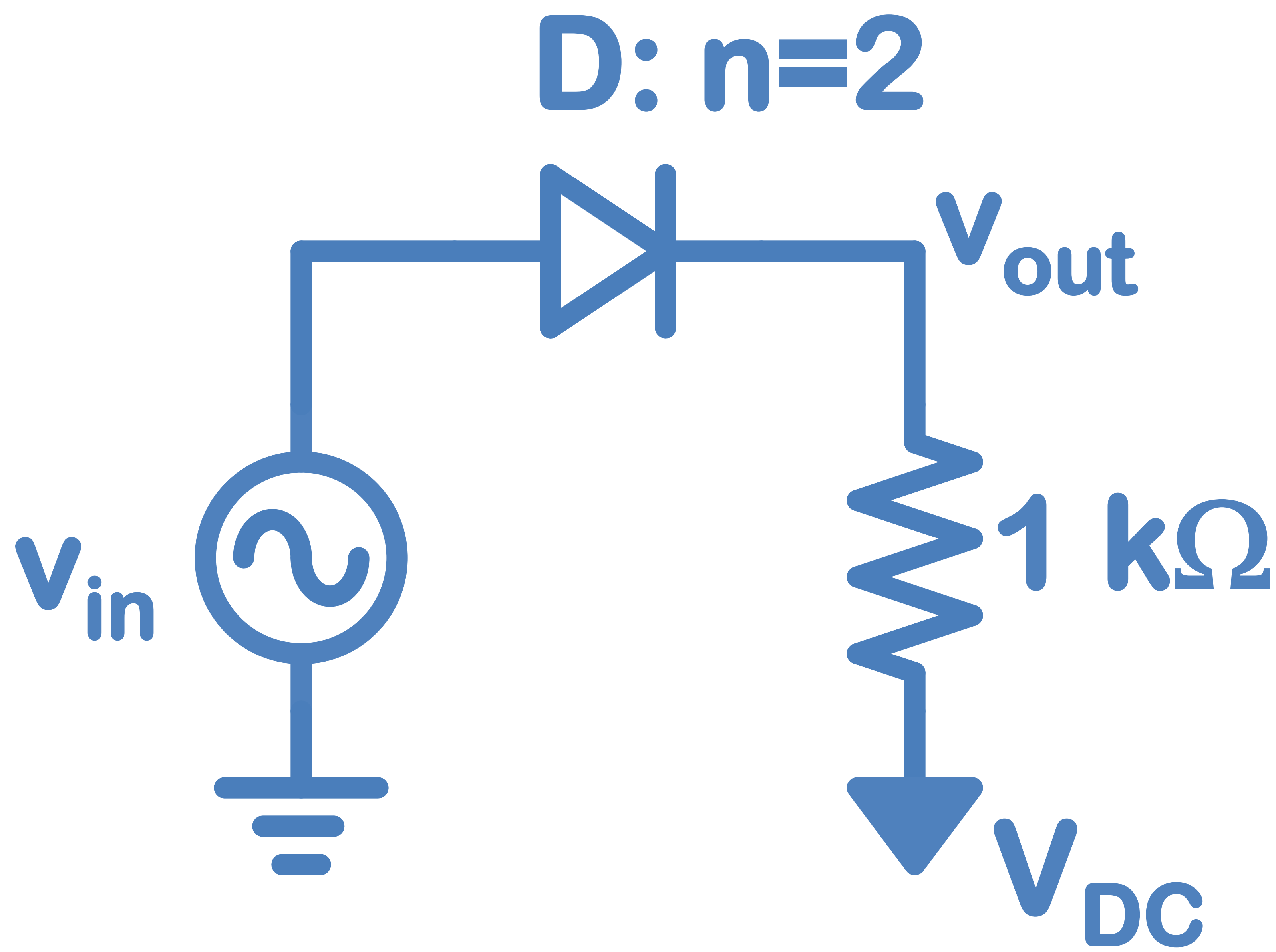
Consider the circuit below to find the small signal relationship: v_{out}/v_{in}



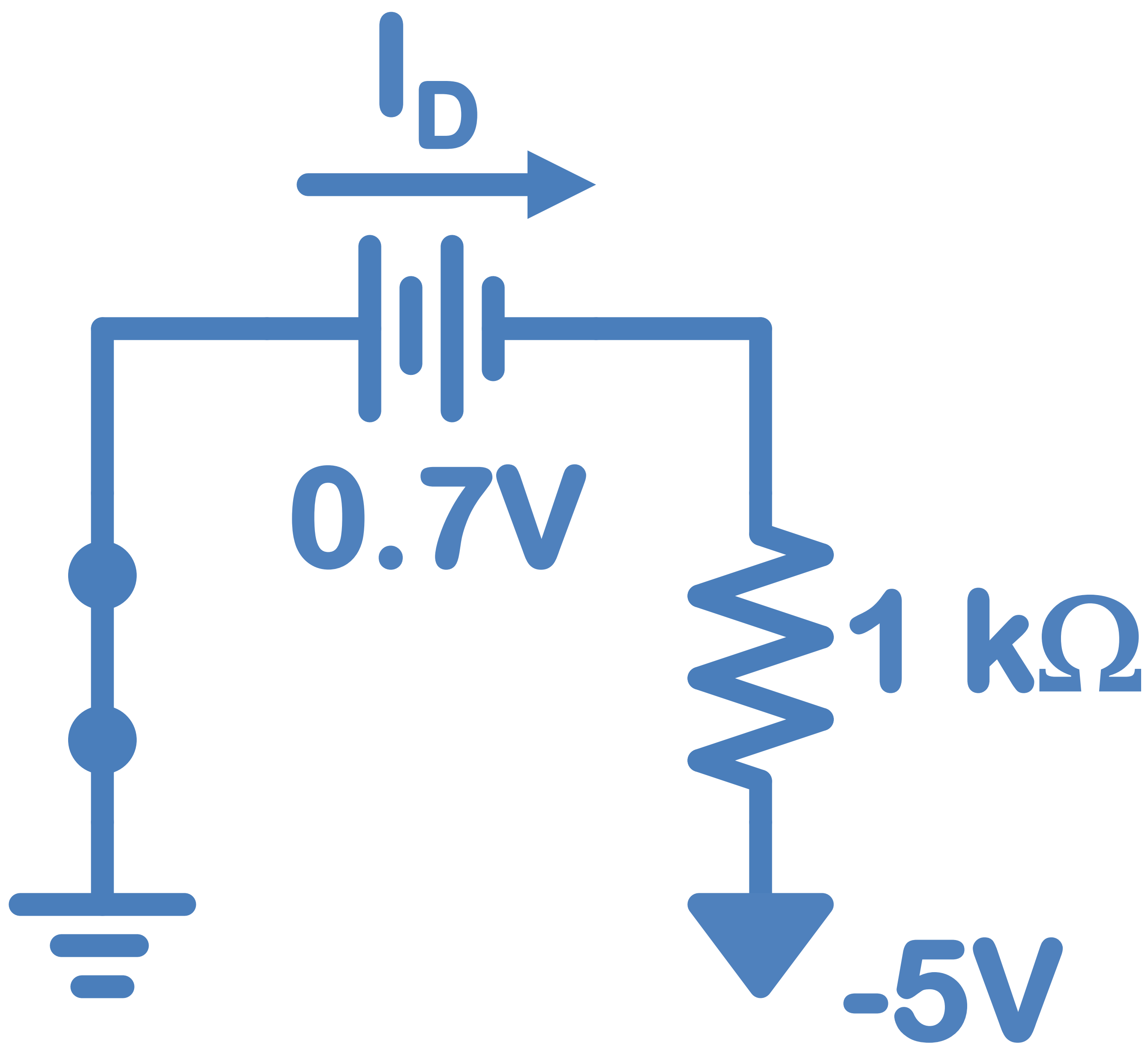
How does v_{out}/v_{in} change for V_{DC}=-0.8V? or V_{DC}=-.071?

How is the small signal model related to the PWL model?

Steps:

1. **LARGE SIGNAL ANALYSIS**
   Use 0.7V CVD model to find I_D with V_{DC}=-5V.
   Remember v_{in}=0 for this part.
2. **SMALL SIGNAL MODEL**
   Calculate the small signal resistance of the diode:
   $$r_d = nV_T/I_D$$
   and replace the diode with the small signal model, r_d.
3. **SMALL SIGNAL ANALYSIS**
   Use the voltage divider eq. to find the relationship: v_{out}/v_{in}
   Remember V_{DC}=0 for this part.

Consider the circuit below to find the small signal relationship: v_{out}/v_{in}

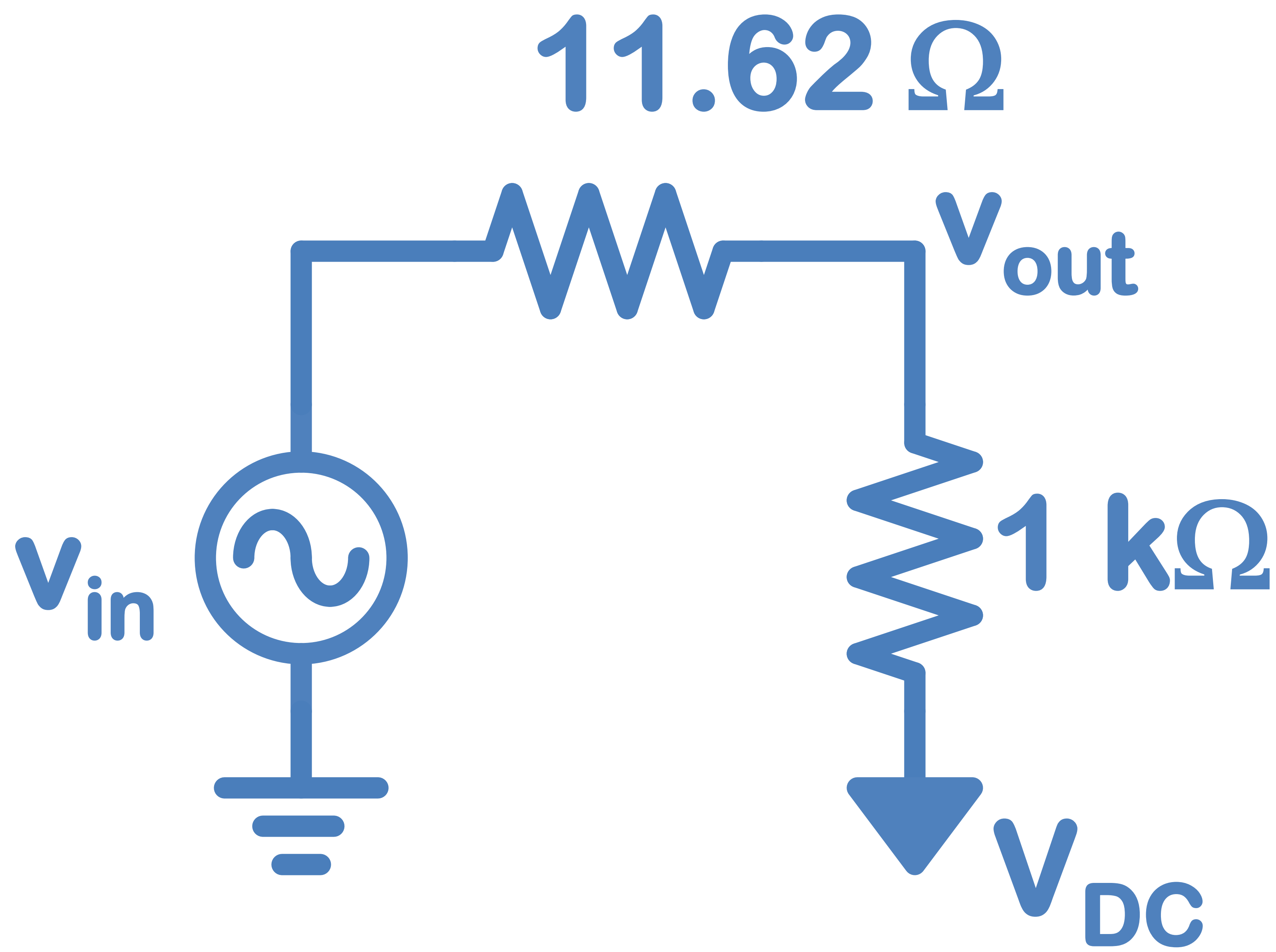


Steps:

1. **LARGE SIGNAL ANALYSIS**
   Use 0.7V CVD model to find I_D with V_{DC}=-5V.
   Remember v_{in}=0 for this part.

