**Example -** Let's examine a $p^+n$ junction in germanium at 300 K where $N_a = 10^{17}$ $cm^{-3}$ and $N_d = 2.5*10^{15}$ $cm^{-3}$.

$kB\_eV := 8.617333 \cdot 10^{-5}$ eV/K   $\varepsilon0 := 8.8541878 \cdot 10^{-12}$ F/m

$kB := 1.380649 \cdot 10^{-23}$ J/K   $qe := 1.602176634 \cdot 10^{-19}$ C

$T := 300$ K   $\varepsilon r\_Ge := 16$   $ni\_Ge := 2.4 \cdot 10^{19}$ $m^{-3}$

$Na := 10^{23}$ $m^{-3}$   $Nd := 2.5 \cdot 10^{21}$ $m^{-3}$   $\frac{Na}{Nd} = 40$

(7.10) $Vt := \frac{kB \cdot T}{qe}$   $Vt = 0.025852$ V

$Vbi := Vt \cdot \ln\left(\frac{Na \cdot Nd}{ni\_Ge^2}\right)$   $Vbi = 0.335581$ V

**Assume $V_R = 0$ V**

(7.29) $xp := \sqrt{\frac{2 \cdot \varepsilon r\_Ge \cdot \varepsilon0 \cdot Vbi}{qe} \cdot \left(\frac{Nd}{Na}\right) \cdot \frac{1}{Na + Nd}}$   $xp = 1.2031 \times 10^{-8}$ m

(7.28) $xn := \sqrt{\frac{2 \cdot \varepsilon r\_Ge \cdot \varepsilon0 \cdot Vbi}{qe} \cdot \left(\frac{Na}{Nd}\right) \cdot \frac{1}{Na + Nd}}$   $xn = 4.81239 \times 10^{-7}$ m

(7.46) $xn\_est := \sqrt{\frac{2 \cdot \varepsilon r\_Ge \cdot \varepsilon0 \cdot Vbi}{qe \cdot Nd}}$   $xn\_est = 4.87218 \times 10^{-7}$ m

$\frac{xn}{xp} = 40$   **yes, $x_n >> x_p$!**   $\frac{|xn - xn\_est|}{xn} \cdot 100 = 1.242$ %

(7.31) $W := \sqrt{\frac{2 \cdot \varepsilon r\_Ge \cdot \varepsilon0 \cdot Vbi}{qe} \cdot \left(\frac{Na + Nd}{Na \cdot Nd}\right)}$   $W = 4.9327 \times 10^{-7}$ m

(7.44) $W\_est := \sqrt{\frac{2 \cdot \varepsilon r\_Ge \cdot \varepsilon0 \cdot Vbi}{qe \cdot Nd}}$   $W\_est = 4.87218 \times 10^{-7}$ m

$\frac{|W - W\_est|}{W} \cdot 100 = 1.227$ %

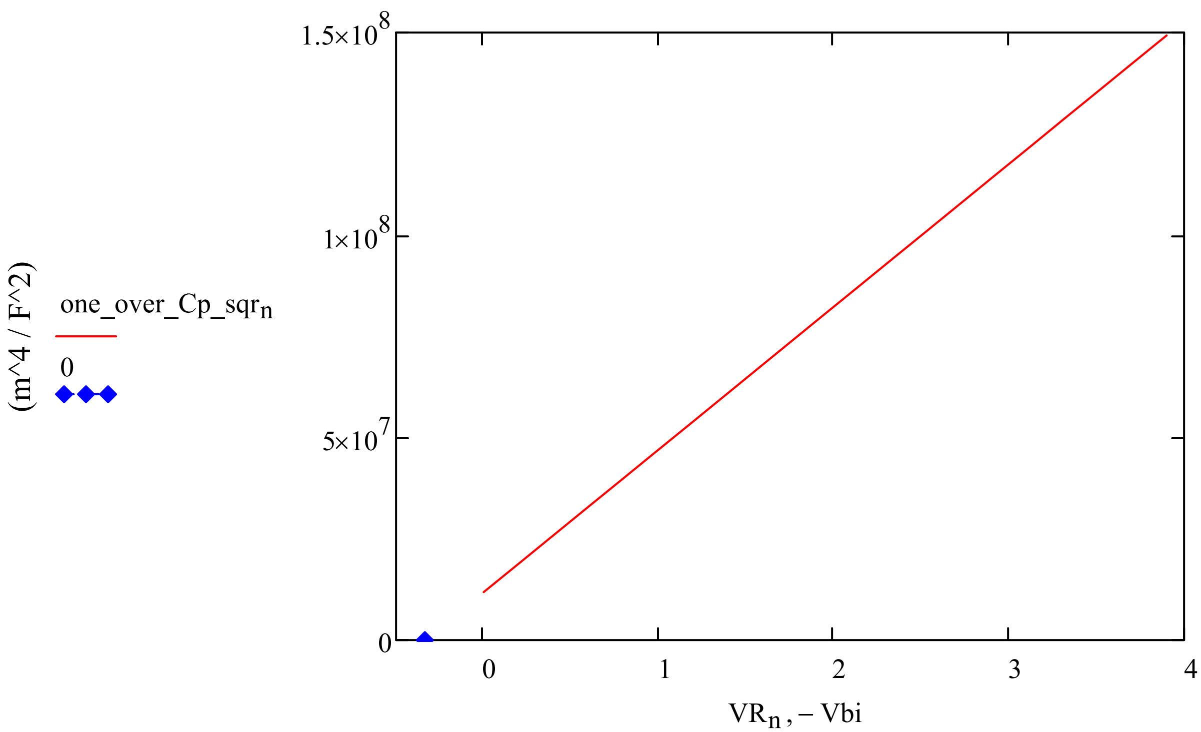
(7.42) $Cp := \frac{\varepsilon r\_Ge \cdot \varepsilon 0}{W}$ $\quad Cp = 2.872 \times 10^{-4}$ F/m$^2$

(7.47) $Cp\_est := \left[\frac{qe \cdot (\varepsilon r\_Ge \cdot \varepsilon 0) \cdot Nd}{2 \cdot Vbi}\right]^{0.5}$ $\quad Cp\_est = 2.9077 \times 10^{-4}$ F/m$^2$

$\frac{|Cp - Cp\_est|}{Cp} \cdot 100 = 1.242$ %

**Now, plot $(1/C')^2$ versus $V_R$**

$n := 0..20$ $\quad VR_n := \frac{n}{20} \cdot 3.9$ $\quad one\_over\_Cp\_sqr_n := \frac{2 \cdot (Vbi + VR_n)}{qe \cdot (\varepsilon r\_Ge \cdot \varepsilon 0) \cdot Nd}$




$-Vbi = -0.3356$ V