Diodes for Signal Processing

EE122

D. W. Parent

Diodes can be used for more than just rectification.

- Light emitting diodes
- Laser diodes
- Solar Cells
- Signal Processing

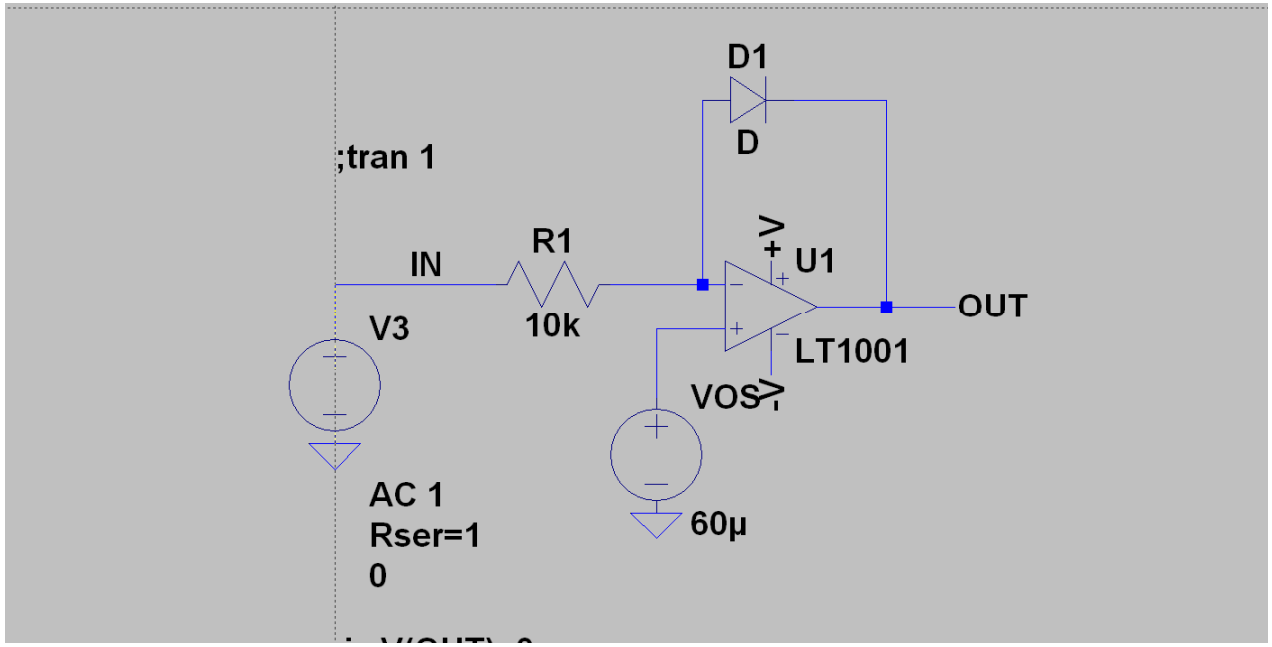
$$I = I_s \times (e^{\frac{V}{\eta V_T}} - 1)$$

This is a lot of floating point operations.
I count 17!

$$e^x = 1 + x + \frac{x^2}{2} + \frac{x^3}{6} + \frac{x^4}{24} .....$$

Log amplifier

$$V_{out} = -V_T \ln\left(\frac{V_{in}}{I_s R}\right)$$



There are 4 DC spice parameters for a diode

IS Saturation current (Given in Amps)
N Emission Coefficient (No Units)
RS Parasitic resistance (Given in Ω)
BV Breakdown Voltage (Given in Volts)
IBV Breakdown Current (Given in Amps)

GMIN is a small resistance
To prevent a value of zero current form Flowing. Usually set to 10^{-12}S