   I_D=(-.7--5)/1000=4.3mA

Consider the circuit below to find the small signal relationship: v_{out}/v_{in}



Steps:

1. **LARGE SIGNAL ANALYSIS**

   Use 0.7V CVD model to find I_D with V_{DC}=-5V.

   Remember v_{in}=0 for this part.

2. **SMALL SIGNAL MODEL**

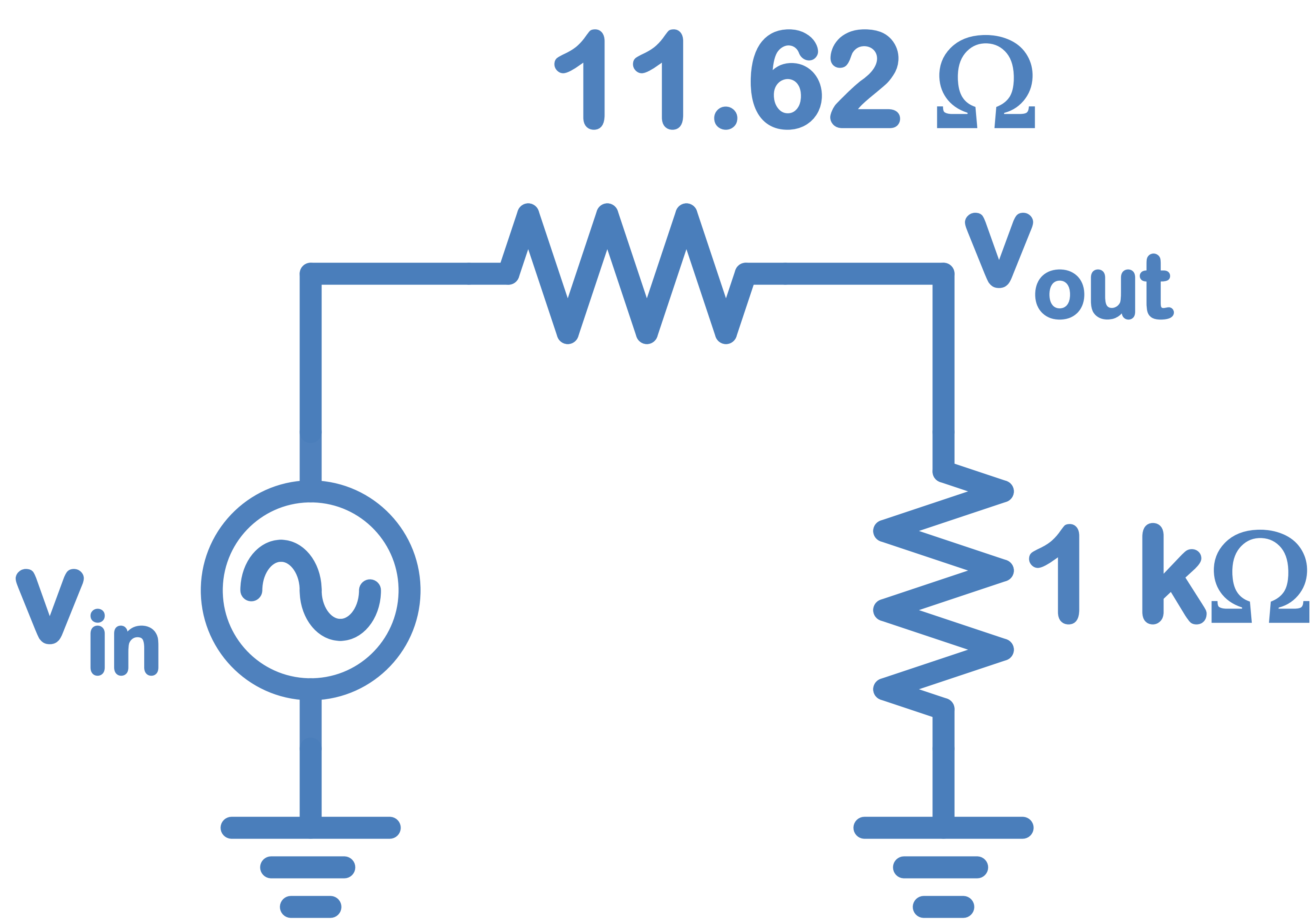
   Calculate the small signal resistance of the diode:

   $$r_d = nV_T/I_D$$

   and replace the diode with the small signal model, r_d.

   r_d=2*25mV/4.3mA=11.62Ω

Consider the circuit below to find the small signal relationship: v_{out}/v_{in}



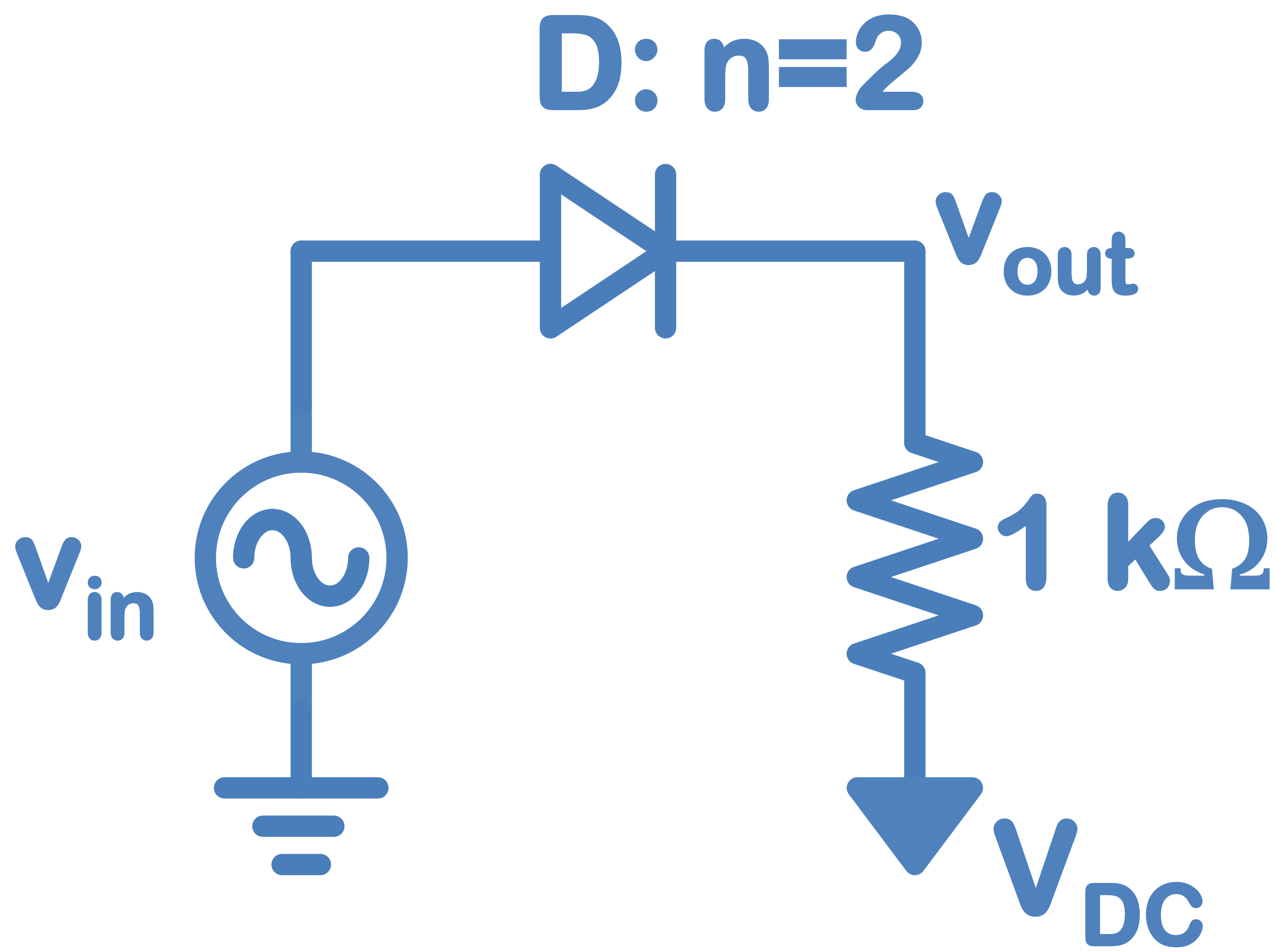
v_{out}/v_{in}=1000/1011.62

v_{out}/v_{in}=0.99

Steps:

1. <u>**LARGE SIGNAL ANALYSIS**</u>
   Use 0.7V CVD model to find I_D with V_{DC}=-5V.
   <u>*Remember v_{in}=0 for this part.*</u>
2. <u>**SMALL SIGNAL MODEL**</u>
   Calculate the small signal resistance of the diode:
   $$r_d=nV_T/I_D$$
   and replace the diode with the small signal model, r_d.
3. <u>**SMALL SIGNAL ANALYSIS**</u>
   Use the voltage divider eq. to find the relationship: v_{out}/v_{in}
   <u>*Remember V_{DC}=0 for this part.*</u>

