Activity: Integrated Resistors

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I. Calculations

For any integrated resistor with a nominal temperature T_{ref} and temperature coefficient α, the temperature dependence is modeled by

$$R = R_{ref}[1 + \alpha(T - T_{ref})]$$

where R_{ref} is the resistance at $T = T_{ref}$.

Suppose R_{n+} is an n^+ polysilicon resistor with the following parameters:

- $R_{shn} = 100\Omega/\square$
- $T_C = -800ppm/^oC$ at $T_{NOM} = 27^oC$

similarly, R_{p+} is a p^+ polysilicon resistor with the following parameters:

- $R_{shp} = 180\Omega/\square$
- $T_C = 200ppm/^oC$ at $T_{NOM} = 27^oC$

The series resistance R_{tot} is equal to:

$$R_{tot} = R_{ref,n}[1+\alpha_n(T-T_{ref})] + R_{ref,p}[1+\alpha_p(T-T_{ref})]$$

For a temperature independent device, the CTAT and PTAT parameters must cancel each other. Since the resistors have the same widths,

$$\begin{aligned}
\alpha_n R_{ref,n}(T - T_{ref}) &= -\alpha_p R_{ref,p}(T - T_{ref}) \\
\alpha_n R_{ref,n} &= -\alpha_p R_{ref,p} \\
\frac{R_{ref,n}}{R_{ref,p}} &= \frac{-\alpha_p}{\alpha_n} \\
\frac{R_{sh,n} \cdot l_n}{R_{sh,p} \cdot l_p} &= \frac{-\alpha_p}{\alpha_n} \\
\frac{l_n}{l_p} &= \frac{-\alpha_p R_{sh,p}}{\alpha_n R_{sh,n}} = 0.45 \\
l_n &= 0.45 \cdot l_p
\end{aligned}$$

Substituting the lengths,

$$R_{sh,n}\frac{l_n}{w_n} + R_{sh,p}\frac{l_p}{w_p} = 1k\Omega$$

Since $w = 2\mu m$, $l_n = 4\mu m$ and $l_p \approx 8.8888\mu m$

II. Simulations

The resistance is obtained by measuring the current across a 1V DC source.

The plots are shown below

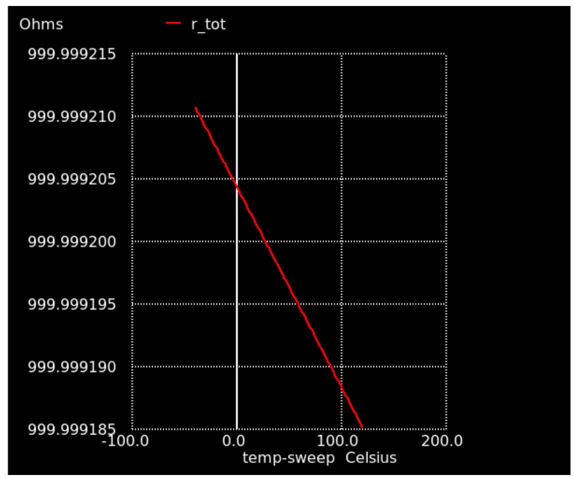

Fig. 1. TEMP SWEEP: -40^oC to 125^oC

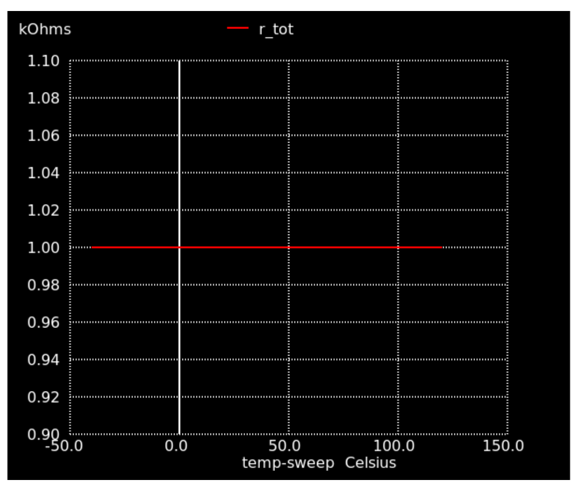

Fig. 2. A zoomed out Fig. 1

The resulting resistance is temperature independent, as expected.