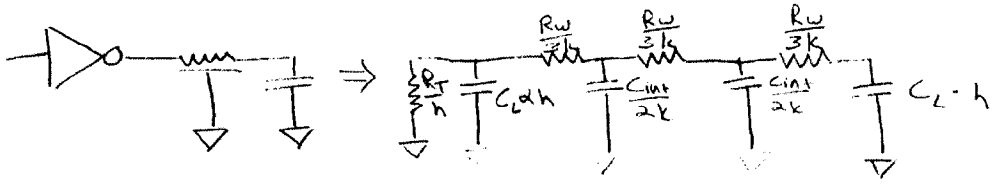
1) Unit Circuit Model



unit detail δ: $\frac{R_T}{h} \cdot C_L \alpha h + \frac{C_{int}}{2k}\left(\frac{R_w}{3k} + \frac{R_T}{h}\right) + \frac{C_{int}}{2k}\left(\frac{2R_w}{3k} + \frac{R_T}{h}\right) + C_L \cdot h \cdot \frac{R_w}{k}$

Elmore

$= \frac{R_T}{h}\left(C_L \alpha h + \frac{C_{int}}{k} + C_L \cdot h\right) + \frac{C_{int}}{k}\left(\frac{R_w}{2k}\right) + C_L \cdot h \cdot \frac{R_w}{k}$

$= R_T C_L \alpha + \frac{R_T C_{int}}{hk} + R_T C_L + \frac{C_{int} R_w}{2k^2} + \frac{C_L R_w h}{k}$

Total delay $T_{50\%} = k \ln 2 = 0.69\left(R_T C_L \alpha k + \frac{R_T C_{int}}{h} + R_T C_L k + \frac{C_{int} R_w}{2k} + C_L R_w h\right)$

Set Partials = 0

$\frac{dT}{dk} = 0$: $R_T C_L \alpha + R_T C_L - \frac{C_{int} R_w}{2k^2} = 0$

$k = \sqrt{\frac{C_{int} R_w}{2(R_T C_L \alpha + R_T C_L)}}$

$\frac{dT}{dh} = 0$: $C_L R_w - \frac{R_T C_{int}}{h^2} = 0$

$h = \sqrt{\frac{R_T C_{int}}{C_L R_w}}$

$T = 0.69\left(R_T C_L \alpha \sqrt{\frac{C_{int} R_w}{2(R_T C_L \alpha + R_T C_L)}} + \frac{R_T C_{int}}{\sqrt{\frac{R_T C_{int}}{C_L R_w}}} + R_T C_L \sqrt{\frac{C_{int} R_w}{2(R_T C_L \alpha + R_T C_L)}} + C_L R_w \sqrt{\frac{R_T C_{int}}{C_L R_w}}\right)$

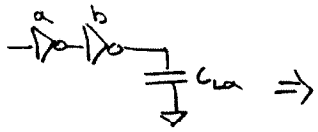
$= 0.69\left[(\alpha+1)\sqrt{\frac{R_T C_L C_{int} R_w}{2(\alpha+1)}} + 2\sqrt{R_T C_{int} C_L R_w} + \sqrt{C_{int} R_w R_T C_L (\alpha+1)}\right]$

$= 0.69\left[\sqrt{R_T C_L C_{int} R_w}\left(\frac{\alpha+1}{\sqrt{2(\alpha+1)}} + 2 + \sqrt{\alpha+1}\right)\right]$

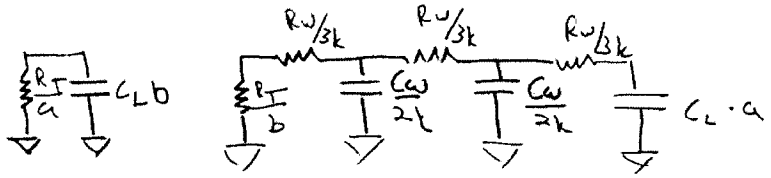
$= 0.69\sqrt{R_T C_L C_{int} R_w}\left[2 + 2\sqrt{\frac{\alpha+1}{2}}\right]$

