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Exercise 6:
The Diode

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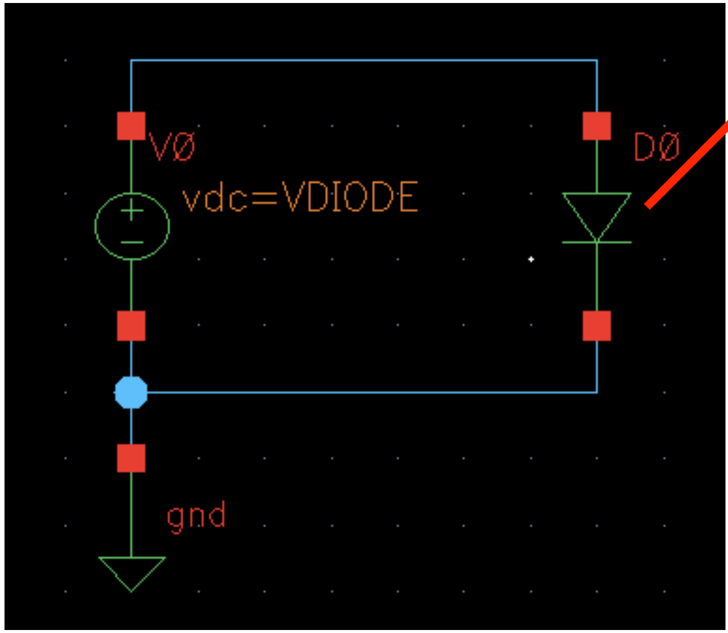
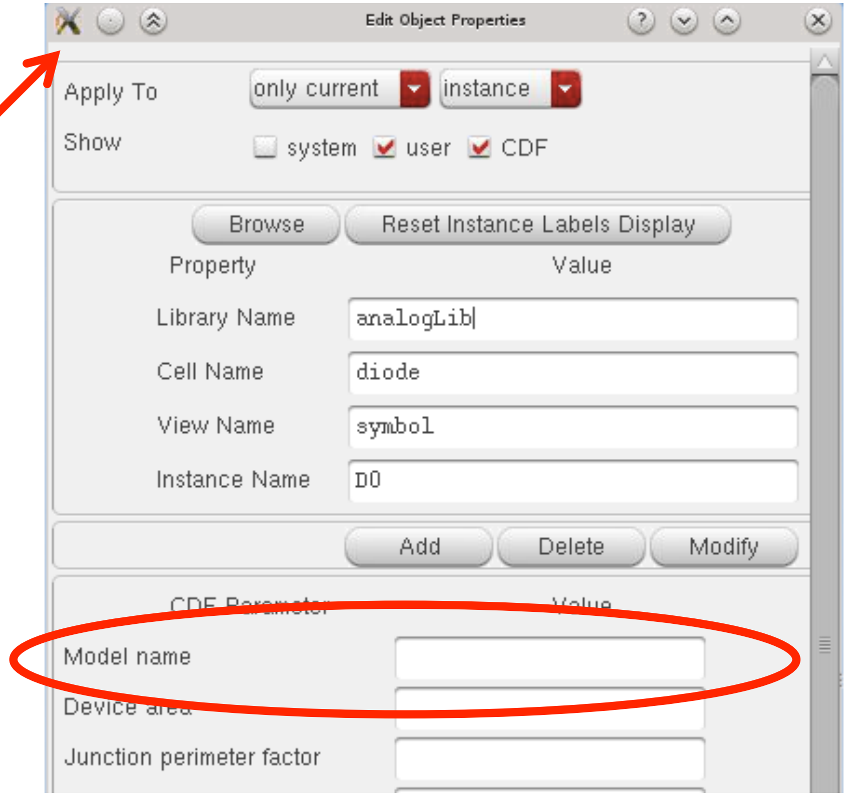
DC Characteristic

- Create the following schematic.
  - The diode is taken from `analogLib`
  - Note that NO model is associated to this 'generic' diode



