Board Parameters

All units in mils

```
In[52]:= Boardthickness = 125; (* mil *)
         Copper = 3;           (* oz/sq inch; 1 oz = 1.4 mil *)
         Corethickness = 42.5 - 2 * Copper * 1.4 ;   (* mil *)
         Prepregthickness = 37.4;   (* mil *)
         Er = 4.7;             (* dielectric constant*)
         Layers = 4 ;          (* top: signal; middle1 & bottom: ground; middle2: RF *)
         rule = {planethickness → Prepregthickness,
           planeplane → Corethickness + Prepregthickness + traceheight,
           corethickness → Corethickness, prepregthickness → Prepregthickness,
           boardthickness → Boardthickness, er → Er,
           layers → Layers, copper → Copper, traceheight → copper * 1.4};
```

Microline

$$\text{In[11]:= } \texttt{Zm[w\_] :=} \frac{87}{\sqrt{\texttt{er} + 1.41}} \texttt{Log}\left[\frac{5.98\,\texttt{planethickness}}{0.8\,\texttt{w} + \texttt{traceheight}}\right]$$

$$\text{In[12]:= } \texttt{Speedm :=} \frac{1}{12}\, 1.017 \sqrt{0.475\,\texttt{er} + 0.67} \quad \texttt{(* in ns/inch *)}$$

```
In[13]:= Zm[27] //. rule
```

```
Out[13]= 76.0143
```

```
In[14]:= Solve[Zm[w] == Z0, w] // Simplify
         % /. Z0 → 50 //. rule
```

$$\text{Out[14]= } \left\{\left\{\texttt{w} \to 7.475\, e^{-0.0114943 \sqrt{1.41 + 1.\,\texttt{er}}\ \texttt{Z0}}\ \texttt{planethickness} - 1.25\ \texttt{traceheight}\right\}\right\}$$

```
Out[15]= {{w → 62.2843}}
```

```
In[16]:= Speedm //. rule
```

```
Out[16]= 0.144386
```

Stripline

$$\text{In[38]:= } \texttt{Z[w\_] :=} \frac{60}{\sqrt{\texttt{er}}} \texttt{Log}\left[\frac{4\,\texttt{planeplane}}{0.67\,\pi\,\texttt{w}\,(0.8 + \texttt{traceheight}/\texttt{w})}\right]$$

$$\text{In[39]:= } \texttt{Speed :=}\ 1/12\ 1.017 \sqrt{\texttt{Er}} \quad \texttt{(* in ns/inch *)}$$

In[40]:=
```
Z[38] //. rule // N
```

Out[40]=
```
39.4373
```

In[41]:=
```
Solve[Z[w] == Z0, w] // Simplify
% /. Z0 → 50 //. rule
```

Out[41]=
$$\left\{\left\{w \to 2.37545\, e^{-0.0166667\, \sqrt{er}\ Z0}\ \text{planeplane} - 1.25\ \text{traceheight}\right\}\right\}$$

Out[42]=
```
{{w → 24.278}}
```

In[43]:=
```
Speed //. rule          (* ns/inch *)
Table[2^i, {i, -4, 4}]
tracelen = 1/Speed Table[2^i, {i, -4, 4}] //. rule (* trace length in inch *)
```

Out[43]=
```
0.183734
```

Out[44]=
$$\left\{\frac{1}{16}, \frac{1}{8}, \frac{1}{4}, \frac{1}{2}, 1, 2, 4, 8, 16\right\}$$

Out[45]=
```
{0.340166, 0.680333, 1.36067, 2.72133, 5.44266, 10.8853, 21.7706, 43.5413, 87.0826}
```

In[46]:=
$$\frac{\text{tracelen} - 0.1\,\pi}{2}$$

Out[46]=
```
{0.0130036, 0.183087, 0.523253, 1.20359, 2.56425, 5.28558, 10.7282, 21.6136, 43.3842}
```