Note: [illegible] assume $C_{int} = C_L$

2) Unit Circuit



$\Rightarrow$ Unit Model w/o output capacitances



$$S = \frac{R_T}{a} \cdot C_L \cdot b + \frac{C_w}{2k}\left(\frac{R_w}{3k} + \frac{R_T}{b}\right) + \frac{C_w}{2k}\left(\frac{2R_w}{3k} + \frac{R_T}{b}\right) + C_L \cdot a\left(\frac{R_w}{k} + \frac{R_T}{b}\right)$$

$$= R_T \cdot C_L \cdot \frac{b}{a} + \frac{C_w}{2k}\left(\frac{R_w}{k} + \frac{2R_T}{b}\right) + C_L \cdot a\left(\frac{R_w}{k} + \frac{R_T}{b}\right)$$

$$S = R_T C_L\left(\frac{b}{a} + \frac{a}{b}\right) + \frac{C_w R_w}{2k^2} + \frac{C_w}{2k}\frac{2R_T}{b} + \frac{C_L a R_w}{k}$$

Total Delay $= \ln(2) \cdot k \cdot S$

$$= \ln 2 \left(R_T C_L k\left(\frac{b}{a} + \frac{a}{b}\right) + \frac{C_w R_w}{2k} + \frac{C_L \cdot R_T}{b} + C_L a R_w\right)$$

Set partials to zero:

$$\frac{d}{da} = 0 \;:\; R_T C_L k\left(\frac{1}{b} - \frac{b}{a^2}\right) + C_L R_w = 0$$

$$\frac{d}{db} = 0 \;:\; R_T C_L k\left(\frac{1}{a} - \frac{a}{b^2}\right) - \frac{C_w R_T}{b^2} = 0$$

$$\frac{d}{dk} = 0 \;:\; R_T C_L\left(\frac{b}{a} + \frac{a}{b}\right) - \frac{C_w R_w}{2k^2}$$

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In[45]:= Solve[{Rt * Cl * k * (1 / b - b / a^2) + Cl * Rw == 0,
  Rt * Cl * k * (1 / a - a / (b^2)) - Cw * Rt / (b^2) == 0,
  Rt * Cl * (b / a + a / b) - Rw * Cw / (2 * (k^2)) == 0}, {a, b, k}]
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Out[45]=

$$\left\{\left\{b \to \frac{1}{Cl\,Rt}\left(2\left(-\frac{2\,2^{3/4}\,Cw^6\,Rw^5}{Cl\left(Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2\right)^2\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}}-\right.\right.\right.$$

$$\left.\left.\left.\frac{2^{3/4}\,Cw^4\,Rw^3}{Cl\left(Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2\right)\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}}\right)\right),$$

$$a \to \frac{1}{Cl}\left(\frac{2^{1/4}\,Cw}{\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}+\frac{2\,2^{1/4}\,Cw^3\,Rw^2}{\left(Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2\right)\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}\right),$$

$$k \to -\frac{\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}{2\,2^{1/4}}\Big\},$$

$$\left\{b \to \frac{1}{Cl\,Rt}\left(2\left(-\frac{2\,i\,2^{3/4}\,Cw^6\,Rw^5}{Cl\left(Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2\right)^2\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}}-\right.\right.\right.$$

$$\left.\left.\left.\frac{i\,2^{3/4}\,Cw^4\,Rw^3}{Cl\left(Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2\right)\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}}\right)\right),$$

$$a \to \frac{1}{Cl}\left(-\frac{i\,2^{1/4}\,Cw}{\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}-\frac{2\,i\,2^{1/4}\,Cw^3\,Rw^2}{\left(Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2\right)\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}\right),$$

$$k \to -\frac{i\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}{2\,2^{1/4}}\Big\},$$

$$\left\{b \to \frac{1}{Cl\,Rt}\left(2\left(\frac{2\,i\,2^{3/4}\,Cw^6\,Rw^5}{Cl\left(Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2\right)^2\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}}+\right.\right.\right.$$

$$\left.\left.\left.\frac{i\,2^{3/4}\,Cw^4\,Rw^3}{Cl\left(Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2\right)\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}}\right)\right),$$