$$I_s := 1 \times 10^{-7}$$

$$n := 2$$

$$r_s := 100$$

$$V_t := .0259$$

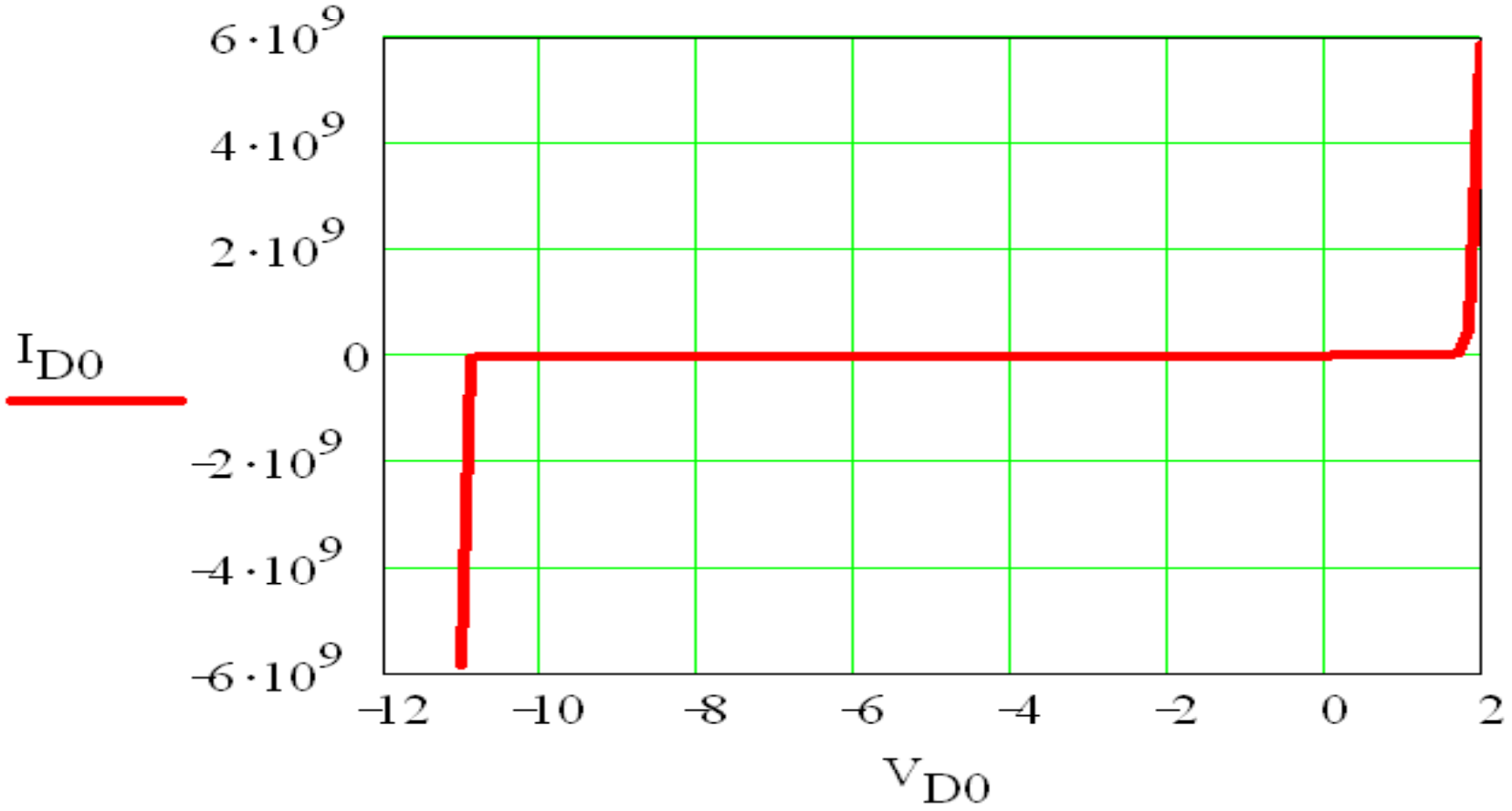
$$BV := 10$$

$$G_{min} := 1 \times 10^{-9}$$

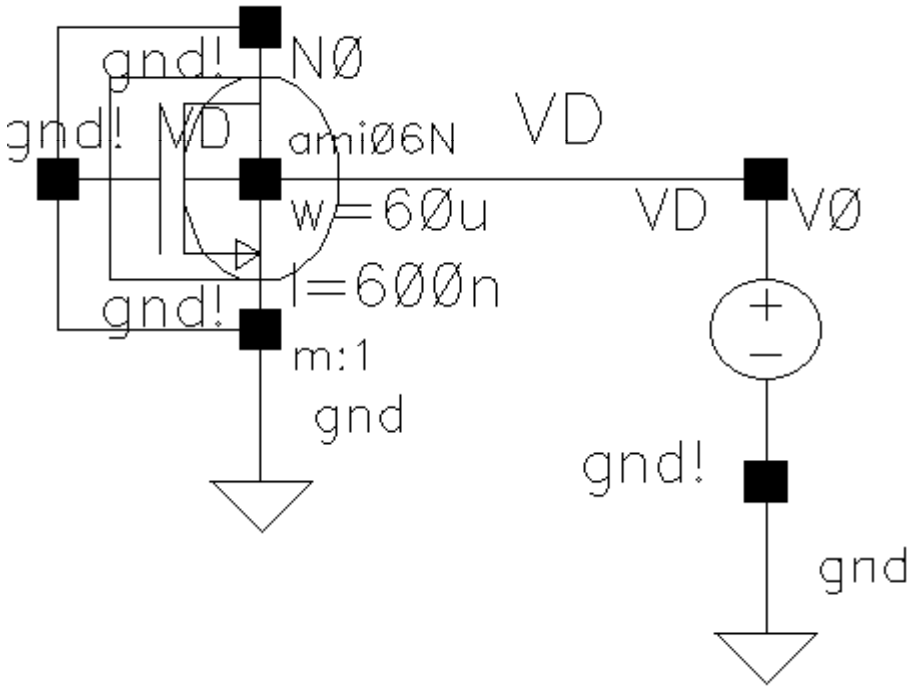
$$IBV := I_s \cdot \frac{BV}{V_t}$$

$$I_{D0_i} := \begin{cases} \left[I_s \cdot \left(e^{\frac{V_{D0_i}}{n \cdot V_t}} - 1 \right) + V_{D0_i} \cdot G_{min} \right] & \text{if } V_{D0_i} > -BV \\ (-IBV) & \text{if } V_{D0_i} = -BV \\ \left[-I_s \cdot \left[e^{\frac{-\left(BV + V_{D0_i}\right)}{V_t}} - 1 + \frac{BV}{V_t} \right] \right] & \text{if } V_{D0_i} < -BV \end{cases}$$