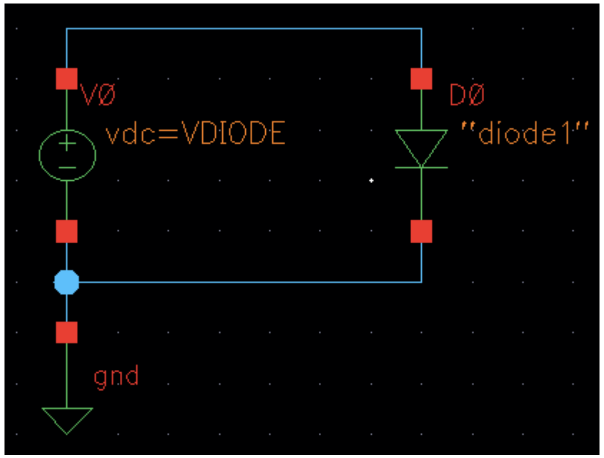


Trying a DC simulation

- Perform a DC simulation of VDIODE from 0…1V
  - An error occurs:

```
Error found by spectre during hierarchy flattening.
    ERROR (CMI-2119): D0: Instance (of type diode) requires the use of a model.
```

- Now assign a model with name '`diode1`' to the diode:



- Run the simulation again. You get a *different* error:

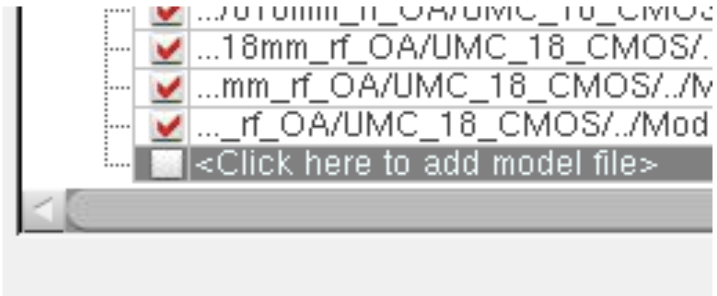
```
Error found by spectre during circuit read-in.
    ERROR (SFE-23): "input.scs" 36: The instance `D0' is referencing an undefined model
```

Defining a Model

- Create a text file `MyDiode.lib` with the following model definition:

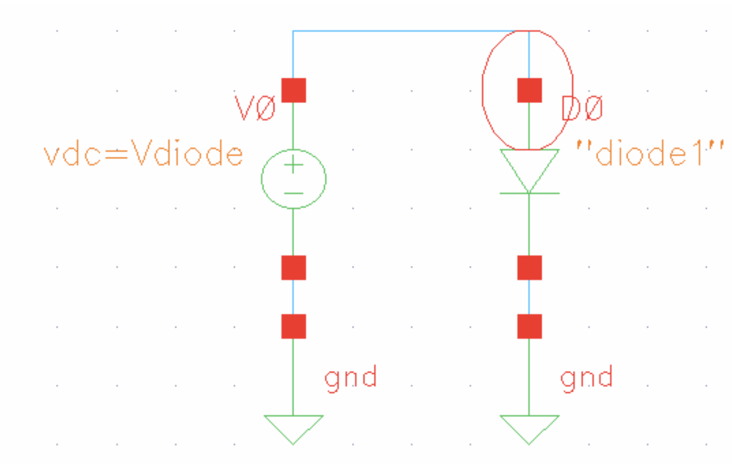
```
.MODEL diode1 d
+IS=1e-08 RS=0.05 N=1.5 EG=0.6
+XTI=0.05 BV=50 IBV=5e-08 CJO=1e-11 VJ=0.7 M=0.5
```

- The simulator needs to know about this file:
  - In `Setup->Model Libraries...`, add the file `MyDiode.lib`.