$$a \to \frac{1}{Cl}\left(\frac{i\,2^{1/4}\,Cw}{\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}+\frac{2\,i\,2^{1/4}\,Cw^3\,Rw^2}{\left(Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2\right)\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}\right),$$

$$k \to \frac{i\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}{2\,2^{1/4}}\Big\},$$

$$\left\{b \to \frac{1}{Cl\,Rt}\left(2\left(\frac{2\,2^{3/4}\,Cw^6\,Rw^5}{Cl\left(Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2\right)^2\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}}+\right.\right.\right.$$

$$\left.\left.\left.\frac{2^{3/4}\,Cw^4\,Rw^3}{Cl\left(Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2\right)\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}}\right)\right),$$

$$a \to \frac{1}{Cl}\left(-\frac{2^{1/4}\,Cw}{\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}-\frac{2\,2^{1/4}\,Cw^3\,Rw^2}{\left(Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2\right)\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}\right),$$

$$k \to \frac{\left(\frac{-Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}{2\,2^{1/4}}\Big\},$$

$$\left\{b \to \frac{1}{Cl\,Rt}\left(2\left(-\frac{2\,2^{3/4}\,Cw^6\,Rw^5}{Cl\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}\left(Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2\right)^2}-\right.\right.\right.$$

$$\left.\left.\left.\frac{2^{3/4}\,Cw^4\,Rw^3}{Cl\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}\left(Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2\right)}\right)\right),$$

$$a \to \frac{1}{Cl}\left(\frac{2^{1/4}\,Cw}{\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}+\frac{2\,2^{1/4}\,Cw^3\,Rw^2}{\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}\left(Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2\right)}\right),$$

$$k \to -\frac{\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}{2\,2^{1/4}}\Big\},$$

$$\left\{b \to \frac{1}{Cl\,Rt}\left(2\left(-\frac{2\,i\,2^{3/4}\,Cw^6\,Rw^5}{Cl\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}\left(Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2\right)^2}-\right.\right.\right.$$

$$\left.\left.\left.\frac{i\,2^{3/4}\,Cw^4\,Rw^3}{Cl\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}\left(Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2\right)}\right)\right),$$

$$a \to \frac{1}{Cl}\left(-\frac{i\,2^{1/4}\,Cw}{\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}-\frac{2\,i\,2^{1/4}\,Cw^3\,Rw^2}{\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}\left(Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2\right)}\right),$$

$$k \to -\frac{i\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}{2\,2^{1/4}}\Big\},$$

$$\left\{b \to \frac{1}{Cl\,Rt}\left(2\left(\frac{2\,i\,2^{3/4}\,Cw^6\,Rw^5}{Cl\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}\left(Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2\right)^2}+\right.\right.\right.$$

$$\left.\left.\left.\frac{i\,2^{3/4}\,Cw^4\,Rw^3}{Cl\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}\left(Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2\right)}\right)\right),$$

$$a \to \frac{1}{Cl}\left(\frac{i\,2^{1/4}\,Cw}{\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}+\frac{2\,i\,2^{1/4}\,Cw^3\,Rw^2}{\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}\left(Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2\right)}\right),$$

$$k \to \frac{i\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}{2\,2^{1/4}}\Big\},$$

$$\left\{b \to \frac{1}{Cl\,Rt}\left(2\left(\frac{2\,2^{3/4}\,Cw^6\,Rw^5}{Cl\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}\left(Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2\right)^2}+\right.\right.\right.$$

$$\left.\left.\left.\frac{2^{3/4}\,Cw^4\,Rw^3}{Cl\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{3/4}\left(Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2\right)}\right)\right),$$

$$a \to \frac{1}{Cl}\left(-\frac{2^{1/4}\,Cw}{\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}-\frac{2\,2^{1/4}\,Cw^3\,Rw^2}{\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}\left(Cw^2\,Rw^2+\sqrt{5}\,Cw^2\,Rw^2\right)}\right),$$

$$k \to -\frac{\left(\frac{-Cw^2\,Rw^2-\sqrt{5}\,Cw^2\,Rw^2}{Cl^2\,Rt^2}\right)^{1/4}}{2\,2^{1/4}}\Big\}\Big\}$$

