0.08098
30	15	7	7.5	1.671	101	0.0716
30	15	8	9	1.499	100.9	0.06427
30	15	9	11	1.361	101	0.05835
30	15	10	13	1.253	100	0.05425
30	15	11	17	1.166	100.3	0.05036
30	15	12	25	1.101	100.5	0.04745



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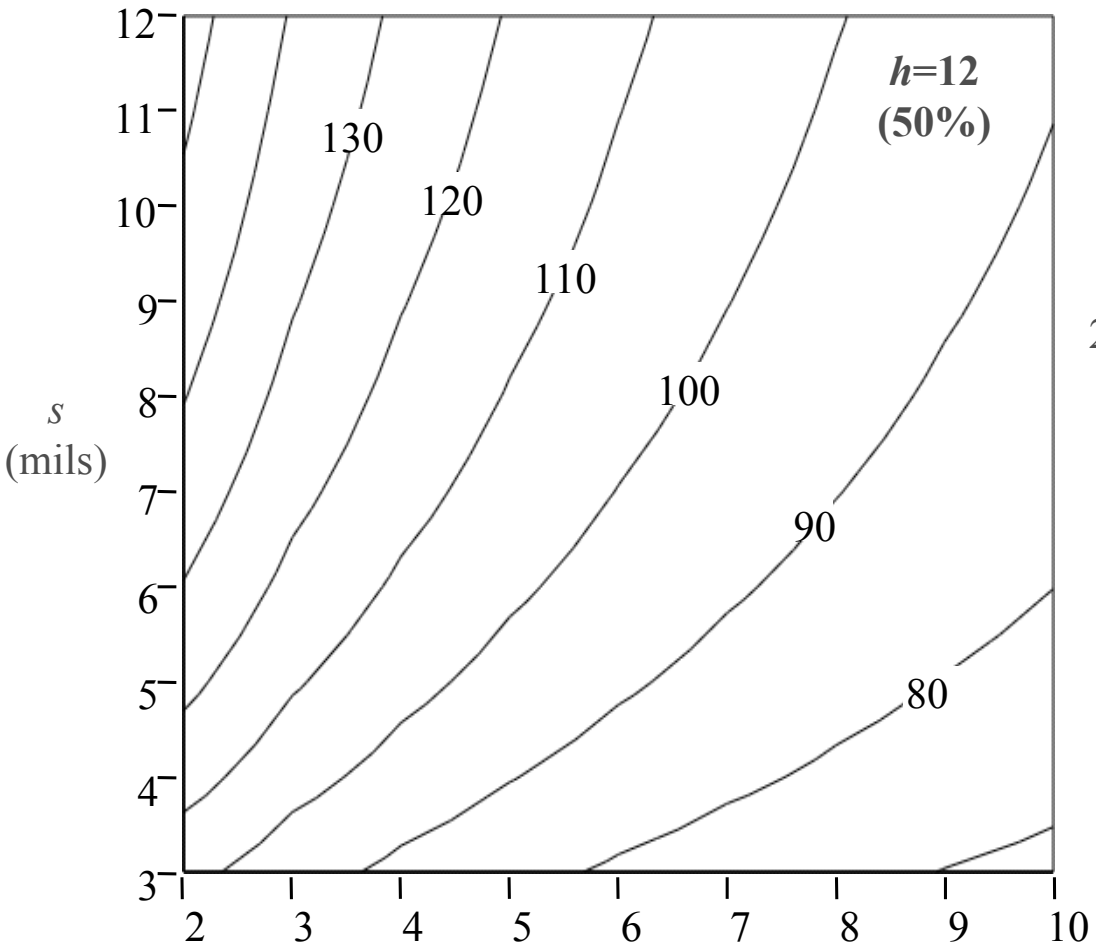
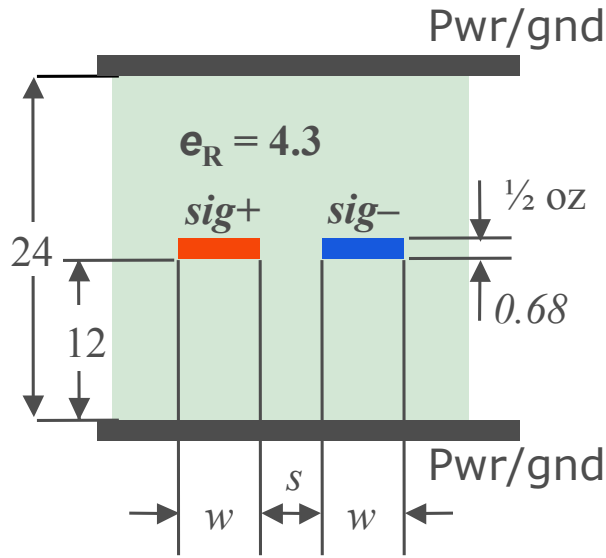
***t*=1/2-oz Cu for all combinations. All dimensions in mils.**

