Modeling a Diode

1. The Current-Voltage Relationship of the Junction

The current-voltage relationship of the p-n junction is given by

$$I = I_S(e^{\frac{V}{V_T}} - 1)$$

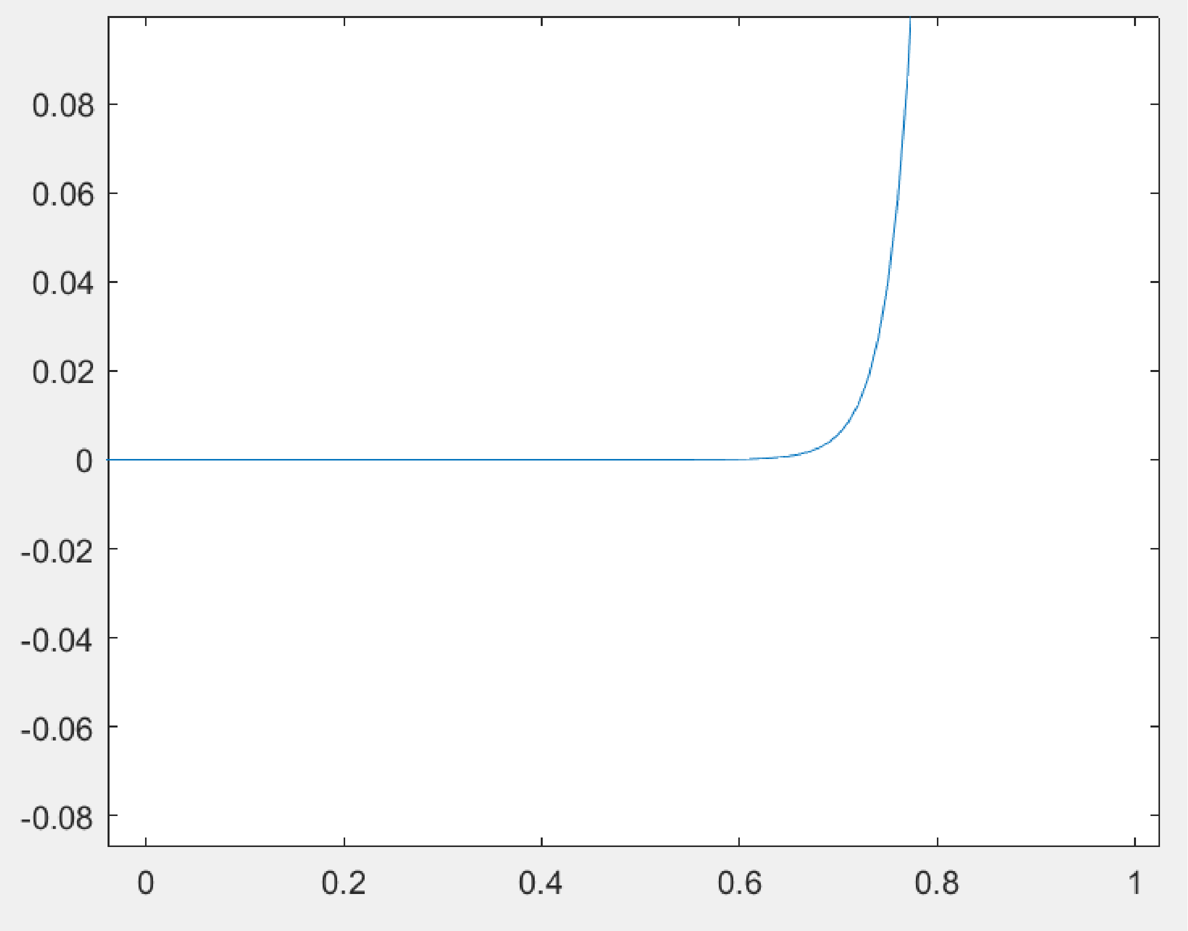
where I_S is the drift current, $V_T = kT/q$ is the thermal voltage. $k = 1.38064852 \times 10^{-23}$ is the Boltzmann constant and $q = 1.60217662 \times 10^{-19}$ is the elementary charge. We'll assume room temperature $T = 300K$.

2. Problem

Due to zener effect or avalanche effect, the diode would breakdown at a certain reverse voltage $V_b = -5V$. Assume the I-V characteristic is linear below $-5V$, with slope = $10^{14}\Omega^{-1}$. Let $I_S = 10^{-14}A$ (Typicla value for I_S is from $10^{-18}A$ to $10^{-12}A$). Use MATLAB to plot the I-V characteristics.

3. Result


10
8
6
4
2
0
-2
-4
-6
-8
-10
-6
-5
-4
-3
-2
-1
0
1



It is shown that in the forward-bias region, the forward voltage (I = 10 mA) is about 0.7V.

4. Codes

```
clc;
clear;

T = 300; % room temperature
I_S = 1e-14; % drift current
k = 1.38064852 * 1e-23; % Boltzmann constant
q = 1.60217662 * 1e-19; % electric charge
V_T = k * T / q; % thermal voltage

lower = -6;
higher = 0.9;
step = 0.01;

V = lower:step:higher;
I_ideal = I_S * (exp(V ./ V_T) - 1);

V_b = -5; % break voltage
break_slope = 1e14;

% piecewise function
break_idx = round((V_b - lower) / step);
% the current at the break point
breakI = I_ideal(break_idx);
% -6 ~ -5
I_break = breakI + break_slope * ((lower:step:V_b-step) - V_b);
% concatenate the two vectors
```

```
I = [I_break, I_ideal(break_idx+1:end)];

plot(V, I);
axis([-6, 1, -10, 10]); % plot range
```