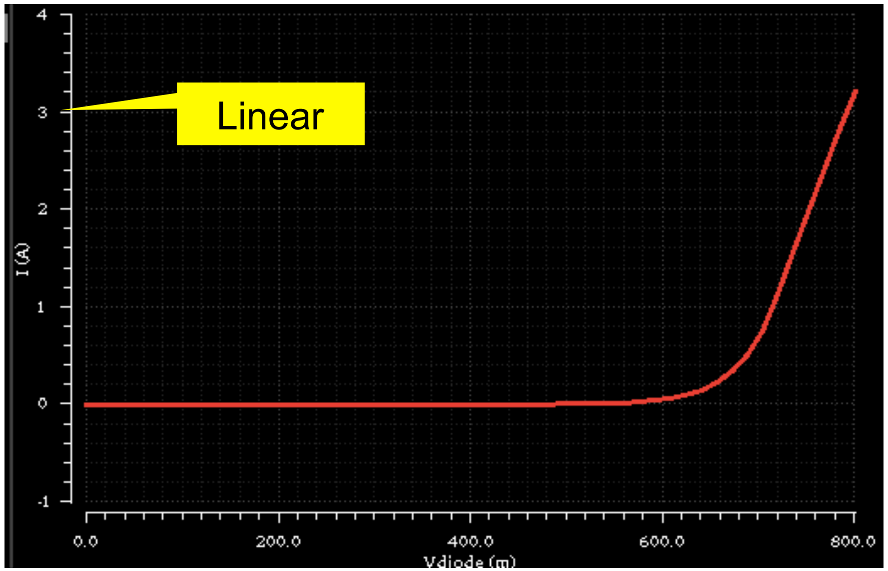


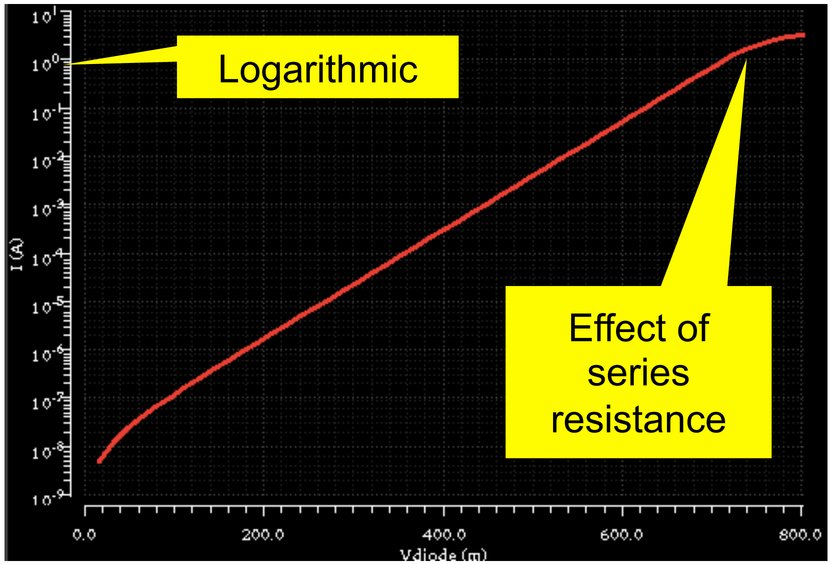
- Run the simulation again.