Asymmetric Stripline

In[48]:=
$$\text{Za}[w\_] := \frac{80}{\sqrt{er}}\ \text{Log}\left[\frac{1.9\ (2 * \text{corethickness} + \text{traceheight})}{0.8\ w + \text{traceheight}}\right]\left(1 - \frac{\text{corethickness}}{4\ \text{prepregthickness}}\right)$$

In[50]:=
$$\text{Speeda} := \frac{1}{12}\ 1.016\ \sqrt{Er}\quad (* \text{ in ns/inch } *)$$

In[66]:=
```
Za[24.5] //. rule // N
```

Out[66]=
```
49.982
```

In[56]:=
```
Solve[Za[w] == Z0, w] // Simplify
% /. Z0 → 50 //. rule
```

Out[56]=
$$\left\{\left\{w \to 0.125\, e^{\frac{\sqrt{er}\ \text{prepregthickness}\ Z0}{20.\ \text{corethickness} - 80.\ \text{prepregthickness}}}\left(38.\ \text{corethickness} + \left(19. - 10.\, e^{-\frac{1.\ \sqrt{er}\ \text{prepregthickness}\ Z0}{20.\ \text{corethickness} - 80.\ \text{prepregthickness}}}\right)\ \text{traceheight}\right)\right\}\right\}$$

Out[57]=
```
{{w → 24.4812}}
```

In[62]:=
```
Speeda //. rule          (* ns/inch *)
Table[2^i, {i, -4, 4}]
tracelen = 1/Speeda Table[2^i, {i, -4, 4}] //. rule (* trace length in inch *)
```

Out[62]= 0.183553

Out[63]= $\left\{\frac{1}{16}, \frac{1}{8}, \frac{1}{4}, \frac{1}{2}, 1, 2, 4, 8, 16\right\}$

Out[64]= {0.340501, 0.681002, 1.362, 2.72401, 5.44802, 10.896, 21.7921, 43.5842, 87.1683}

In[65]:=
```
(tracelen - 0.1 π)/2
```

Out[65]= {0.013171, 0.183422, 0.523923, 1.20493, 2.56693, 5.29094, 10.739, 21.635, 43.4271}

Trace Lengths

$\frac{1}{16}$ ns

```
l[1] = -200 +
  2 * (4213 - 4100) +
  100. π
```

340.159

$\frac{1}{8}$ ns

```
l[2] = -200 +
  2 * (4483 - 4200) +
  100. π
```

680.159

$\frac{1}{4}$ ns

```
l[3] = -200 +
  2 * (4923 - 4300) +
  100. π
```

1360.16

$\frac{1}{2}$ns

```
l[4] = -200 +
  2 * (5703 - 4400) +
  100. π
```

```
2720.16
```

1ns

```
l[5] = -200 +
  2 * (7164 - 4500) +
  100. π
```

```
5442.16
```

2ns

```
l[6] = -200 +
  2 * (9986 - 4600) +
  100. π
```

```
10886.2
```

4ns

```
l[7] = -200 +
  2 * (10700 - 4700) +
  100 π +
  300 π +
  2 * (7200 - 6000) +
  2 * (10700 - 7700) +
  100. π
```

```
21770.8
```

8ns

```
l[8] = -200 +
  2 * (11300 - 4800) +
  100 π +
  300 π +
  2 * (8000 - 5200) +
  2 * (11300 - 6500) +
  100 π +
  300 π +
  2 * (4800 - 4400) +
  2 * (11300 - 6500) +
  100 π / 2 +
  300 π / 2 +
  2 * (4000 - 3157) +
  100. π
```

```
43541.8
```

16ns

```
l[9] = -200 +
  (11800 - 4900) +
  5 * (2 * 100 π + 2 * (8800 - 2400)) +
  (2 * 100 π + 1 * (8800 - 7144)) +
  (9000 - 7144) +
  (14000 - 4900) +
  0.
```

```
87081.9
```

Error (in mils)

```
1000 tracelen - ( l[#] & /@ Range[9])
```

```
{0.00710928, 0.173484, 0.506233, 1.17173,
 0.502729, -0.835277, -0.14835, -0.455965, 0.680724}
```