In[46]:= **Simplify[%]**

Out[46]=

$$\left\{\left\{b \to -\frac{\left(\frac{2}{-1+\sqrt{5}}\right)^{3/4} Rt \left(\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}}{Rw},\ a \to \frac{2^{1/4}\left(-3+\sqrt{5}\right) Cw}{\left(-1+\sqrt{5}\right)^{5/4} Cl \left(\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}},\right.\right.$$

$$k \to -\frac{1}{2}\left(\frac{1}{2}\left(-1+\sqrt{5}\right)\right)^{1/4}\left(\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}\Big\},\ \Big\{b \to -\frac{i\left(\frac{2}{-1+\sqrt{5}}\right)^{3/4} Rt \left(\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}}{Rw},$$

$$a \to -\frac{i\, 2^{1/4}\left(-3+\sqrt{5}\right) Cw}{\left(-1+\sqrt{5}\right)^{5/4} Cl \left(\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}},\ k \to -\frac{1}{2} i \left(\frac{1}{2}\left(-1+\sqrt{5}\right)\right)^{1/4}\left(\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}\Big\},$$

$$\left\{b \to \frac{i\left(\frac{2}{-1+\sqrt{5}}\right)^{3/4} Rt \left(\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}}{Rw},\ a \to \frac{i\, 2^{1/4}\left(-3+\sqrt{5}\right) Cw}{\left(-1+\sqrt{5}\right)^{5/4} Cl \left(\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}},\right.$$

$$k \to \frac{1}{2} i \left(\frac{1}{2}\left(-1+\sqrt{5}\right)\right)^{1/4}\left(\frac{Cw^2\, Rw^2}{Cl^2\, Rt^3}\right)^{1/4}\Big\},\ \Big\{b \to \frac{\left(\frac{2}{-1+\sqrt{5}}\right)^{3/4} Rt \left(\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}}{Rw},$$

Only Real value & Solution

$$a \to -\frac{2^{1/4}\left(-3+\sqrt{5}\right) Cw}{\left(-1+\sqrt{5}\right)^{5/4} Cl \left(\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}},\ k \to \frac{1}{2}\left(\frac{1}{2}\left(-1+\sqrt{5}\right)\right)^{1/4}\left(\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}\Big\},$$

$$\left\{b \to \frac{\left(\frac{2}{1+\sqrt{5}}\right)^{3/4} Rt \left(-\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}}{Rw},\ a \to \frac{2^{1/4}\left(3+\sqrt{5}\right) Cw}{\left(1+\sqrt{5}\right)^{5/4} Cl \left(-\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}},\right.$$

$$k \to -\frac{1}{2}\left(\frac{1}{2}\left(1+\sqrt{5}\right)\right)^{1/4}\left(-\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}\Big\},\ \Big\{b \to \frac{i\left(\frac{2}{1+\sqrt{5}}\right)^{3/4} Rt \left(-\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}}{Rw},$$

$$a \to -\frac{i\, 2^{1/4}\left(3+\sqrt{5}\right) Cw}{\left(1+\sqrt{5}\right)^{5/4} Cl \left(-\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}},\ k \to -\frac{1}{2} i \left(\frac{1}{2}\left(1+\sqrt{5}\right)\right)^{1/4}\left(-\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}\Big\},$$

$$\left\{b \to -\frac{i\left(\frac{2}{1+\sqrt{5}}\right)^{3/4} Rt \left(-\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}}{Rw},\ a \to \frac{i\, 2^{1/4}\left(3+\sqrt{5}\right) Cw}{\left(1+\sqrt{5}\right)^{5/4} Cl \left(-\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}},\right.$$

$$k \to \frac{1}{2} i \left(\frac{1}{2}\left(1+\sqrt{5}\right)\right)^{1/4}\left(-\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}\Big\},\ \Big\{b \to -\frac{\left(\frac{2}{1+\sqrt{5}}\right)^{3/4} Rt \left(-\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}}{Rw},$$

$$\left.a \to -\frac{2^{1/4}\left(3+\sqrt{5}\right) Cw}{\left(1+\sqrt{5}\right)^{5/4} Cl \left(-\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}},\ k \to \frac{1}{2}\left(\frac{1}{2}\left(1+\sqrt{5}\right)\right)^{1/4}\left(-\frac{Cw^2\, Rw^2}{Cl^2\, Rt^2}\right)^{1/4}\Big\}\right\}$$