Solution 6.0



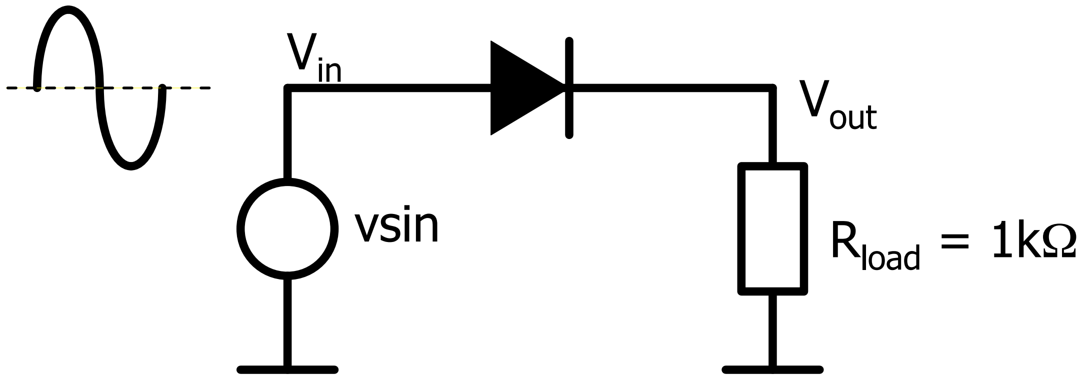
- Current rises exponentially





Exercise 6.1: Simple Rectifier

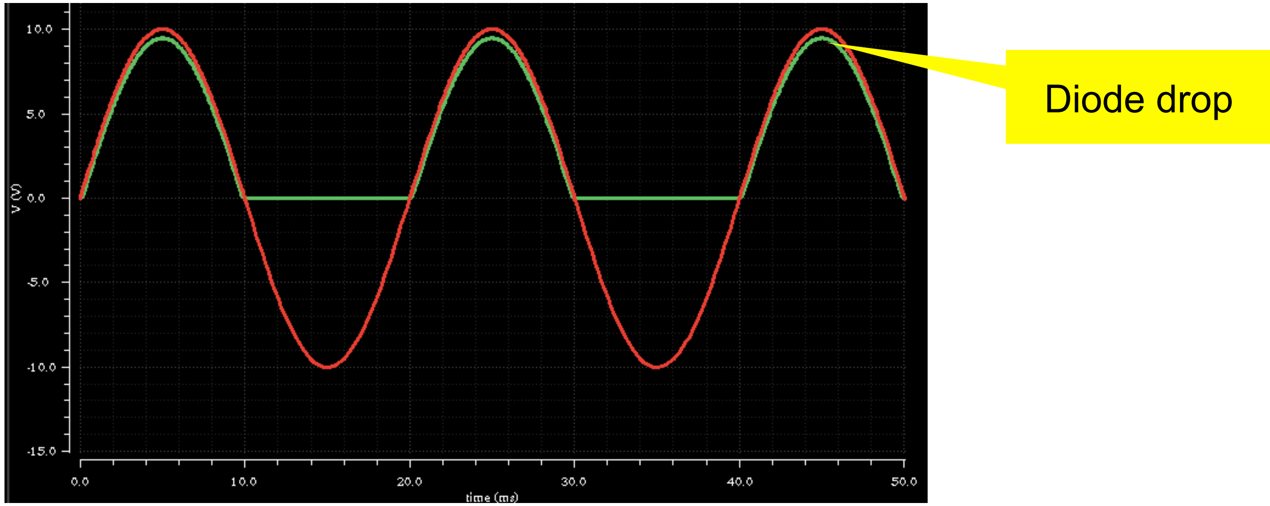
- The diode can be used to generate a DC voltage from an AC voltage. In the simplest case, the negative parts of the AC wave are cut away:



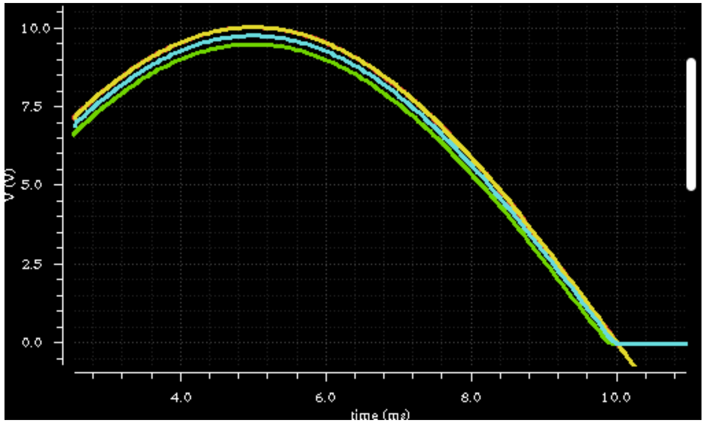
  - Use a sinusoidal source vsin from analogLib (transient sim…) Set parameters Frequency = 50Hz (half way down in the parameter list), Offset = 0, Amplitude = 10V
  - Look at V_{out}. What is the peak amplitude. Why not 10V?
  - Change R_{load} to 1MΩ. How does the peak amplitude change?
  - Go back to R_{load} = 1kΩ. Add a capacitor of 1uF in parallel to R_{load}. What happens?
  - Which C do you need to guarantee V_{out} > 8V? Calculate!