Consider the circuit below to find the small signal relationship: v_{out}/v_{in}



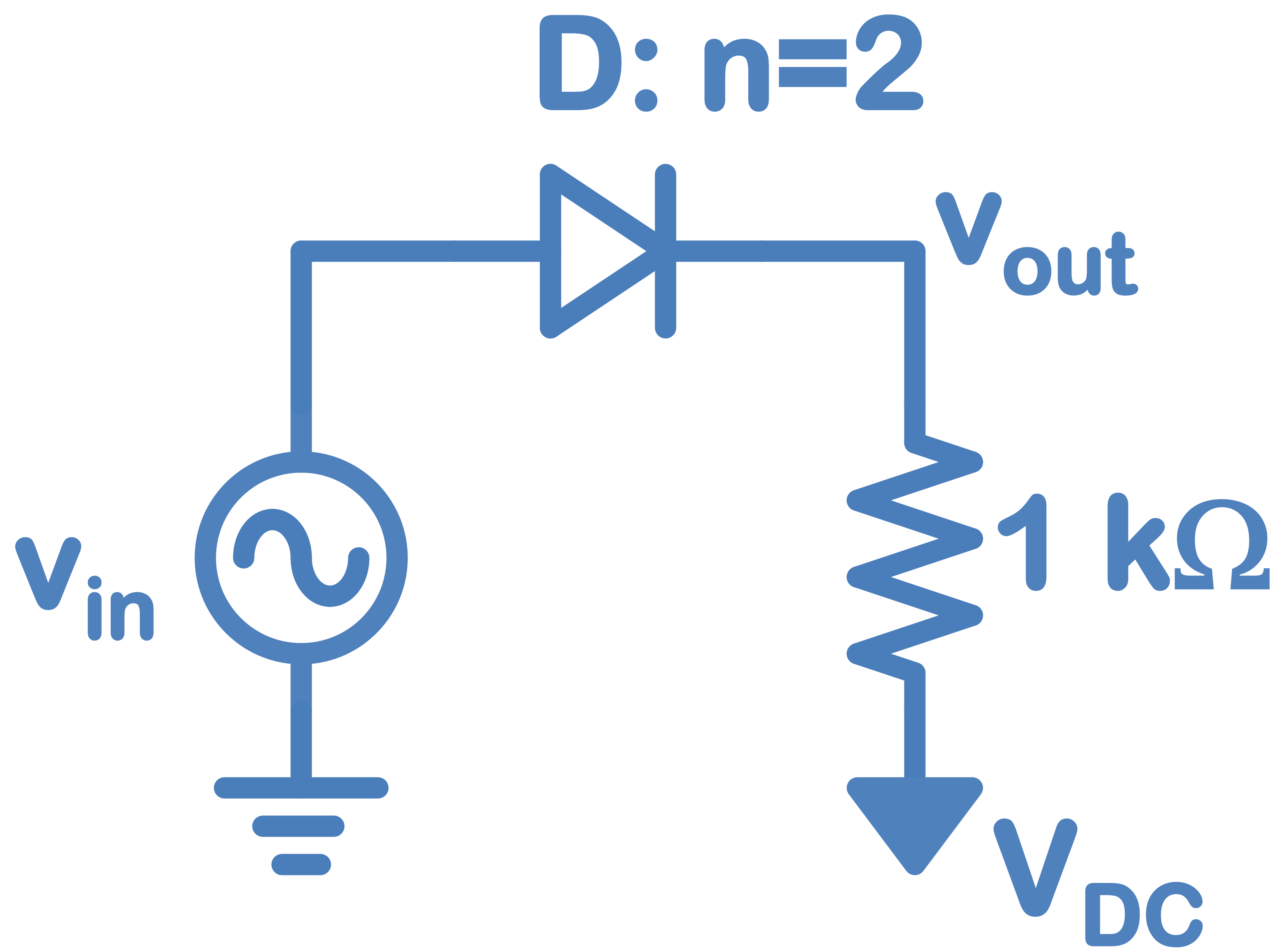
How does v_{out}/v_{in} change for V_{DC}=-0.8V? or V_{DC}=-.071?

-0.8V: .1mA, 500Ω, .66
-0.71V: .01mA, 5 kΩ, .16

Steps:

1. **LARGE SIGNAL ANALYSIS**
   Use 0.7V CVD model to find I_D with V_{DC}=-5V.
   Remember v_{in}=0 for this part.
2. **SMALL SIGNAL MODEL**
   Calculate the small signal resistance of the diode:
   $$r_d = nV_T/I_D$$
   and replace the diode with the small signal model, r_d.
3. **SMALL SIGNAL ANALYSIS**
   Use the voltage divider eq. to find the relationship: v_{out}/v_{in}
   Remember V_{DC}=0 for this part.

Consider the circuit below to find the small signal relationship: v_{out}/v_{in}



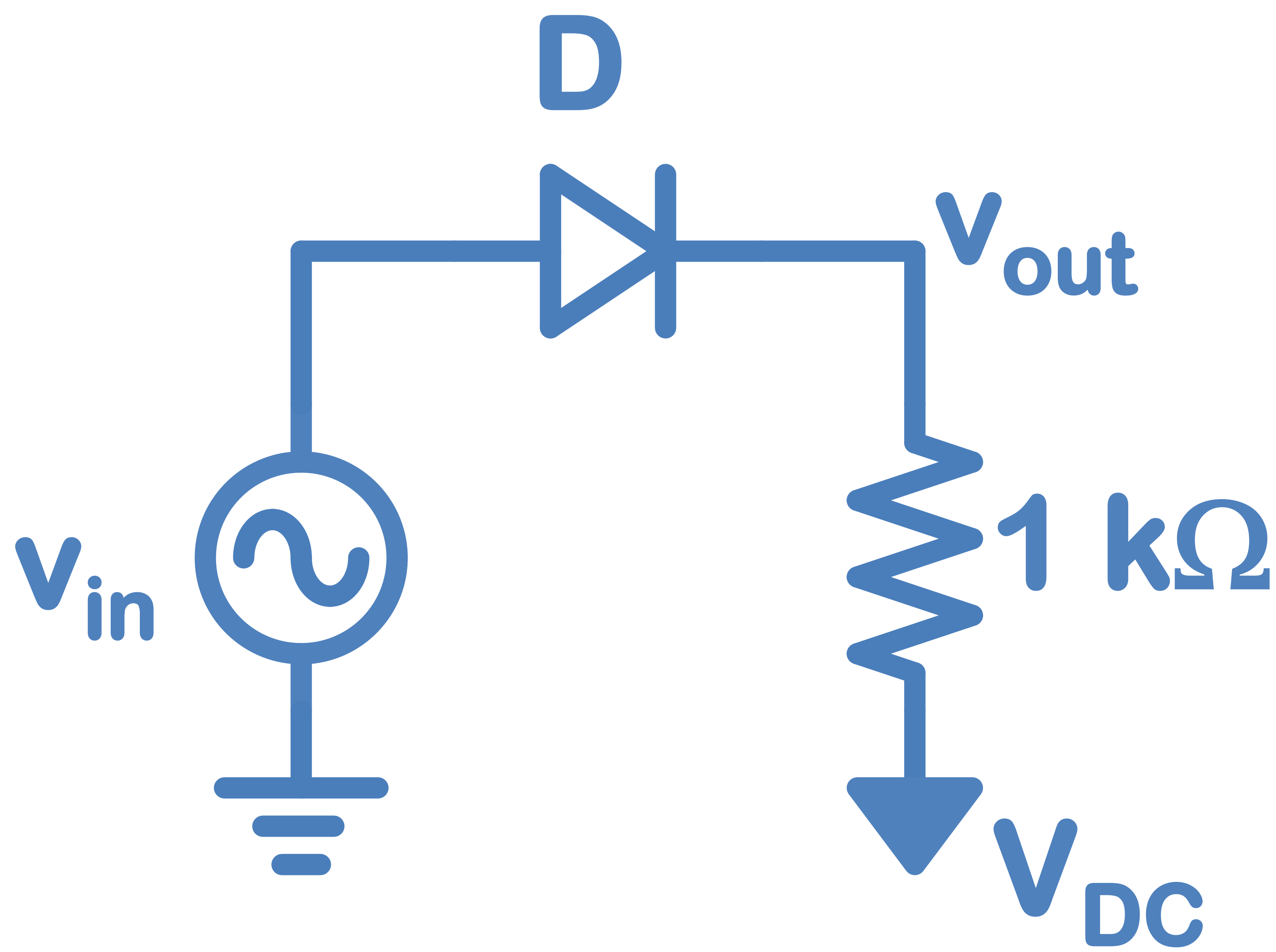
How does v_{out}/v_{in} change for V_{DC}=-0.8V? or V_{DC}=-.071?

How is the small signal model related to the PWL model? Iterative Technique?

Steps:

1. **<u>LARGE SIGNAL ANALYSIS</u>**
   Use 0.7V CVD model to find I_D with V_{DC}=-5V.
   <u>Remember v_{in}=0 for this part.</u>
2. **<u>SMALL SIGNAL MODEL</u>**
   Calculate the small signal resistance of the diode:
   $$r_d = nV_T/I_D$$
   and replace the diode with the small signal model, r_d.
3. **<u>SMALL SIGNAL ANALYSIS</u>**
   Use the voltage divider eq. to find the relationship: v_{out}/v_{in}
   <u>Remember V_{DC}=0 for this part.</u>

Biasing the Diode



A large signal current is generated through the diode to set the small signal resistance.

- In this example, I_D is set by V_{DC} and the 1kΩ resistor.

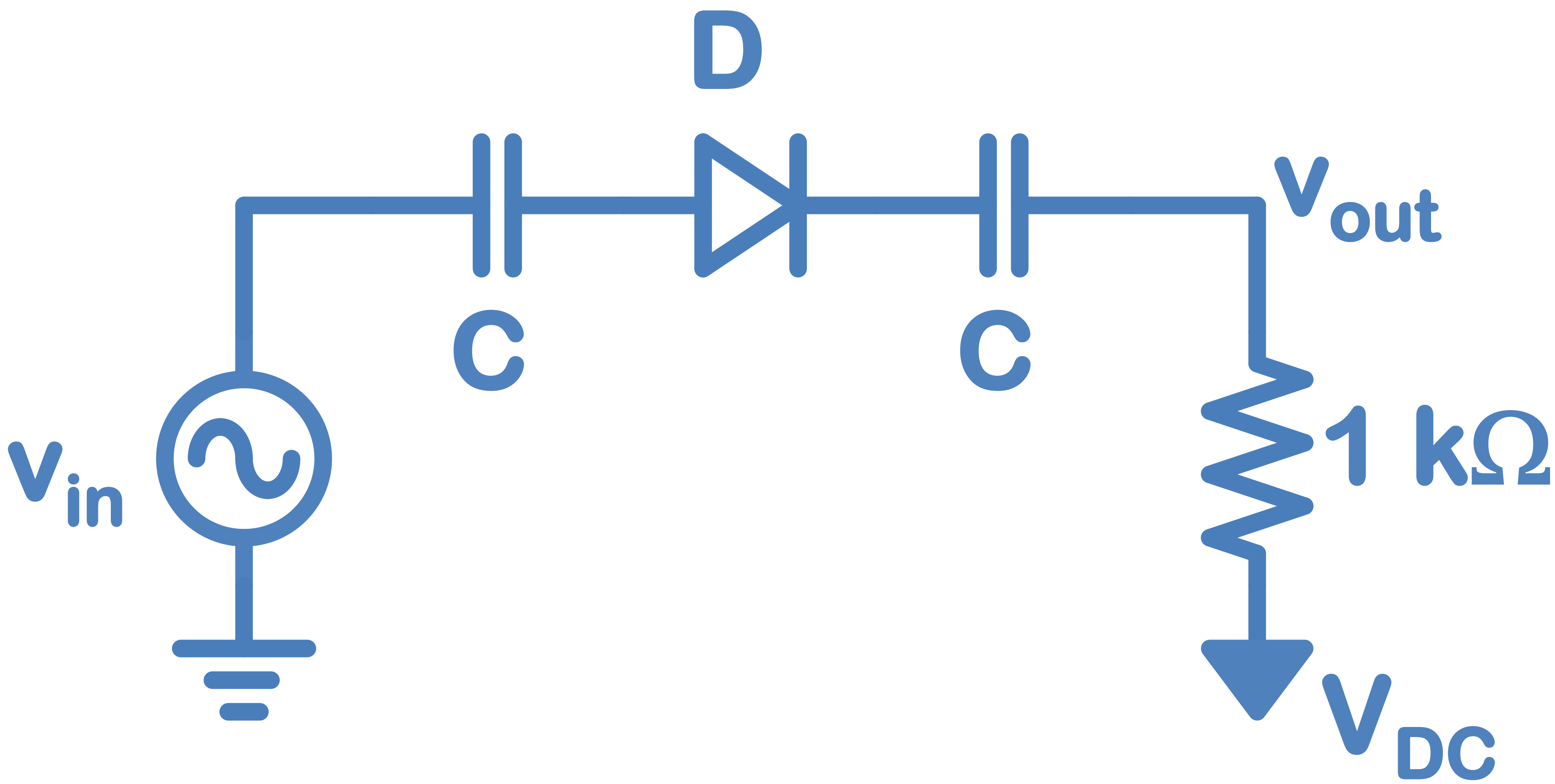
What do we not like about this set-up?

- The small signal source and load are integrated with the large signal source and biasing resistor.

How can we fix this?

- Capacitors and Inductors

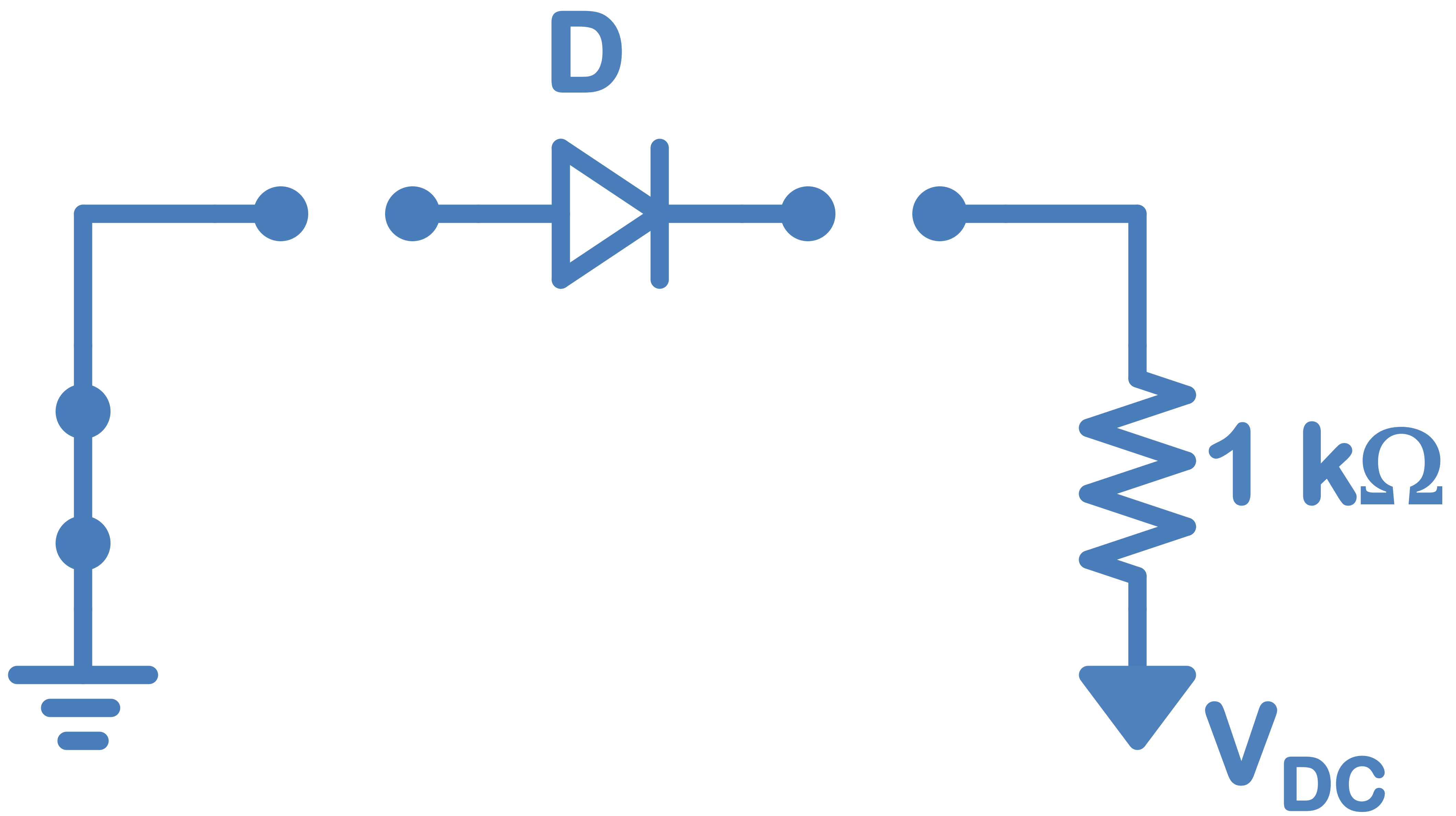
Consider this circuit with Capacitors



What do the capacitors do (C is Large)?

$Z=1/(j\omega C)$:

Consider this circuit with Capacitors

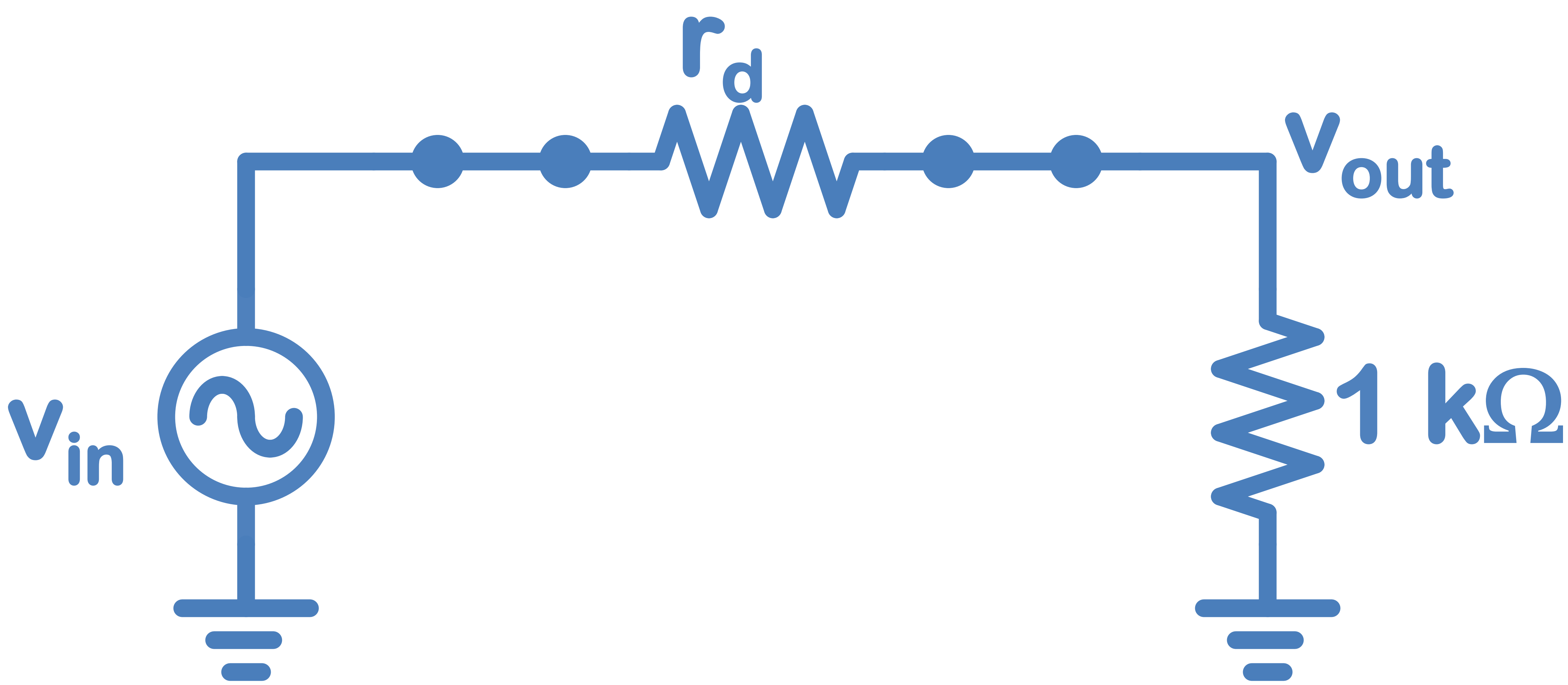


What do the capacitors do (C is Large)?

$Z=1/(j\omega C)$: For Large Signal Model at DC

$Z=\infty$ or an open

Consider this circuit with Capacitors



What do the capacitors do (C is Large)?