3a) $h = 400$ nm $\quad \epsilon_r = 2.8$

$s = 500$ nm

$$C = \frac{\varepsilon W}{s} + \frac{2\pi\varepsilon}{\log s/w}$$

$$Z_0 = \frac{\sqrt{\varepsilon\mu}}{C}$$

$$\frac{\varepsilon W}{s} + \frac{2\pi\varepsilon}{\log \frac{s}{w}} = \frac{\sqrt{\varepsilon\mu}}{Z_0}$$

$$W = \frac{s}{\varepsilon}\left(\frac{\sqrt{\varepsilon\mu}}{Z_0} - \frac{2\pi\varepsilon}{\log \frac{s}{w}}\right) \quad \cdots (1)$$

Solve numerically ----

$$R_{sc} = \frac{\rho}{W h}$$

$$\alpha = \frac{R_{sc}}{2 Z_0}$$

b) if number of empty layers is n.

$$s = (n+1) \times 500 + n \times 400$$

Solve for w with this n.

c)

$$R_{DC} = \frac{P}{wh} \quad \cdots (1)$$

$$C = \frac{\varepsilon w}{s} + \frac{2\pi\varepsilon}{\log(s/w)} \quad \cdots (2)$$

$$Z_0 = \frac{\sqrt{\varepsilon\mu}}{C} \quad \cdots (3)$$

$$\alpha = \frac{R_{DC}}{2Z_0} \Rightarrow Z_0 = \frac{2\alpha}{R_{DC}}$$

$$\Rightarrow R_{DC} = 2Z_0\alpha \quad \cdots (4)$$

~~$w = \frac{h R_{DC}}{\rho}$~~

From (1)

$$w = \frac{\rho}{h R_{DC}} = \frac{\rho}{2Z_0\alpha}$$

From 3

$$C = \frac{\sqrt{\varepsilon\mu}}{w Z_0}$$

Putting in (2)

$$\frac{\sqrt{\varepsilon\mu}}{Z_0} = \frac{\varepsilon w}{s} + \frac{2\pi\varepsilon}{\log(s/w)}$$

$$\frac{\varepsilon w}{s} = \frac{2\pi\varepsilon}{\log(s/w)} - \frac{\sqrt{\varepsilon\mu}}{Z_0}$$

$$s = \frac{\varepsilon w}{\frac{2\pi\varepsilon}{\log(s/w)} - \frac{\sqrt{\varepsilon\mu}}{Z_0}}$$

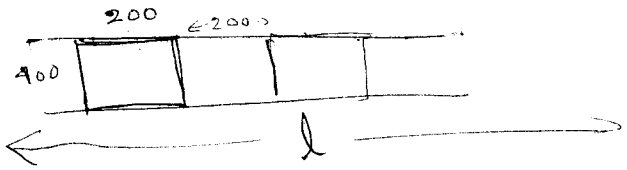
Solve numerically for s

$$s = (n+1) \times 500 + n \times 900$$

$$s = 900n + 500$$

no of empty layers. $\leftarrow n = \frac{s - 500}{900}$

Let m be the no of running tracks



$$l = w + 25$$

$$m = \frac{l}{400}$$

```
w_new=s/epsi * sqrt(epsi * mu)/Z0

do
{
w=w_new
w_new= s/epsi *(   sqrt(epsi * mu)/Z0 - 2*pi*epsi/log(s/w))
vdiff= w_new - w;
}
while(check(vdiff));



int check(long double vdiff)
        {

        if(absolute(vdiff)>=1e-10)
          return 1;
        return 0;
        }

long double absolute(long double ld)
{
        if(ld<0.0)
                return (-1*ld);
        else return (ld);
}
```