Solution 6.1

- The voltage at the resistor rises to ~10V. This leads to a current of ~10V/1k ~ 10mA. This current leads to a (nonlinear) drop on the diode

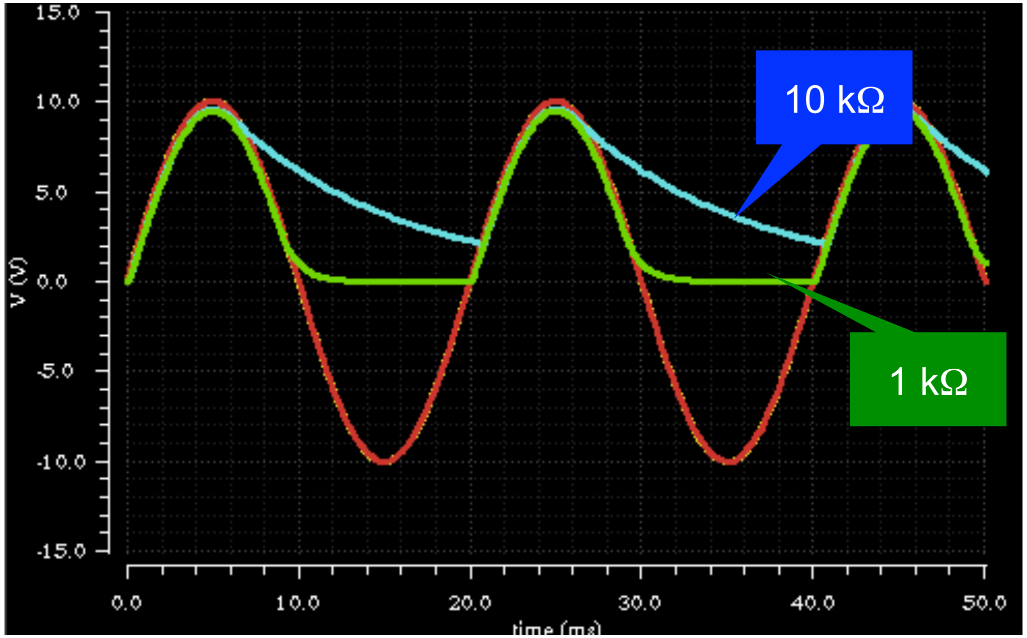


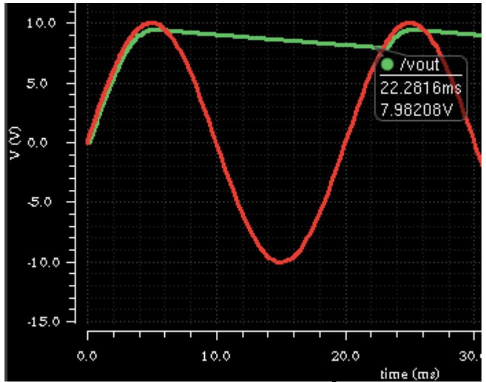
- At higher R, current is smaller and drop is smaller.



Solution 6.1

- The cap is charged and keeps the voltage at the output high.
- It is then discharged by R_{load} with time constant $\tau=R_{load}C$
- Discharge is slower for higher load resistors (and higher C).