Full Diode Response

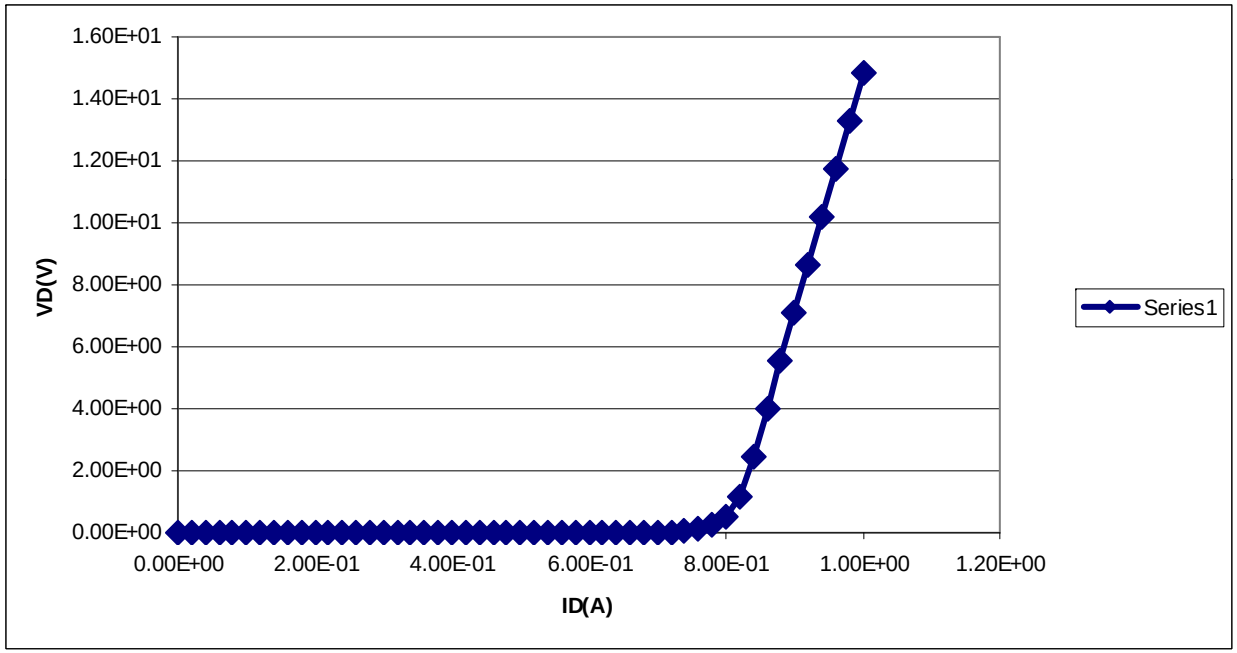


Test the diode of a NMOS

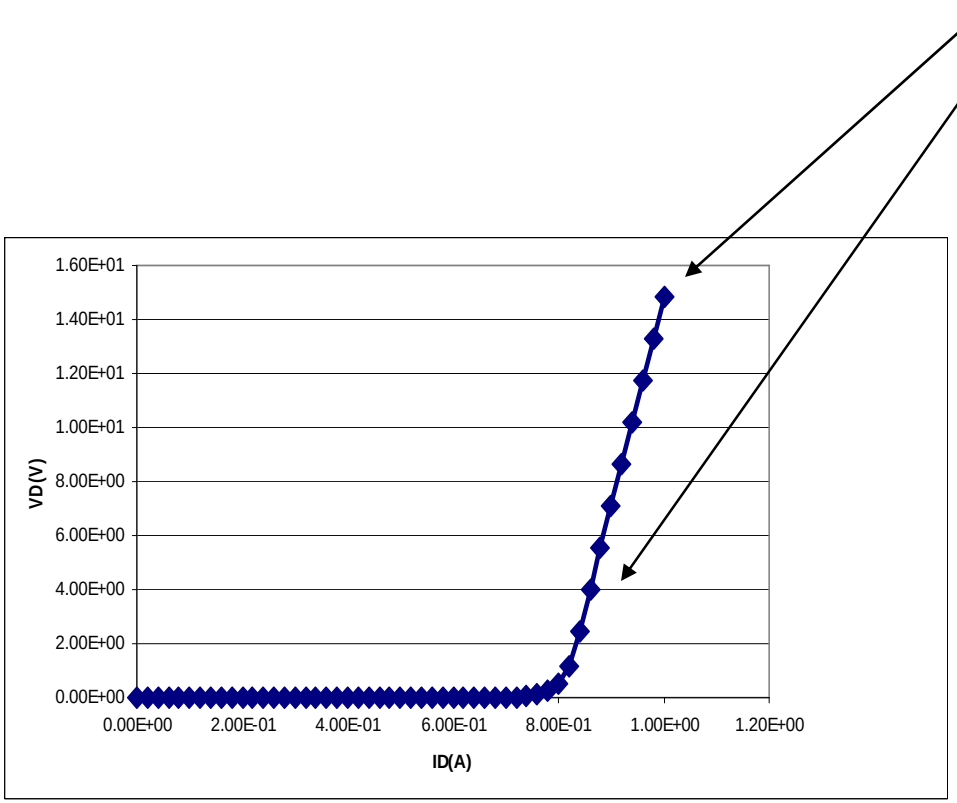


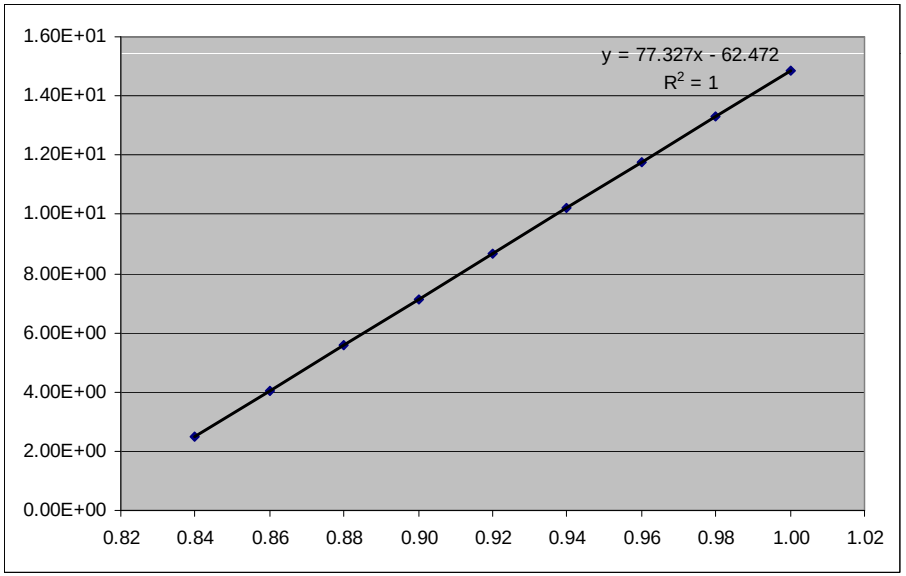
Note there are two diodes being tested.