Z_{DIFF} versus h and w





Edge-coupled stripline

All dimensions in mils

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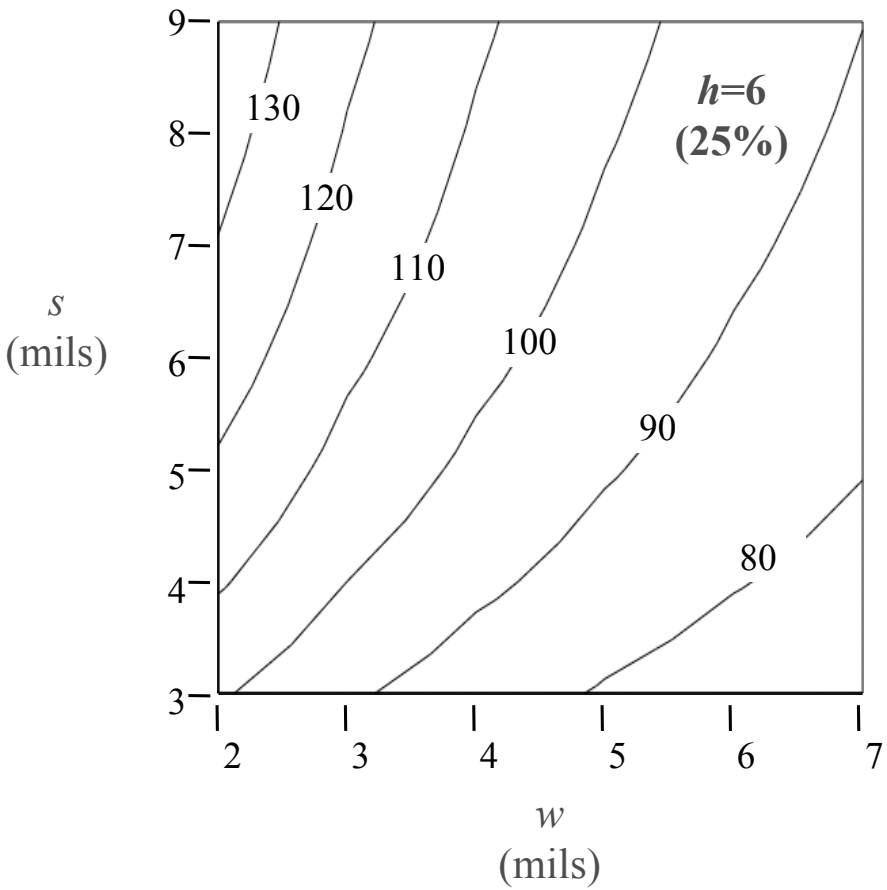
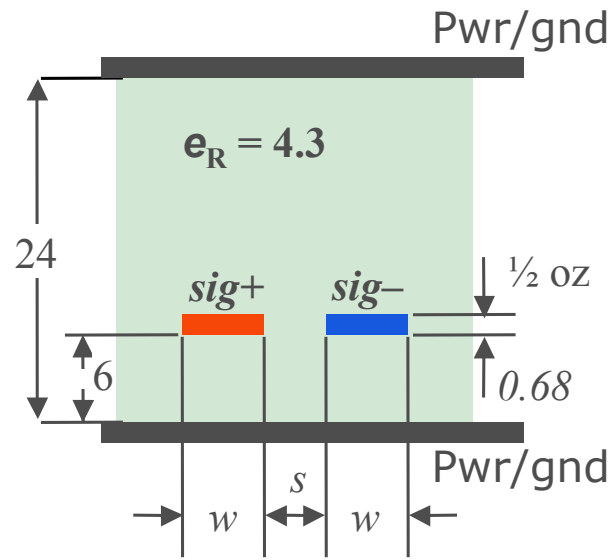
Z_{DIFF} for Offset Stripline