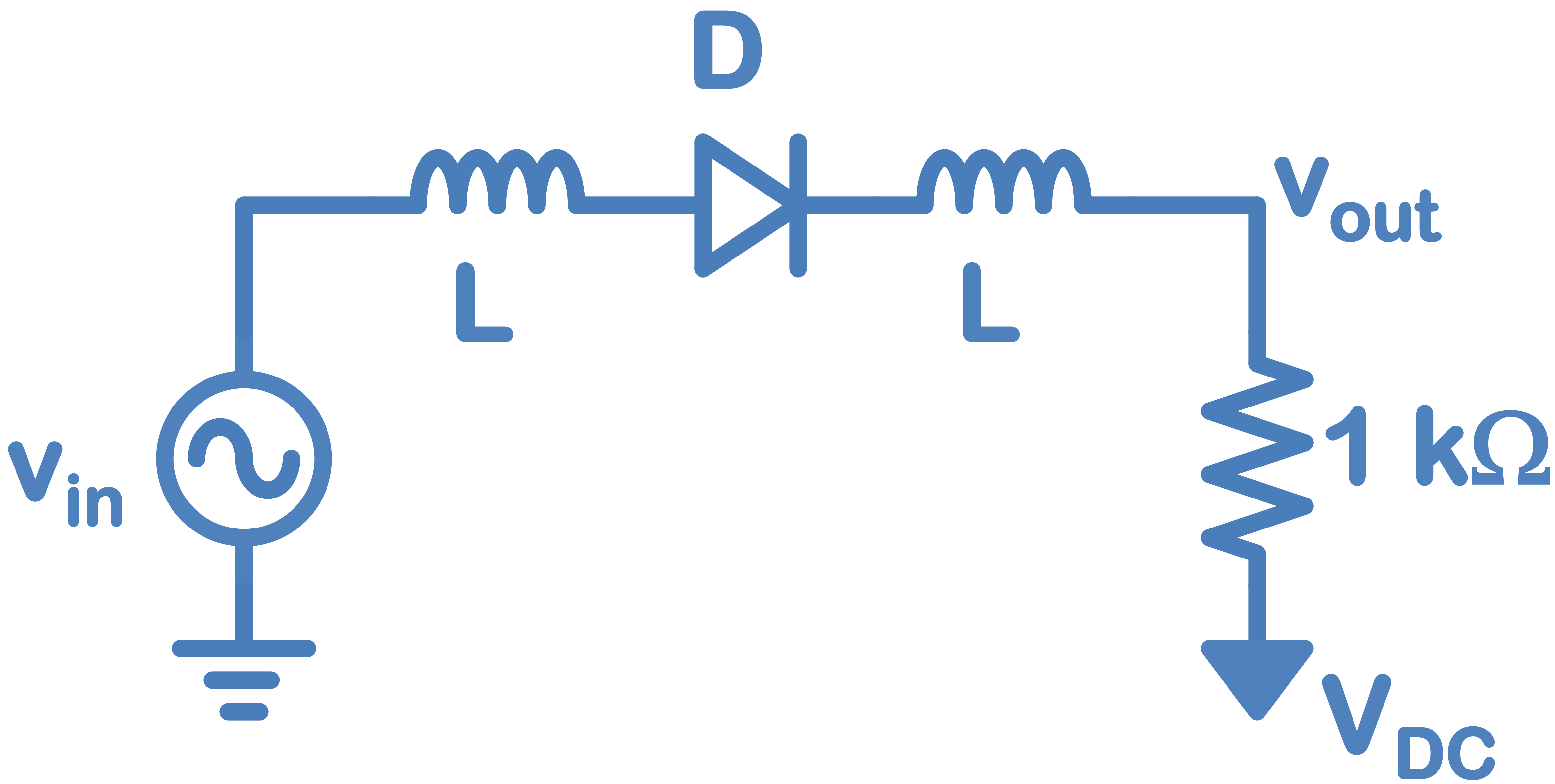
Z=1/(jωC): For Large Signal Model at DC

Z=∞ or an open

For Small Signal Model, Time Varying

Z=0 or a short

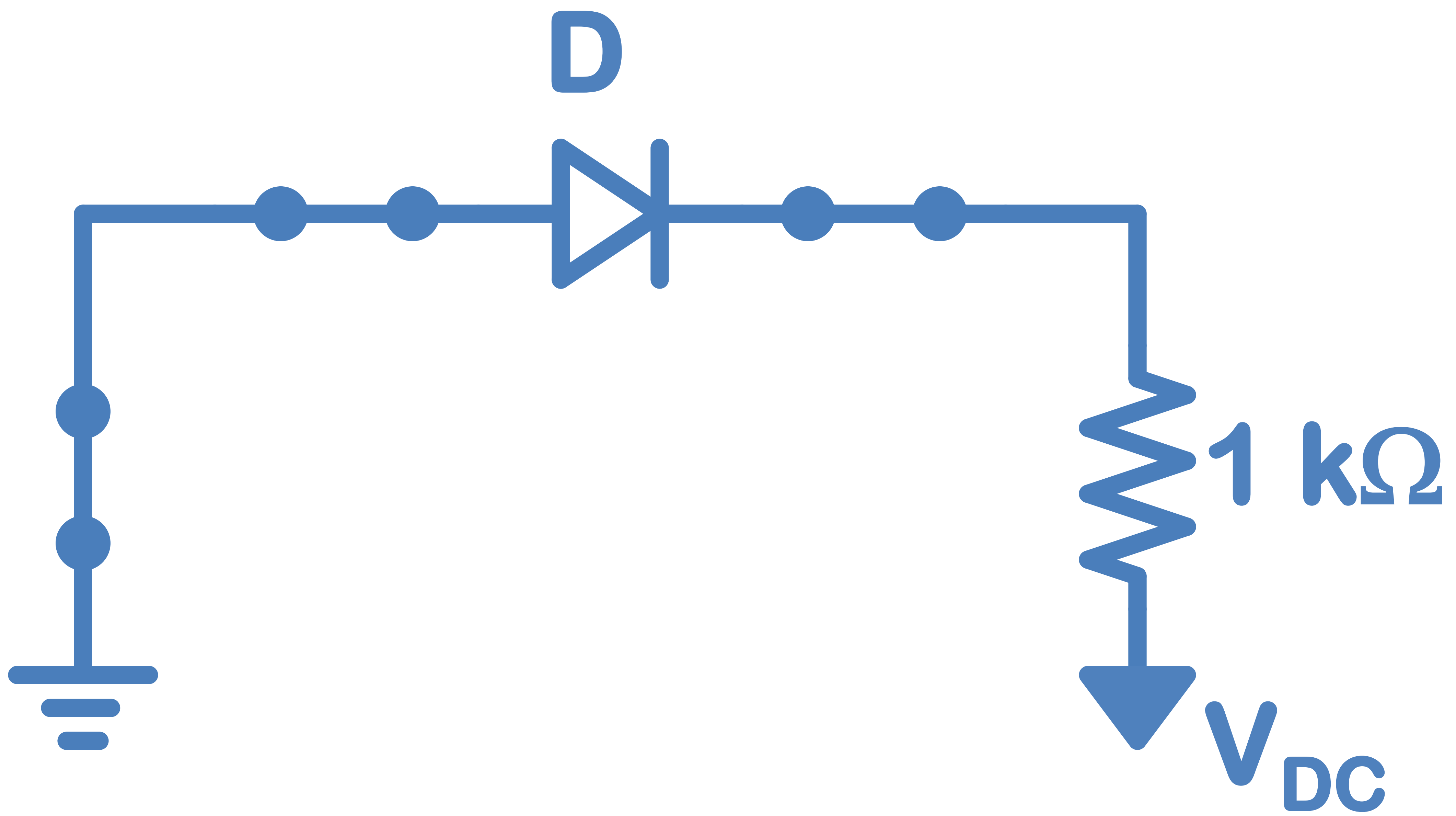
Consider this circuit with Inductors



What do the inductors do (L is Large)?

Z=jωL:

Consider this circuit with Inductors

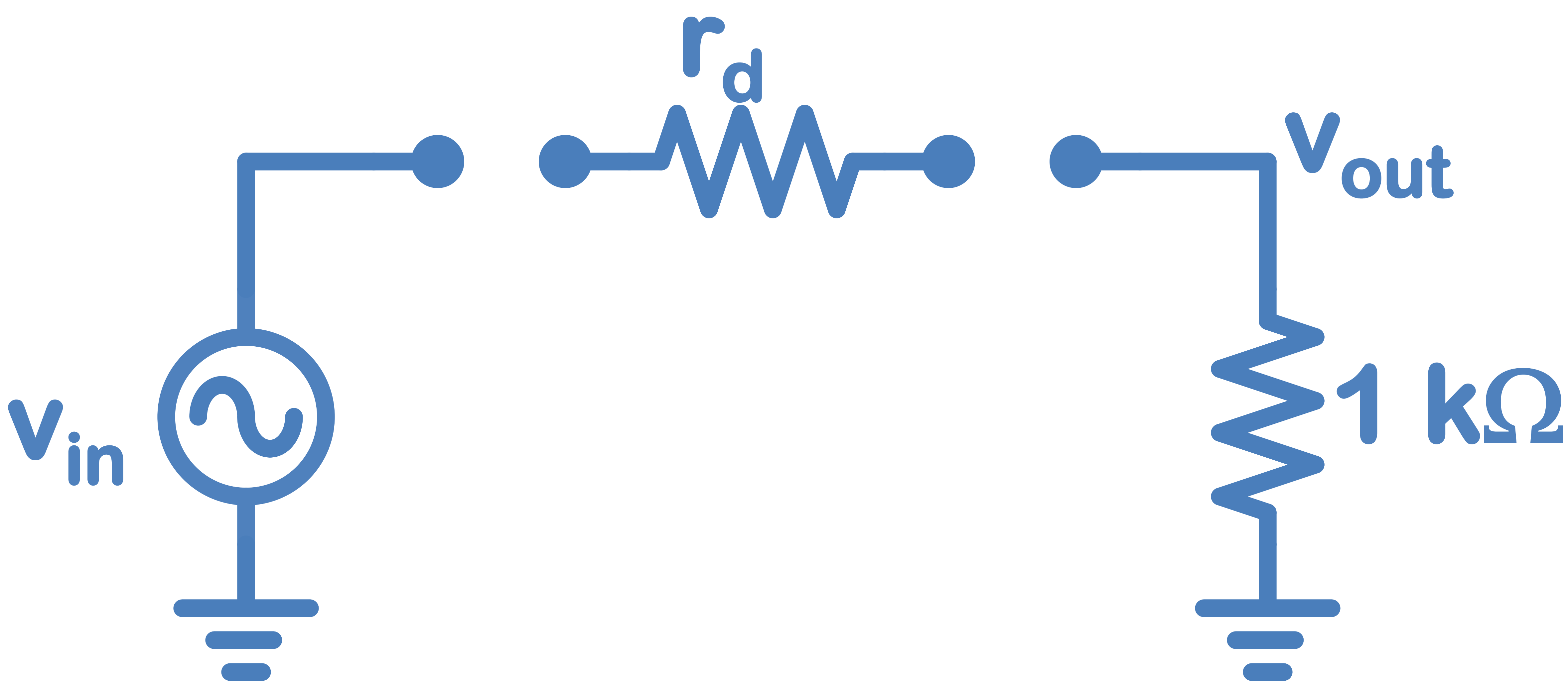


What do the inductors do (L is Large)?

$Z=j\omega L$: For Large Signal Model at DC

$Z=0$ or a short

Consider this circuit with Inductors



What do the inductors do (L is Large)?

Z=jωL: **For Large Signal Model at DC**

Z=0 or a short

For Small Signal Model, Time Varying

Z=∞ or an open

Capacitors and Inductors in Small Signal Analysis

Isolates or Connects sections of the circuit for exclusion or inclusion in small signal analysis or large signal analysis.

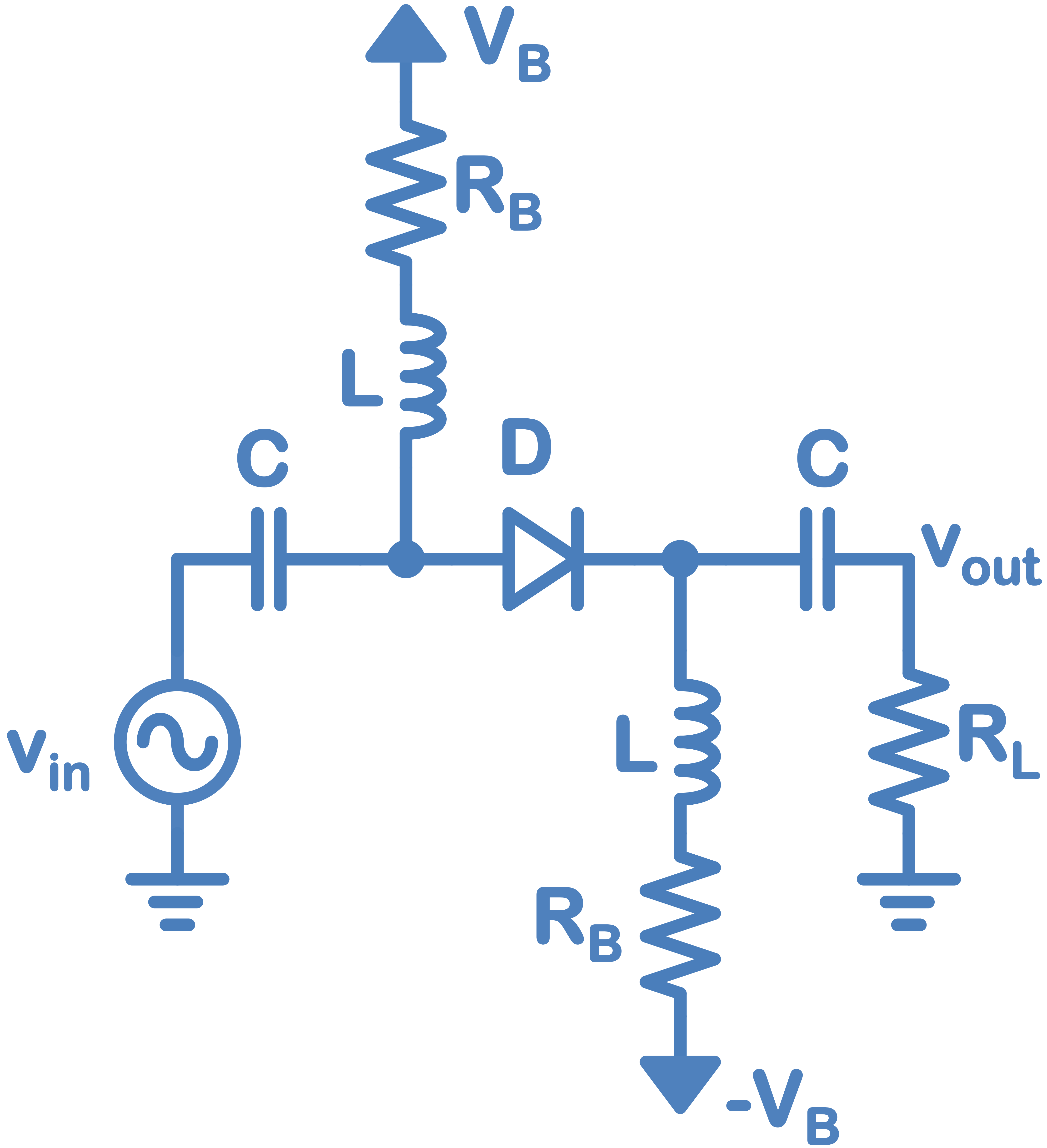
Capacitors: connects components for small signal analysis.

Inductors: connects components for large signal analysis.

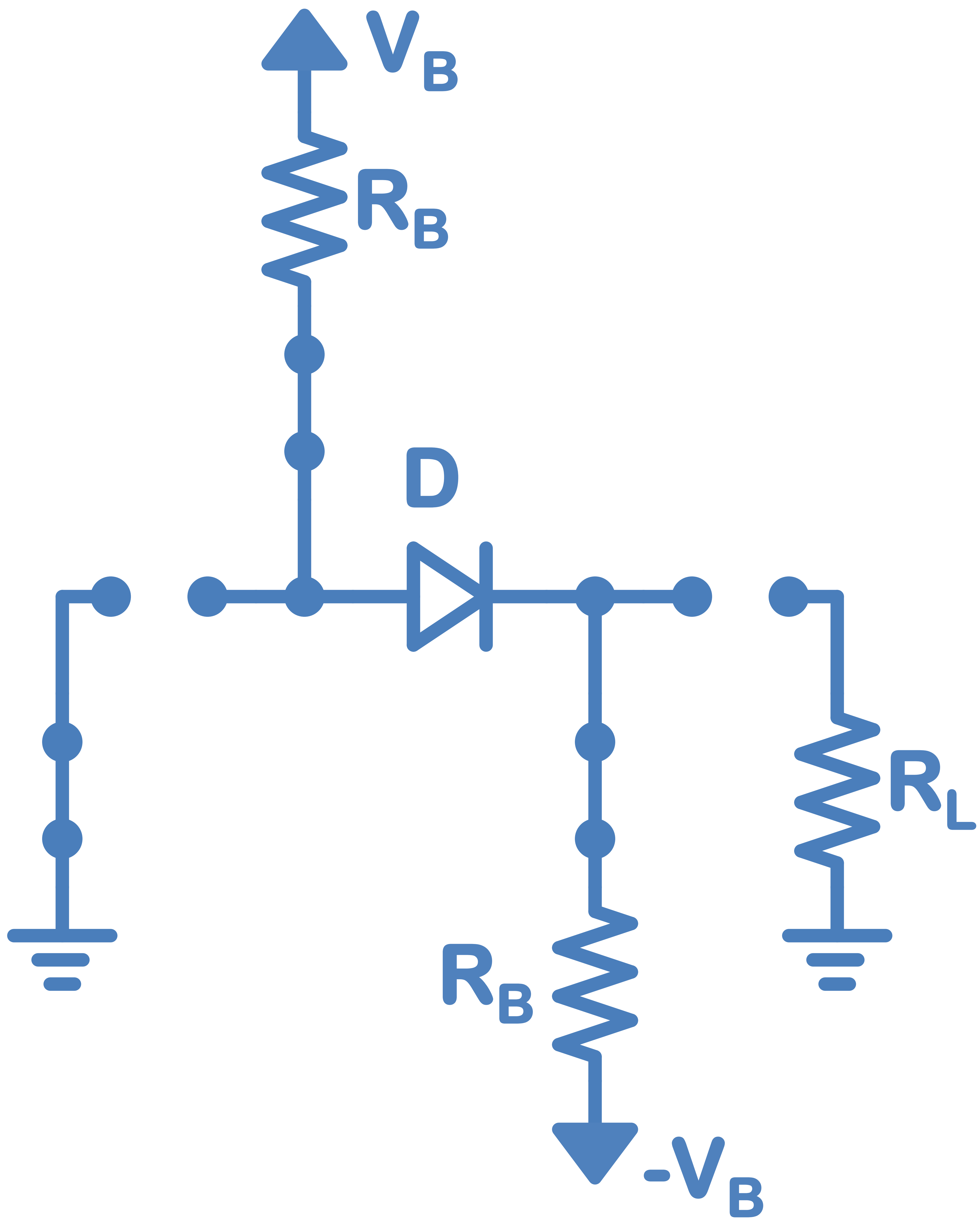
Components in Large Signal and Small Signal Circuits.

Component	Large Signal Circuit Model	Small Signal Circuit Model
Large Signal Voltage (V_S)	V_S	Short
Small Signal Voltage (v_s)	Short	v_s
Large Signal Current (I_S)	I_S	Open
Small Signal Current (i_s)	Open	i_s
Resistor (R)	R	R
Capacitor (C)	Open	Short
Inductor (L)	Short	Open
Diode (D)	D	$r_d=nV_T/I_D$

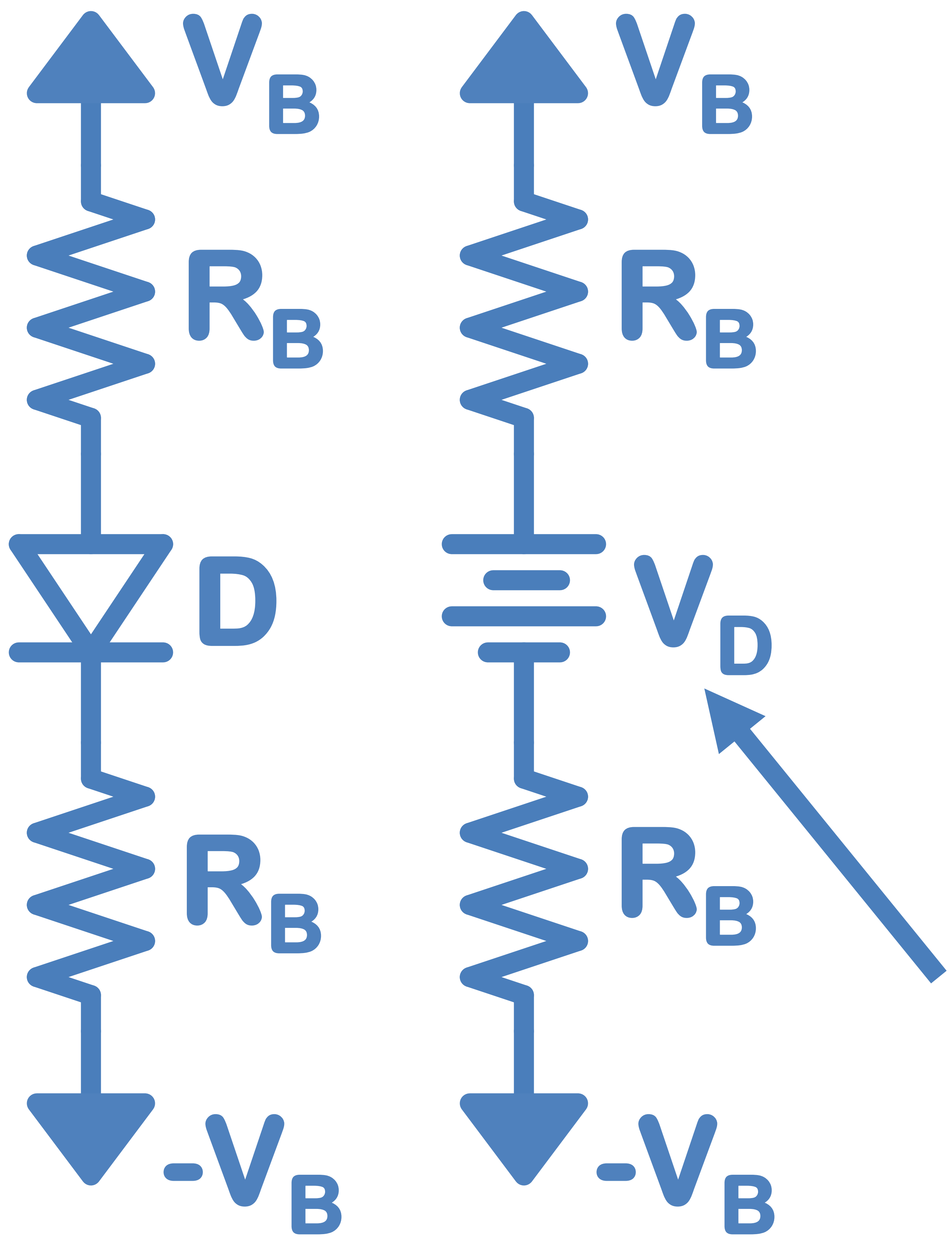
Biased Circuit Small Signal Analysis.



Large Signal Circuit.



Large Signal Circuit Analysis.



Find I_D:

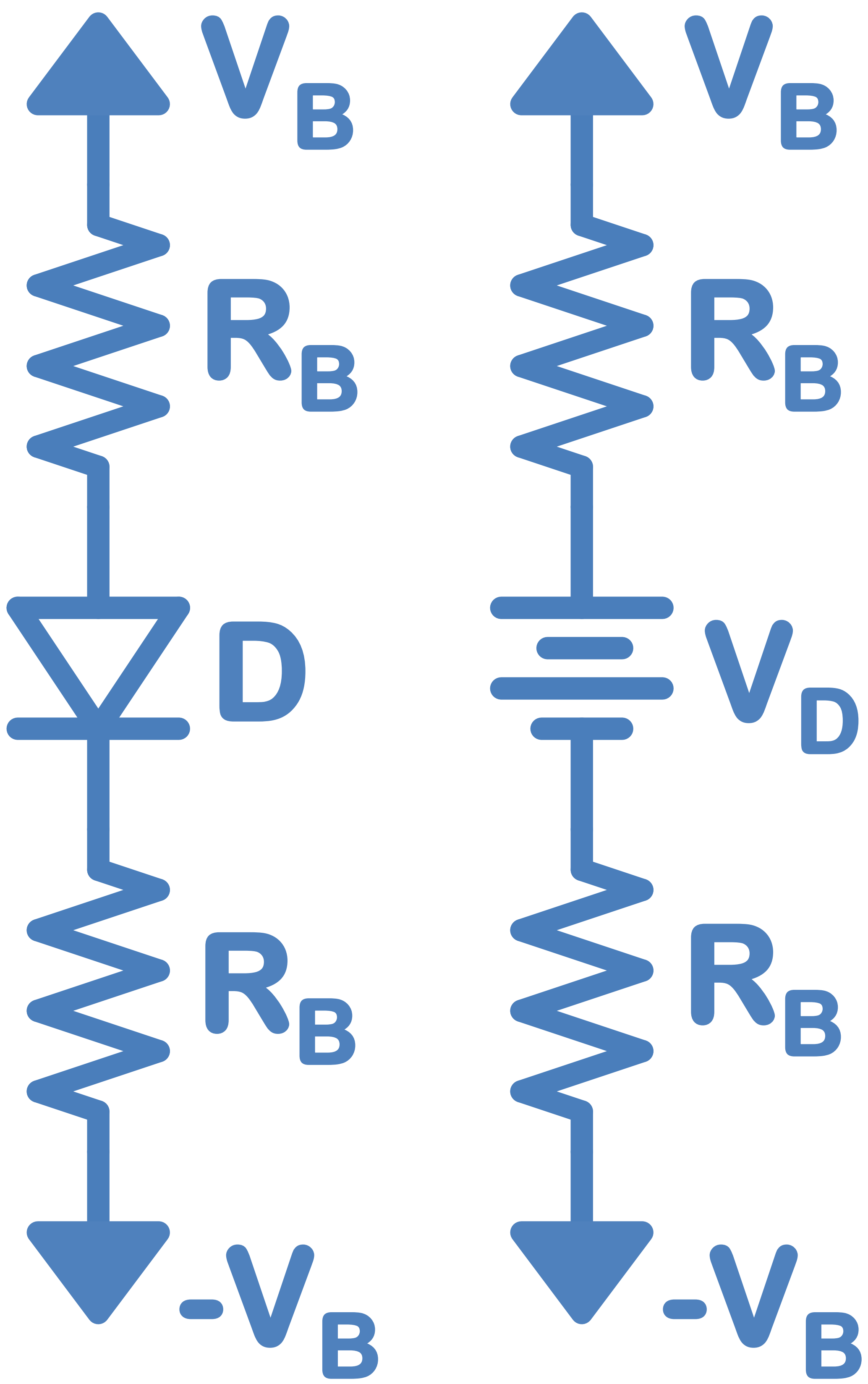
$$I_D = (2V_B - V_D) / (2R_B)$$

Calculate r_d:

$$r_d = nV_T / I_D$$
$$r_d = (2nR_BV_T) / (2V_B - V_D)$$

Why do we start with a voltage for D rather than a current?

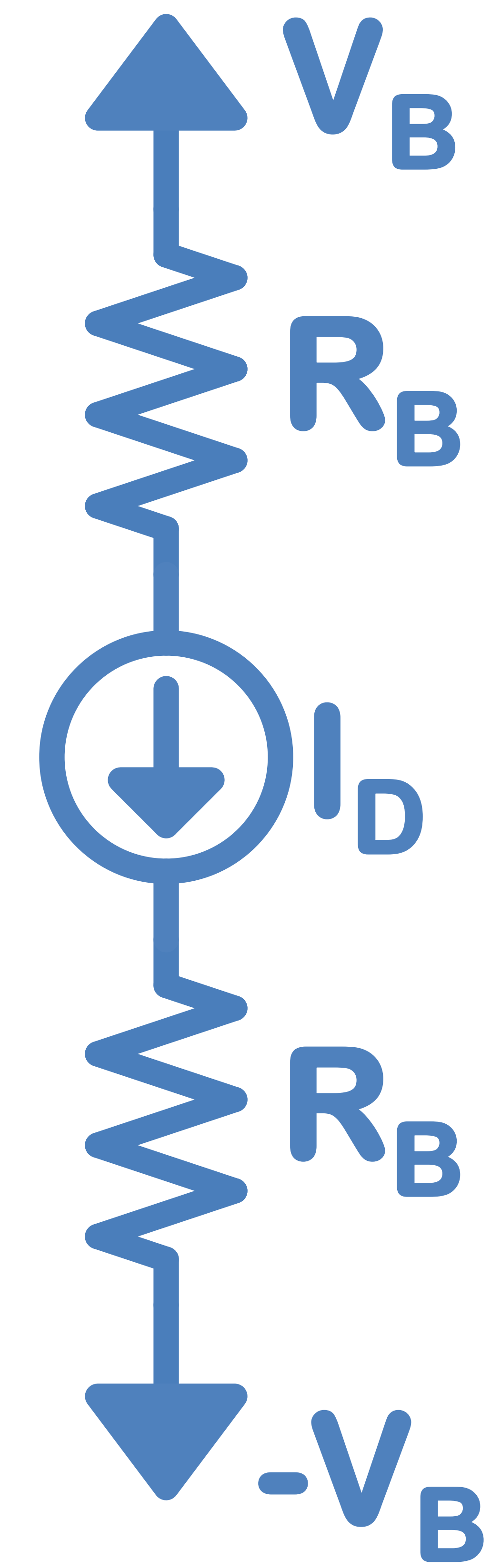
Large Signal Circuit Analysis.



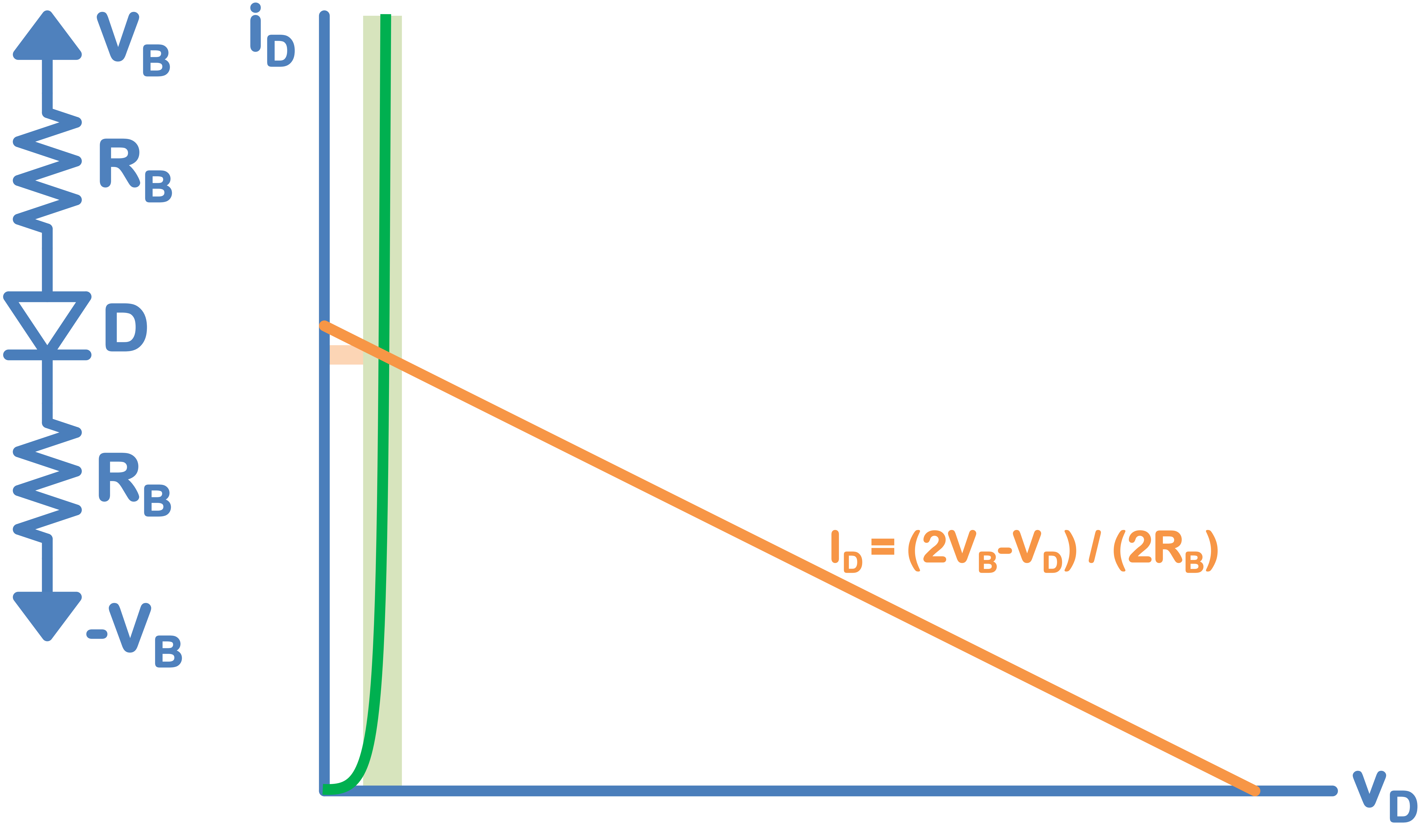
$I_D = (2V_B - V_D) / (2R_B)$

$V_D = 2V_B - 2R_B I_D$

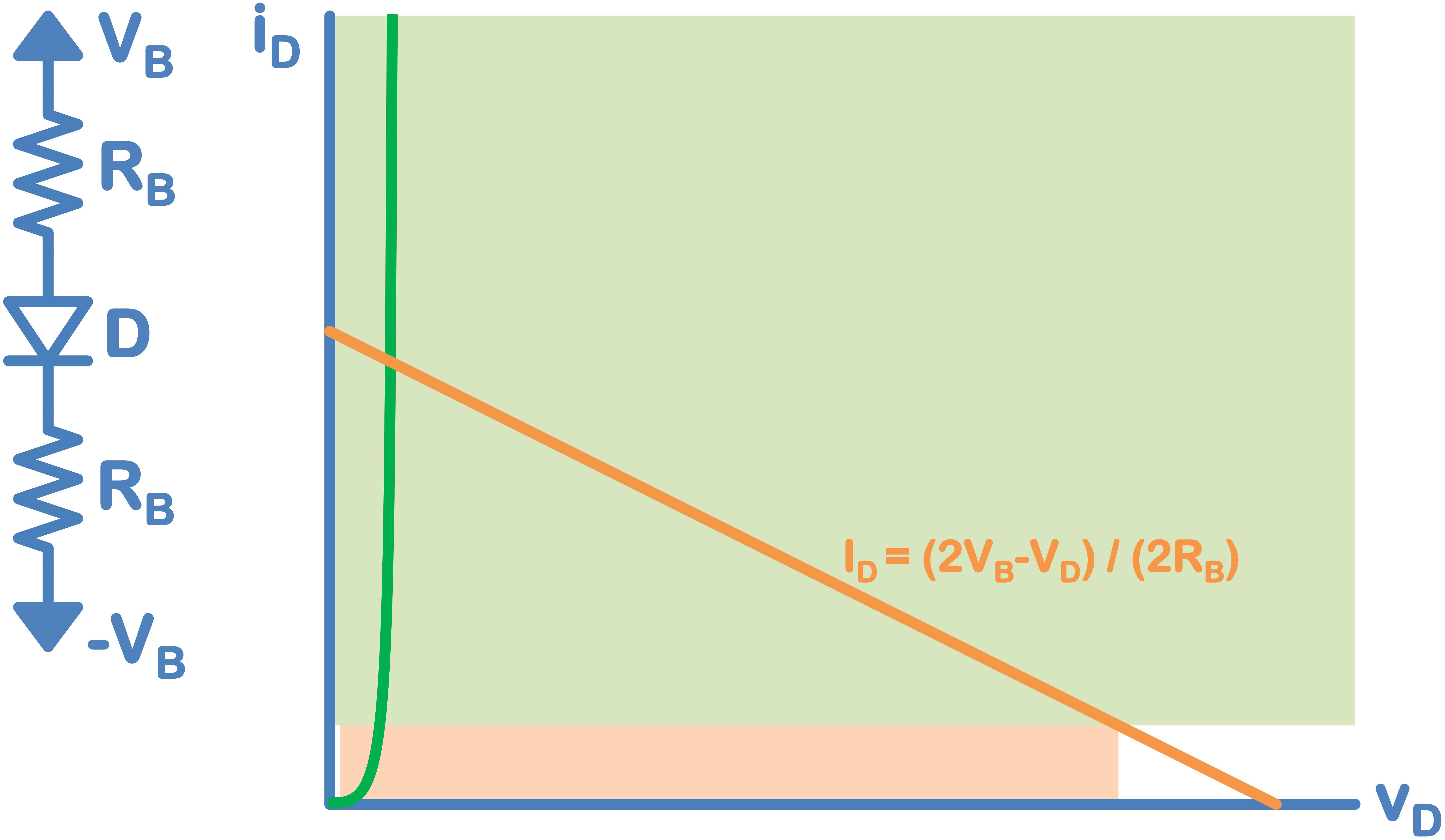
For a typical junction diode, I_D can span several orders of mangnitude (0.1mA to 100mA) for small changes (deltas) in V_D (+/-100mV) around 0.7V.



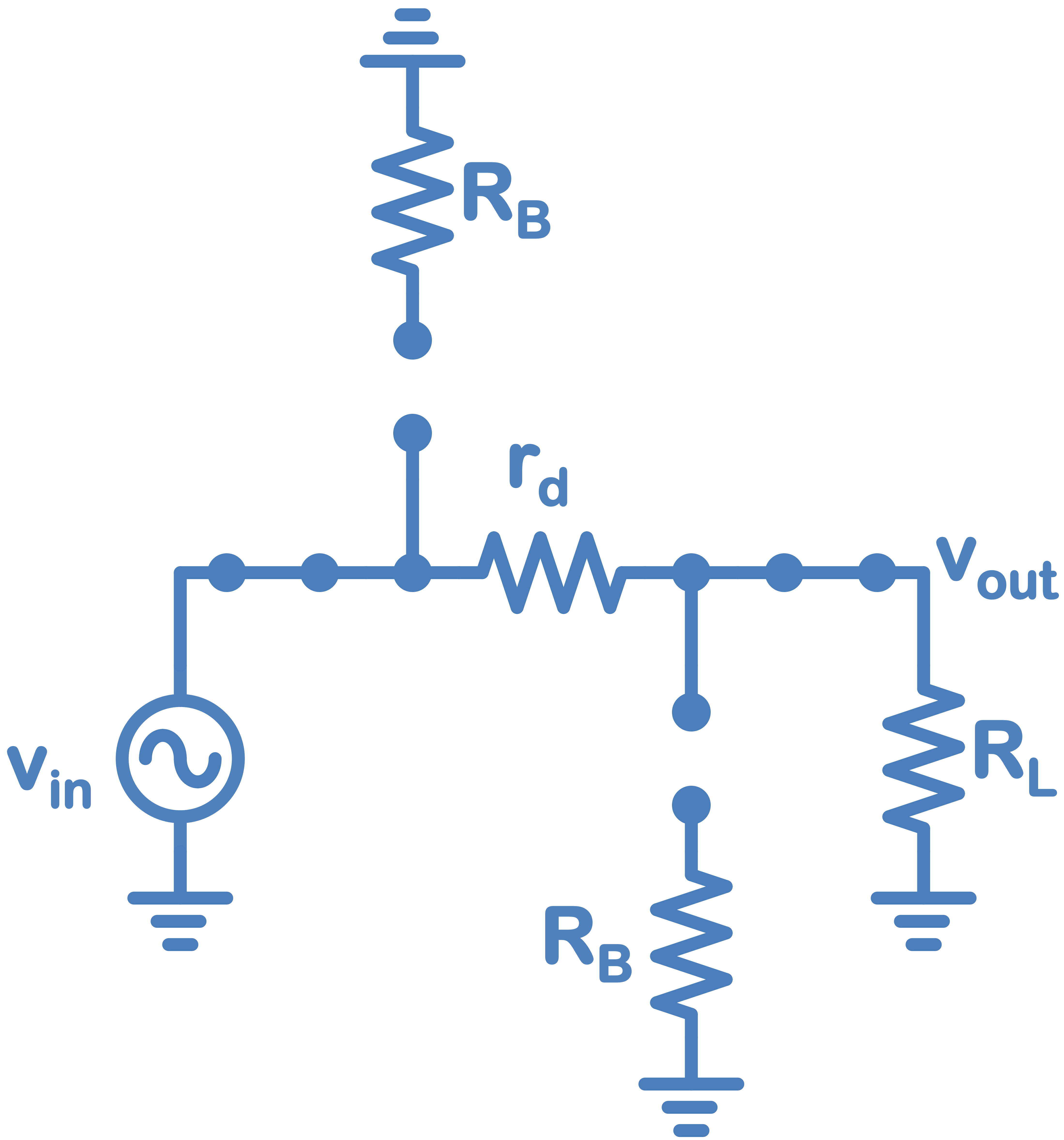
Large Signal Circuit Analysis. Calculating I_D from a guess of V_D.



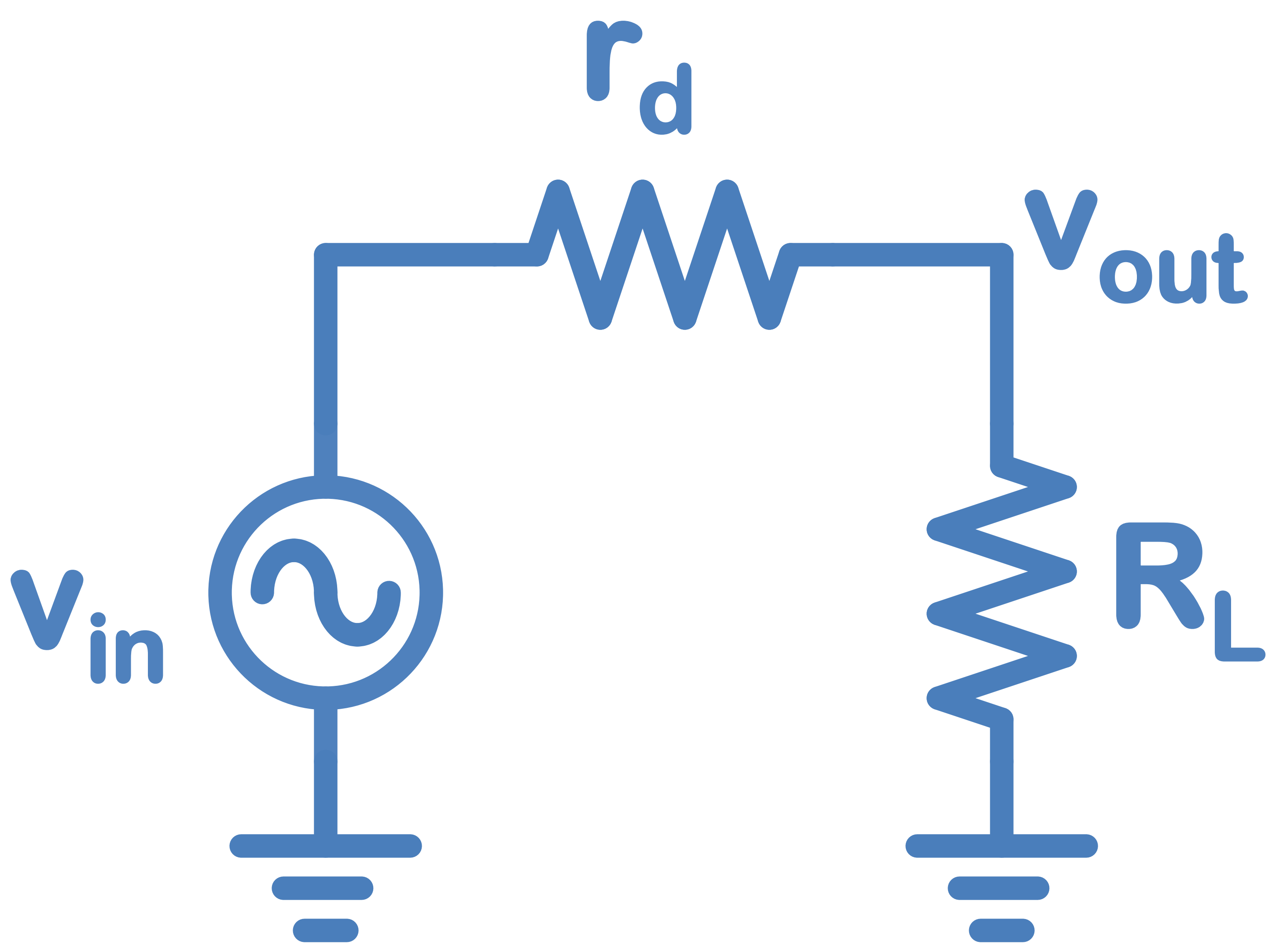
Large Signal Circuit Analysis.
Calculating V_D from a guess of I_D.
could yield results that are not usable



Small Signal Circuit.



Small Signal Circuit and Analysis.



Calculate v_{out}/v_{in}:

$$v_{out}/v_{in} = R_L/(R_L+r_d)$$

where

$$r_d = (2nR_BV_T) / (2V_B-V_D)$$