Forward Bias Diode Linear

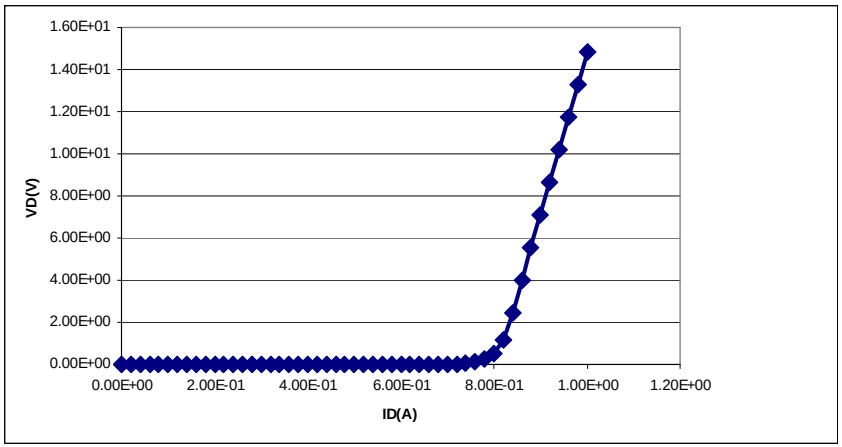


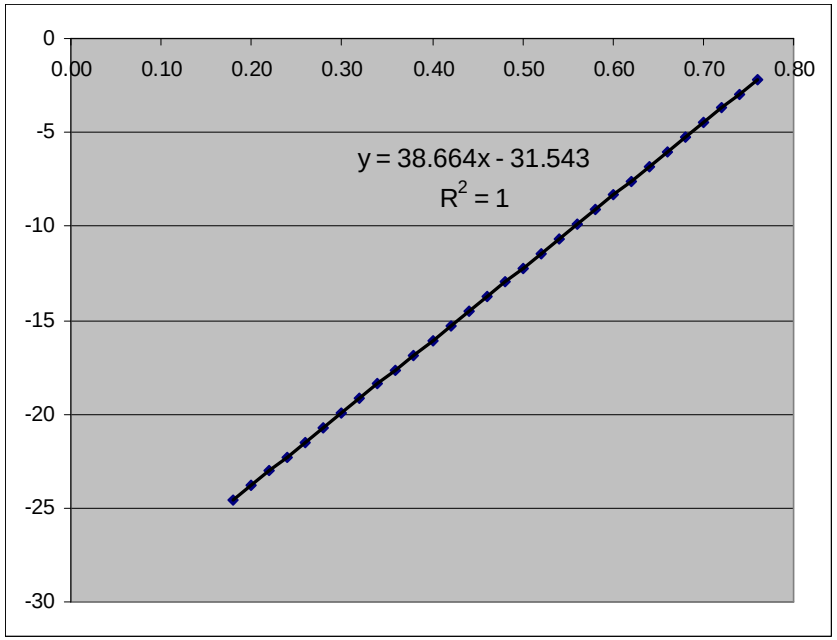
Take the RS value from the Linear part of the diode curve





Forward Bias Ln Scale (RS position omitted)