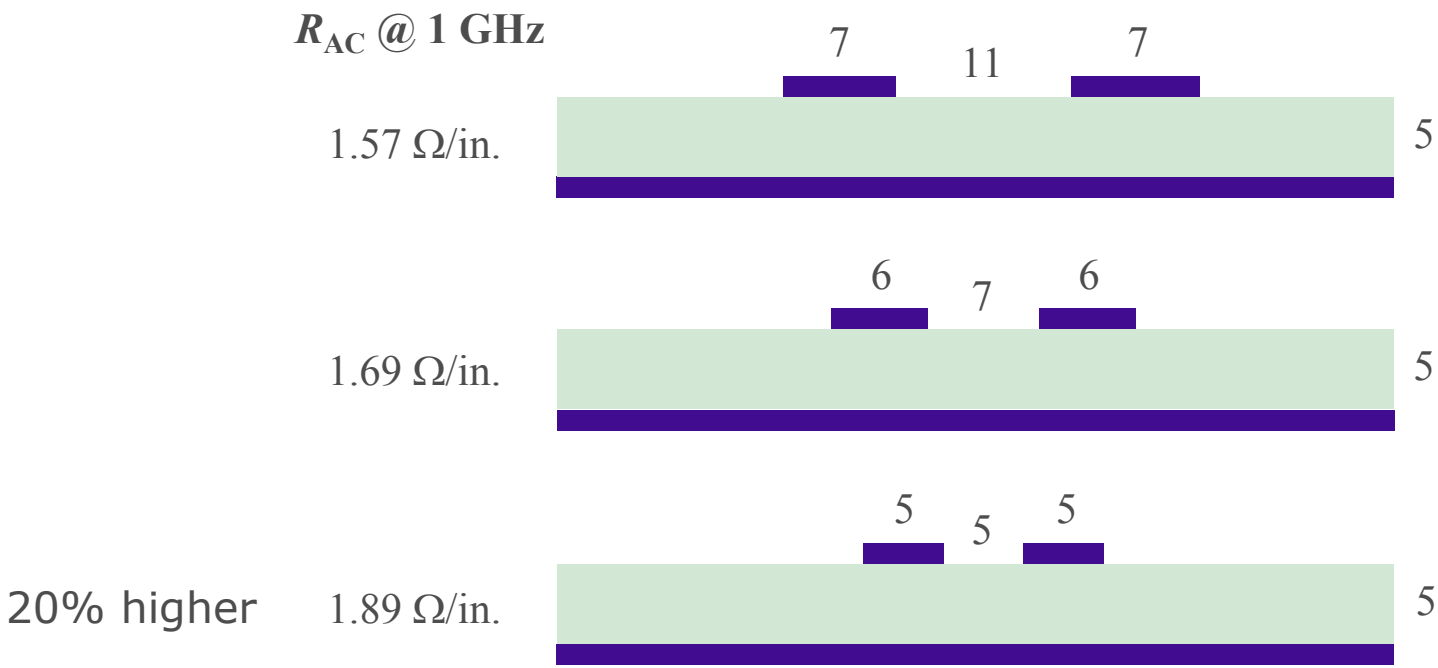




Edge-coupled stripline

All dimensions in mils

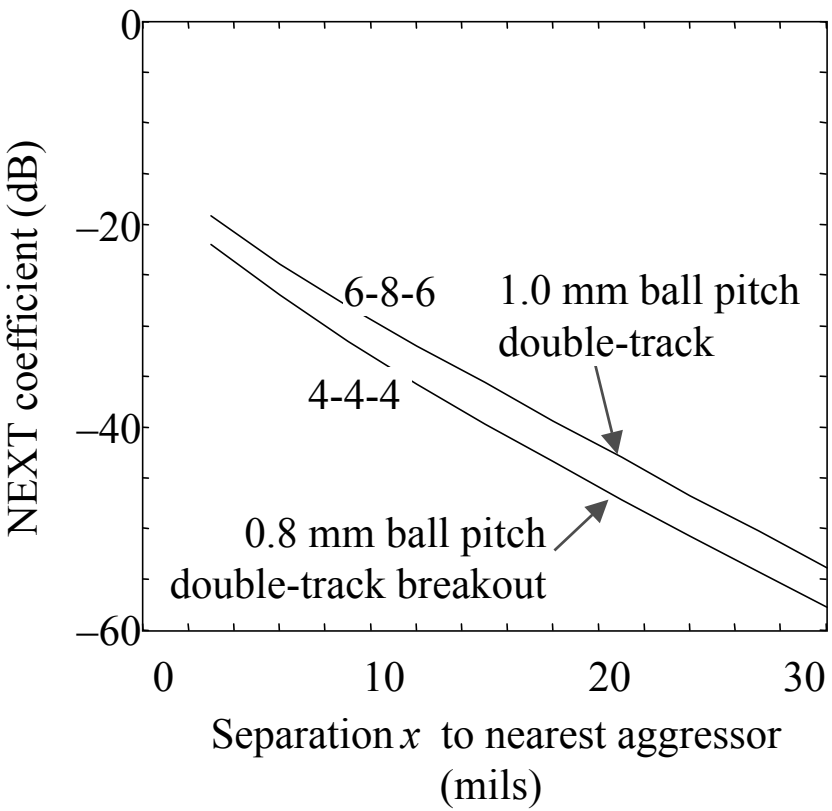
Coupling Effect

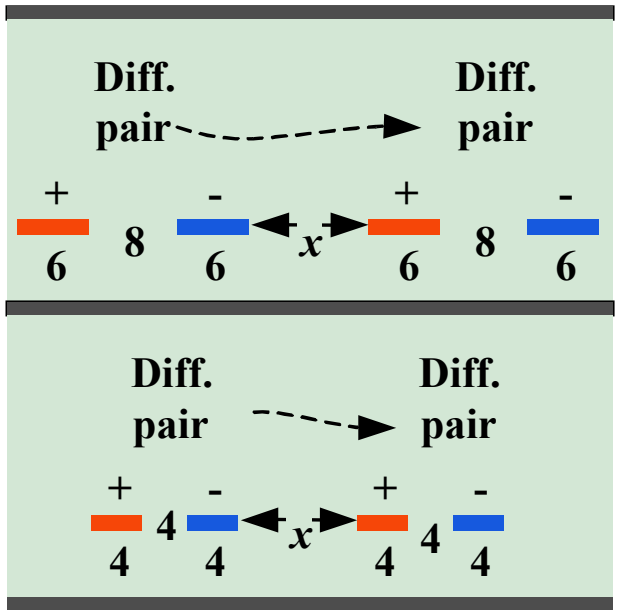


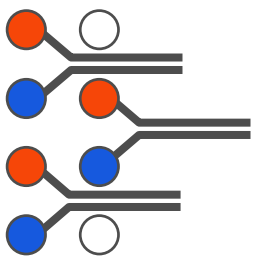
Tighter spacing ⇒ More coupling ⇒ Skinnier Traces
⇒ More resistance ⇒ Smaller signal

100-Ω differential pairs, $e_R = 4.3$

NEXT Crosstalk







b=24 mils.
h=6 mil
t=1/2-oz Cu
ε_R=4.3

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Via Crosstalk

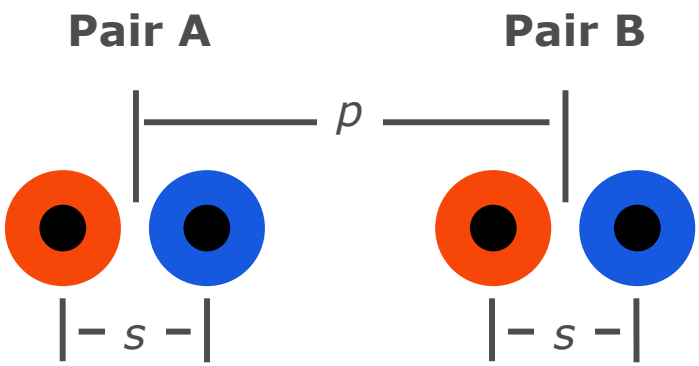
$$L_M = h \cdot 5.08 \cdot \ln\left(\frac{1}{1-(s/p)^2}\right) \text{ nH}$$

$$\frac{v_{\text{NOISE,P-P}}}{v_{\text{INPUT,P-P}}} = \frac{L_M}{Z_{\text{DIFF}}\, t_r}$$

Ex: $s = .060,\ p = .180,\ h = .180$ in. (via length)

$L_M = .108$ nH, $Z_{\text{DIFF}} = 100\ \Omega$

$t_r = 35$ ps



$$\frac{v_{\text{noise, p-p}}}{v_{\text{p-p}}} = .031$$

A problem in dense arrays of thick backplane vias

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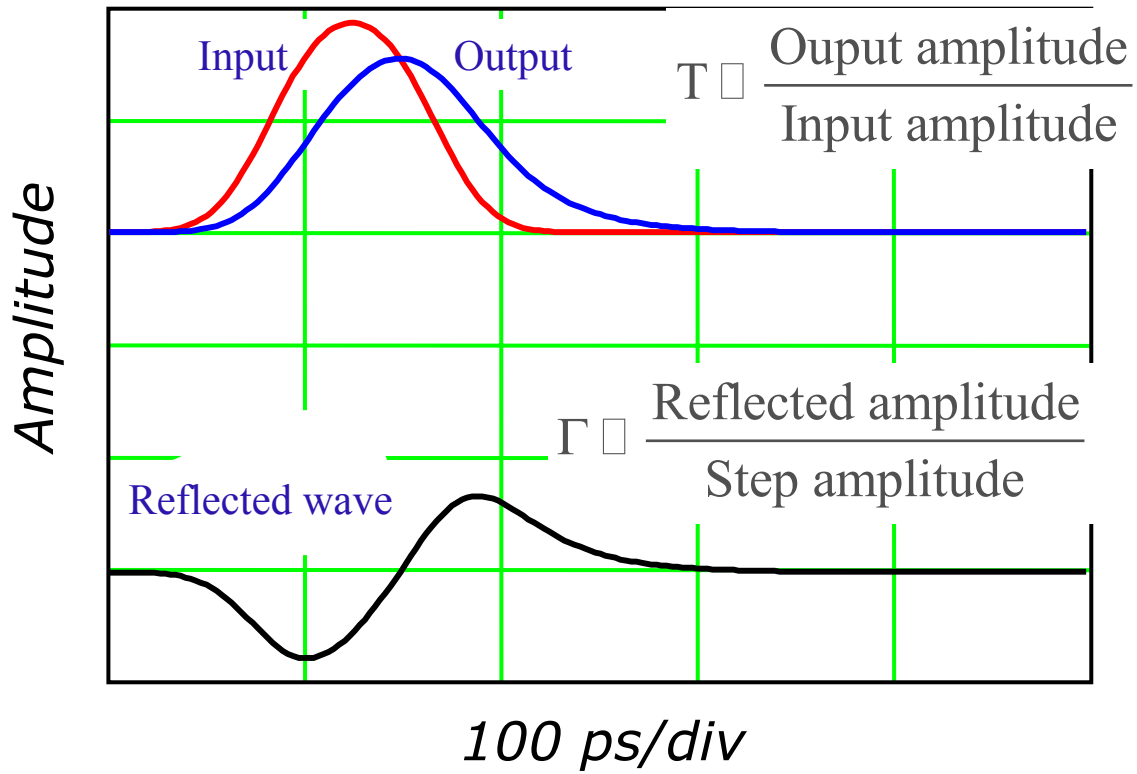
Excess Capacitance

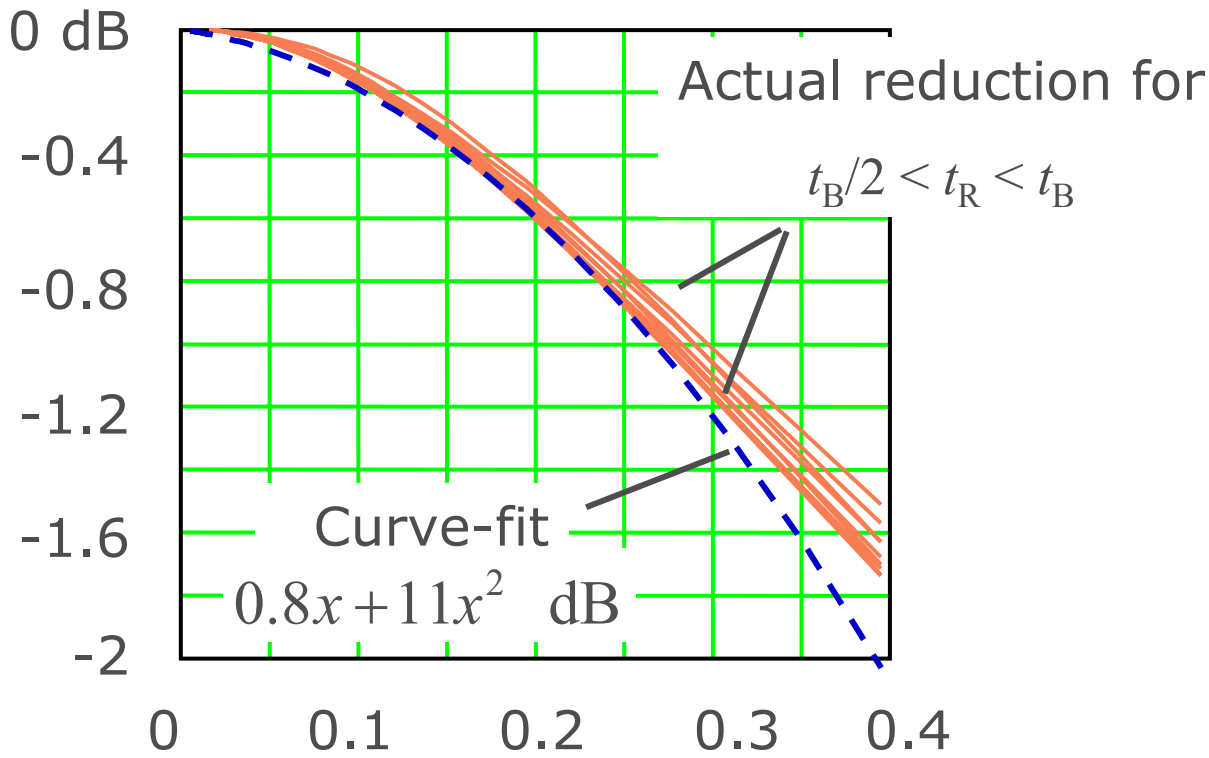


Ex: Z_0=50, C=1.5 pF, t_R=70 ps

Pulse Height Reduction

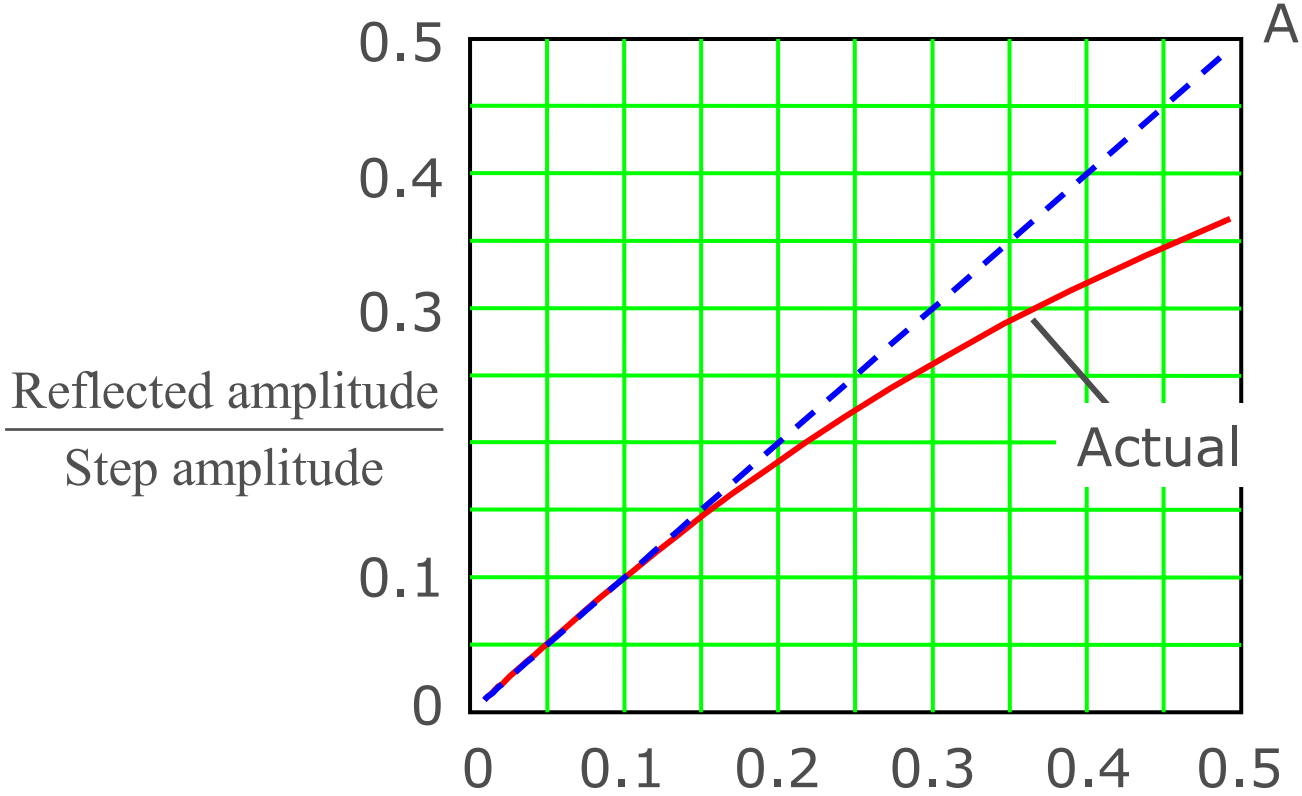
$$\frac{\text{Ouput amplitude}}{\text{Input amplitude}}$$

(dB)



Leading indicator: $x \approx \frac{(1/2) Z_{ODD} C}{t_B}$

Reflection Coefficient

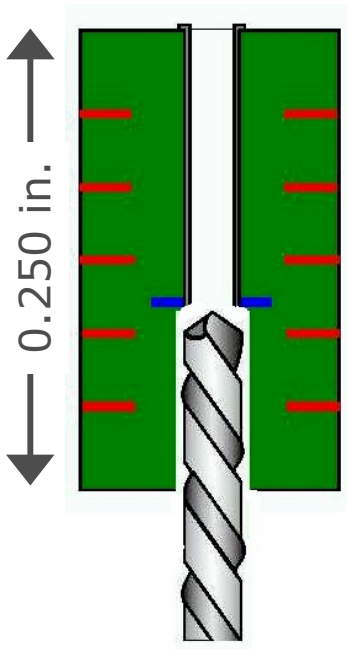


Approximation

$$\Gamma \approx \frac{(1/2) Z_{ODD} C}{t_R}$$

Leading indicator: $r \approx \frac{(1/2) Z_{ODD} C}{t_R}$

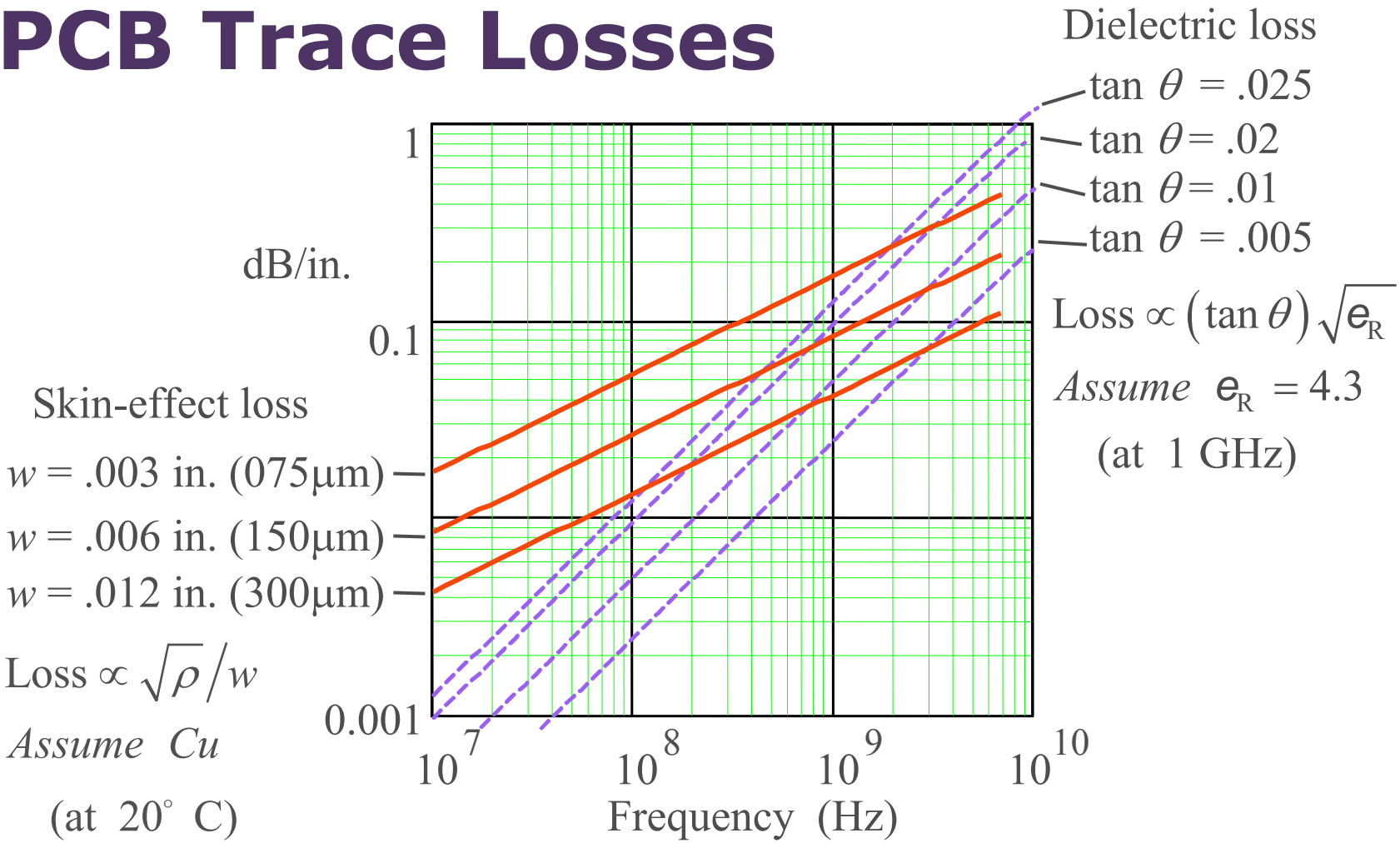
Backdrilling



Drilled hole dia., mil	Plated hole dia., mil	Clearance dia., mil	Pad dia., mil	PTH length, mil	Via capacitance pF
26	22	52	38	100	1.0
26	22	52	38	125	1.3
26	22	52	38	150	1.5
26	22	52	38	225	1.8
26	22	52	38	200	2.0
26	22	52	38	250	2.4
NOTE—(*The data in this table were adapted from Teradyne)*					

In this very thick board the via capacitance scales almost linearly with via length.

PCB Trace Losses



This chart estimates dielectric and skin effect losses for 100-ohm differential striplines

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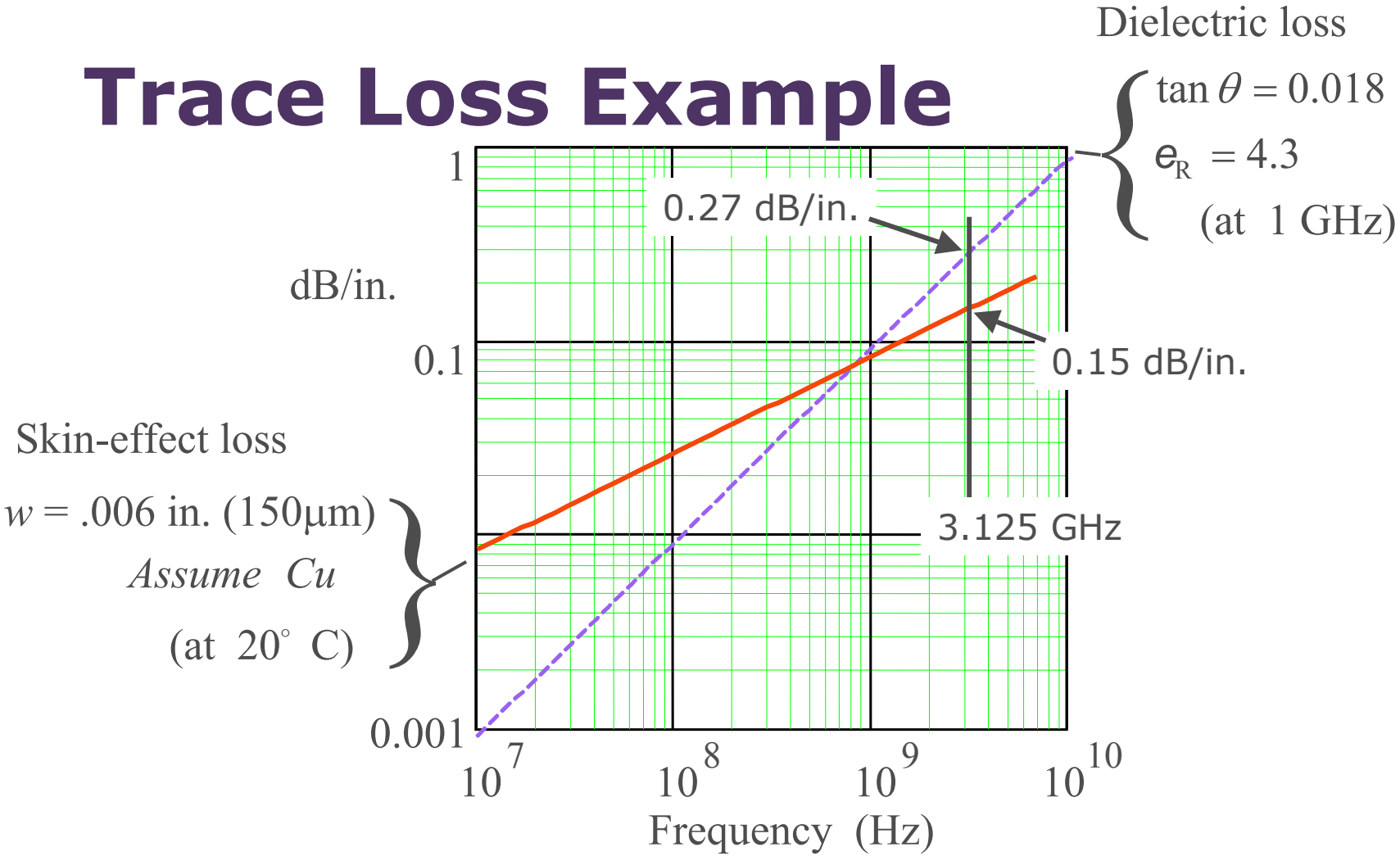
Trace Loss Example



Total trace loss at 3.125 GHz is 0.42 dB/in.
at 26 inches ⇒ 11.5 dB

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Improvements