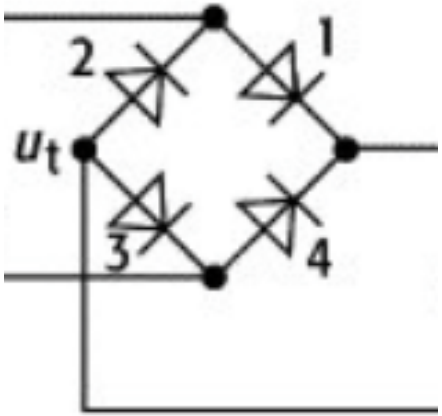


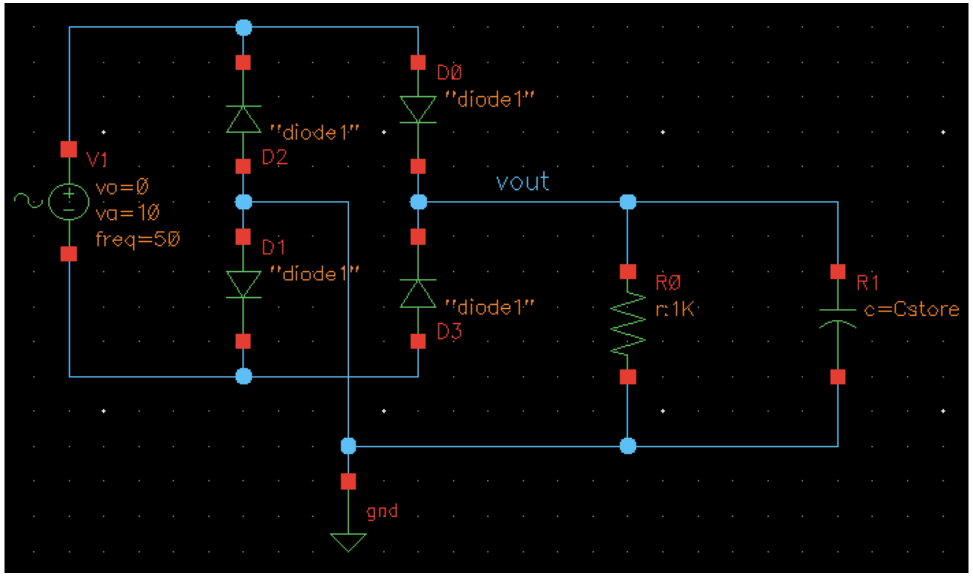


- Initial drop is dU/dT = I/C.
  This must be ~ 2V in 20ms to reach 8V.
  Therefore: C = I dT / dU = 10V / 1kΩ x 20ms / 2V = 100 uF

Exercise 6.2: Full Wave Rectifier

- The full wave rectifier ('Graetz') uses 4 diodes to utilize the negative half-wave as well:
  - make a Schematic