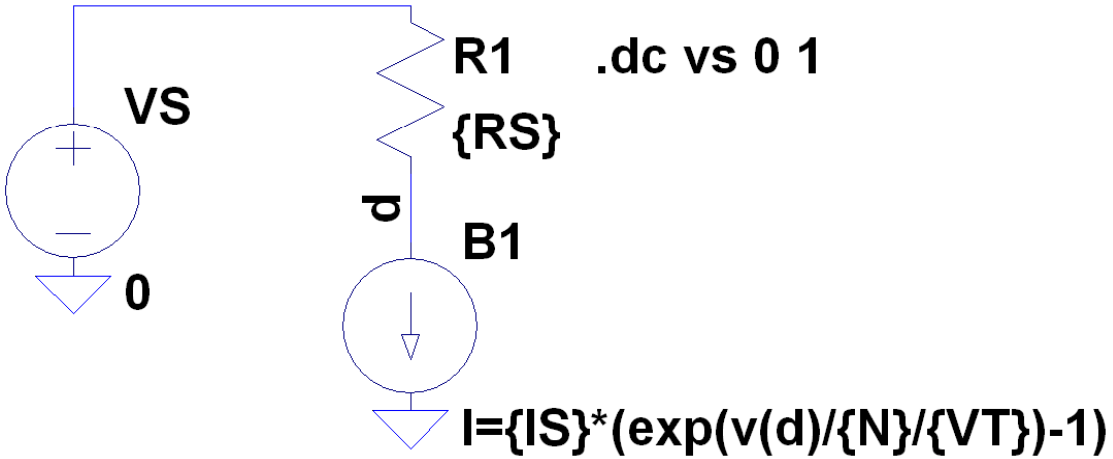


$$I_S := e^{-31.543} \qquad I_S = 2 \times 10^{-14}$$

$$n := \frac{1}{38.664 \cdot .0259} \qquad n = 0.999$$

Do not use linear
Region of Diode
Or too close to 0V.
The RS value and GMIN
Will skew the results.

Behavioral DC models are easy to create.

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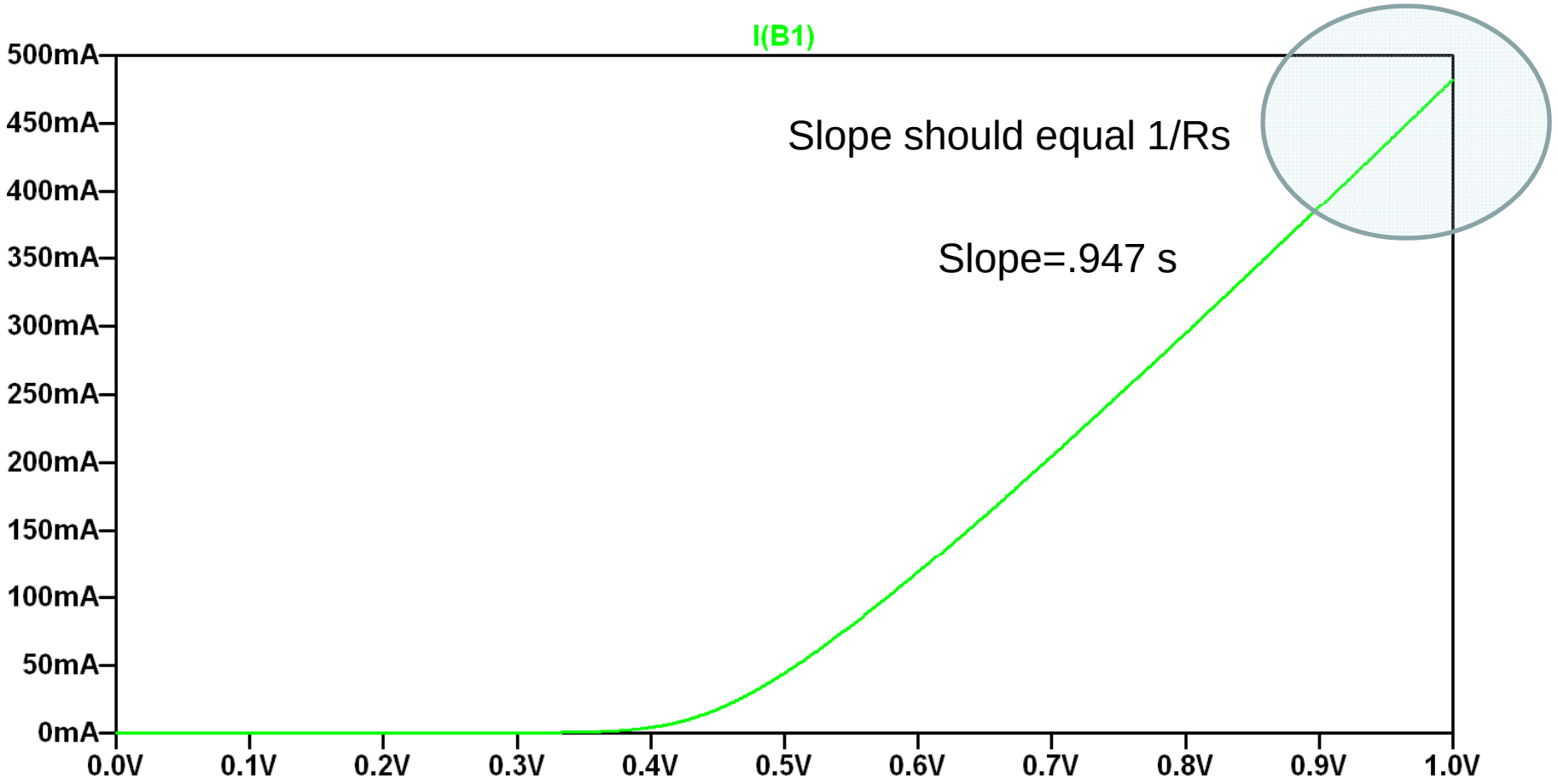
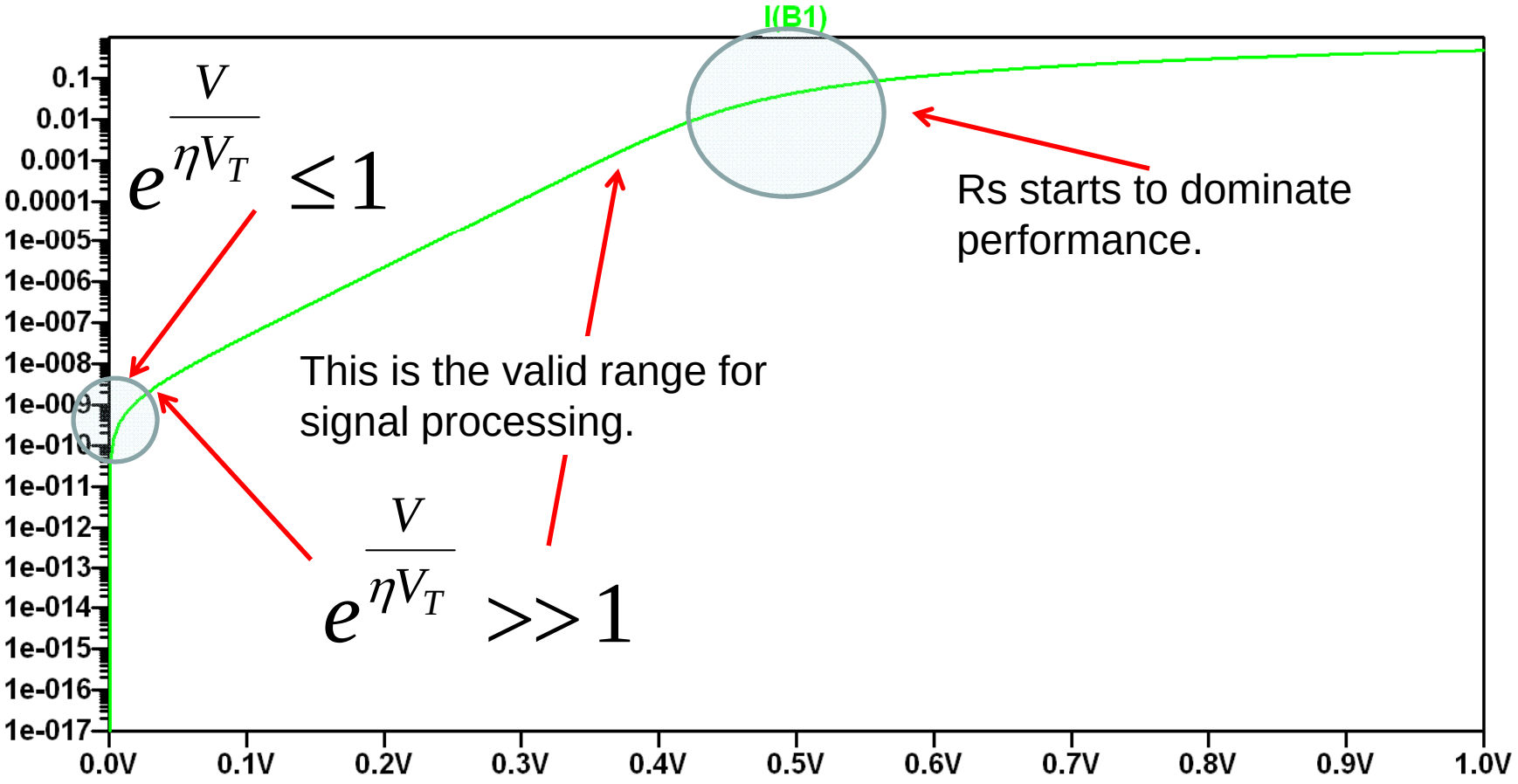
.param N=1
.param IS=1e-9
.param VT=.0259
.param RS=1
```

Series Resistance Dominates at higher voltages.

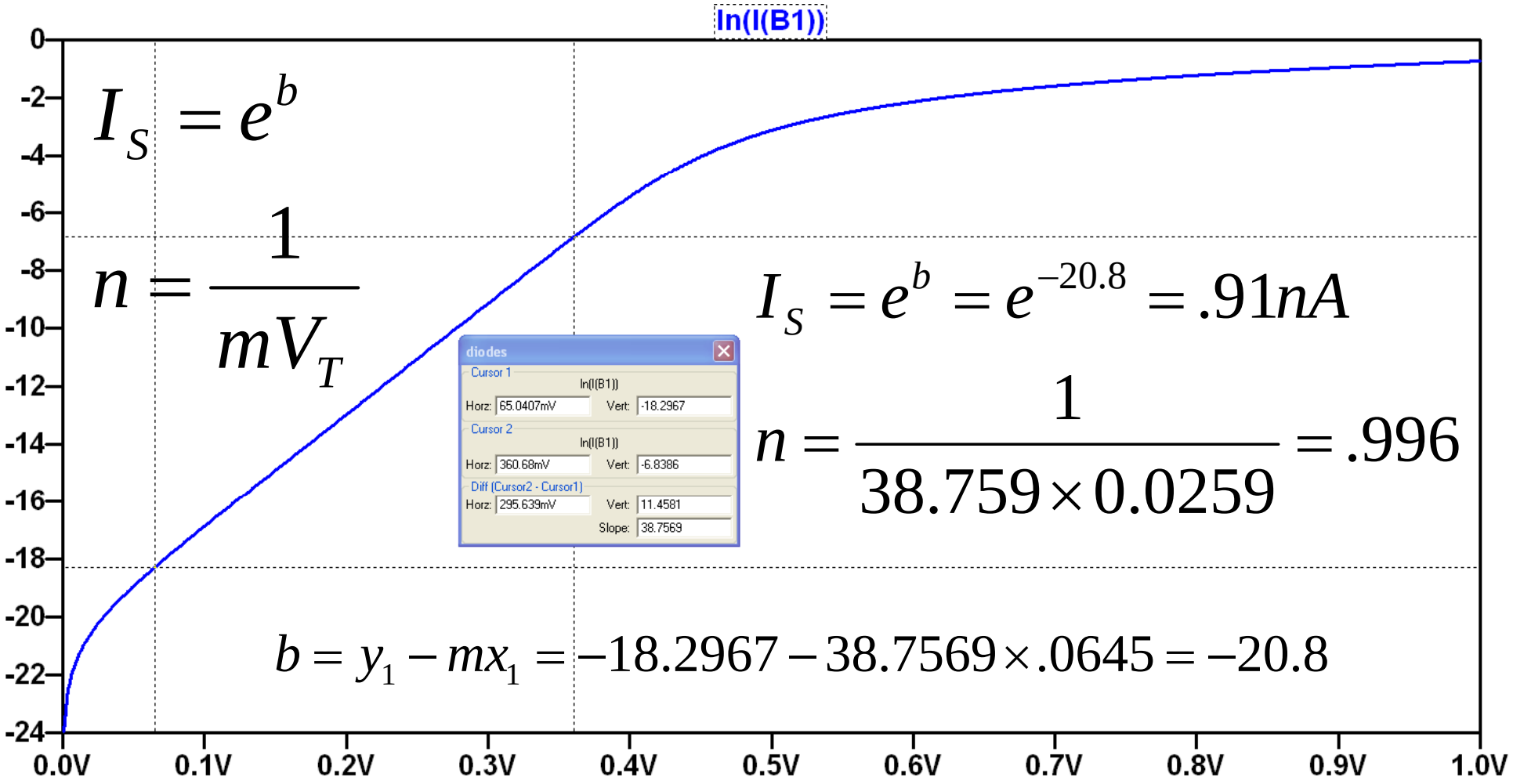


To see exponential function plot log.



Do not use 10 based log to extract Is and n!!!!

Extract IS and n from ln(I)!



Replace Set up with “real” diode.