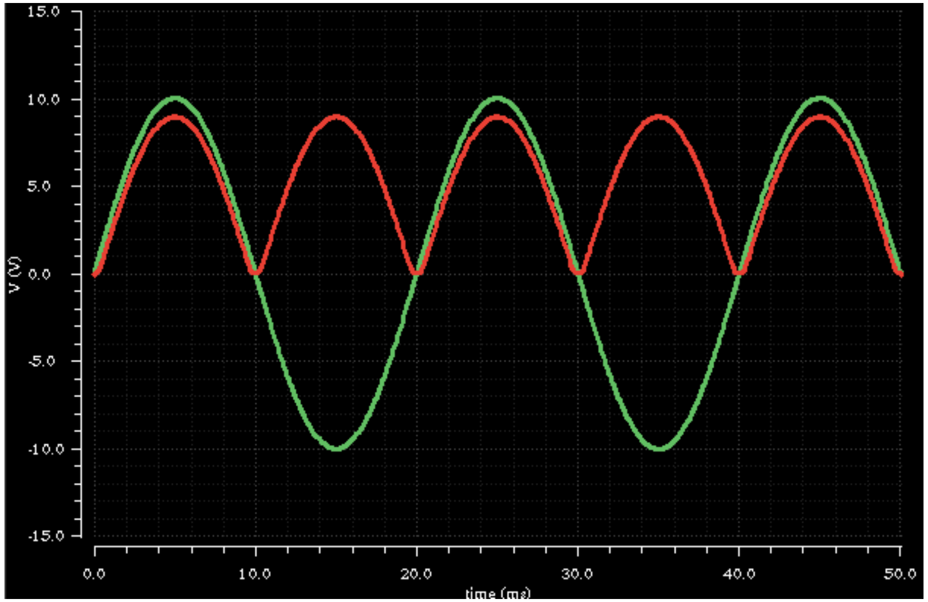




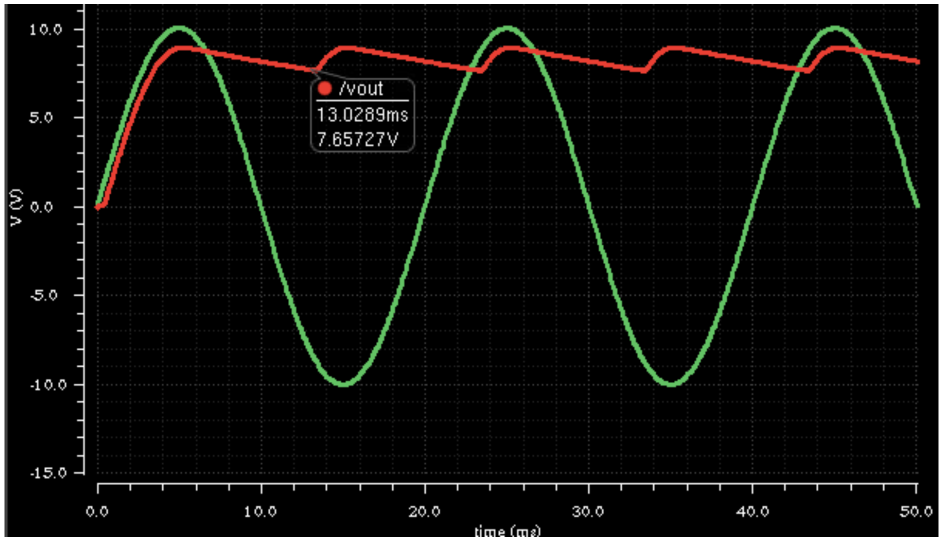
- How does V_{out} look like for C_{store} = 0
- How does the circuit work?
- What is the peak amplitude? Why?
- What C_{load} do you need to guarantee V_{out} > 8V? Calculate!

Solution 6.2

- The diodes provide a current path for both sine polarities.
- Two diodes in the path lead to twice the drop.

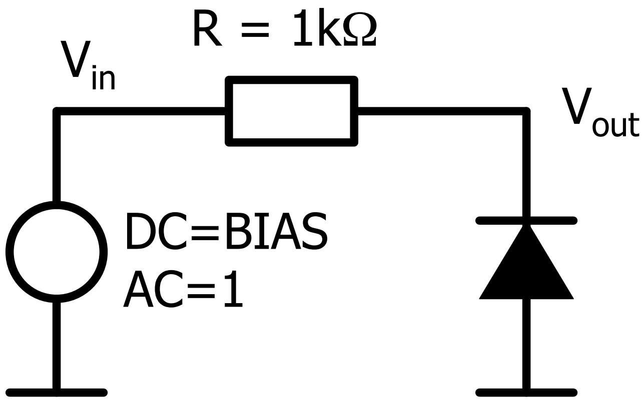


- Time is now half, so that half the cap is sufficient (50uF)



Exercise 6.3: Diode Capacitance

- A voltage dependent capacitance is part of the diode model.
- Implement the following circuit:




```
.MODEL diode1 d
+IS=1e-08 RS=0.05 N=1.5 EG=0.6
+XTI=0.05 BV=50 IBV=5e-08 CJO=1e-11
+VJ=0.7 M=0.5 FC=0.5 TT=1e-09
```

- Make an AC sweep from 1M to 1G or so for BIAS = 1V
  - What is the corner frequency?
- Change BIAS to 10V or 0.5V
  - Does the corner frequency change?
  - Is it changing in the right 'direction'?

Solution 6.3

- Varying DC bias changes capacitance of the diode (higher reverse bias -> smaller capacitance)
- Therefore the corner frequency varies: