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Exercise:
Simulating a Diode

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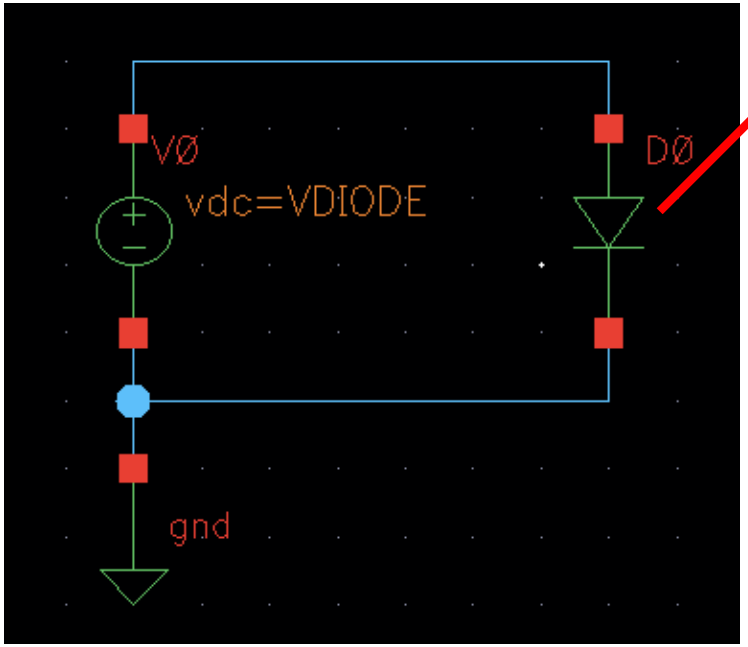
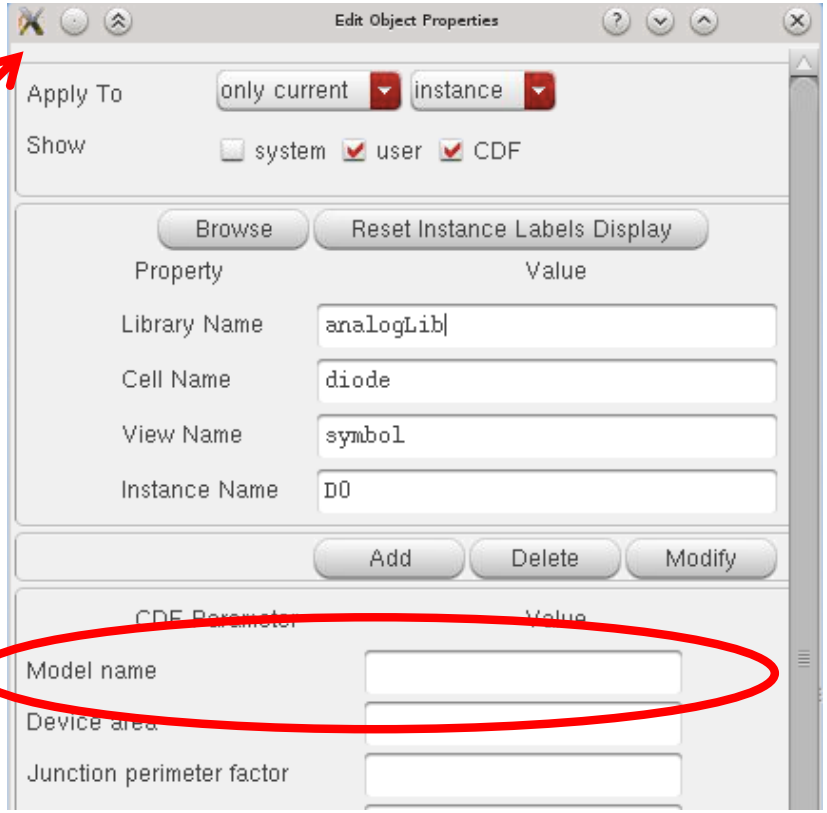
1. Defining a Model

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





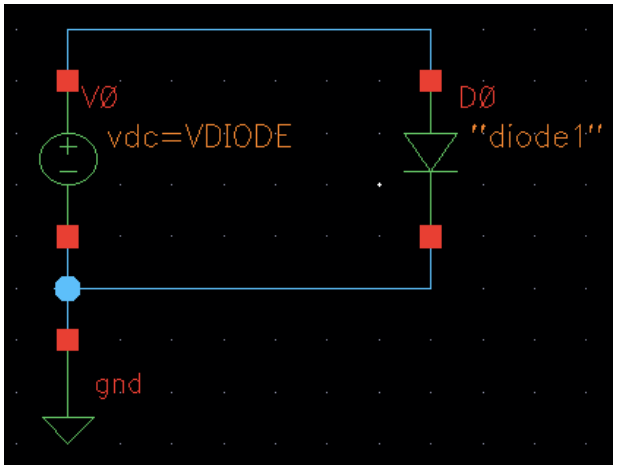
Trying a DC simulation

- Simulate (DC!) the diode current for VDIODE = 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.
```

'No model given'

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



- Run the simulation again:

'model given, but not defined / found'

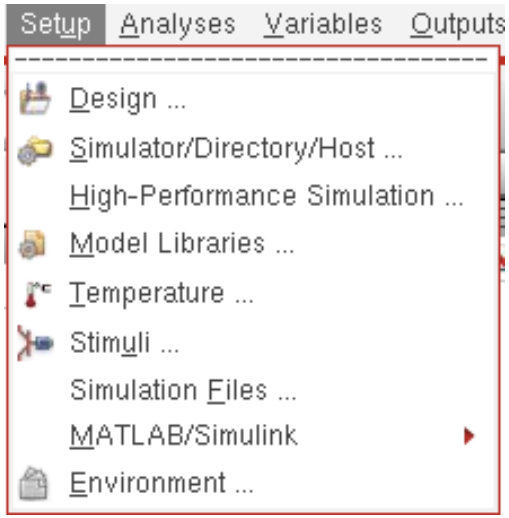
```
Error found by spectre during circuit read-in.
    ERROR (SFE-23): "input.scs" 36: The instance `D0' is referencing an undefined model
```

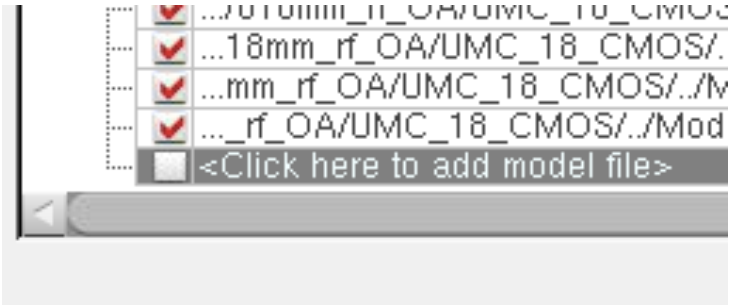
Defining a Model

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

```
.MODEL diode1 d IS=1e-08 RS=1 CJO=1e-11 VJ=0.7 M=0.5
```

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





- Run the simulation again.
- Does the current increase exponentially? Try a log current scale! Sweep only to 0.4V! Why does I(U) become linear?

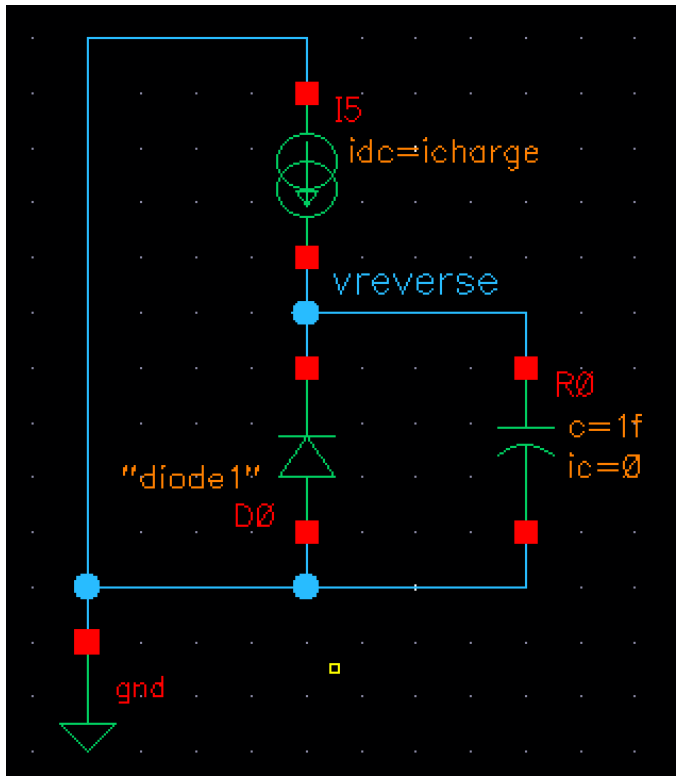
2. Different Models

- Instantiate a second diode with another model '`diode2`'
- Add model '`diode2`' to your `MyDiode.lib`. Change for instance IS to 2e-8.
- Simulate and compare the two diode currents (best in log scale)

- ATTENTION / NOTE:
  - The simulator tries to be efficient and caches the models. If you just change `MyDiode.lib`, the change is not seen. There are (at least) 2 tricks to make sure the new model is used:
    - every time you change the model, use a *different model name* (and update the model name in the schematic)
    - Save `MyDiode.lib` under a *different file name* and include that new file in the model directory dialogue.

3. Capacitance

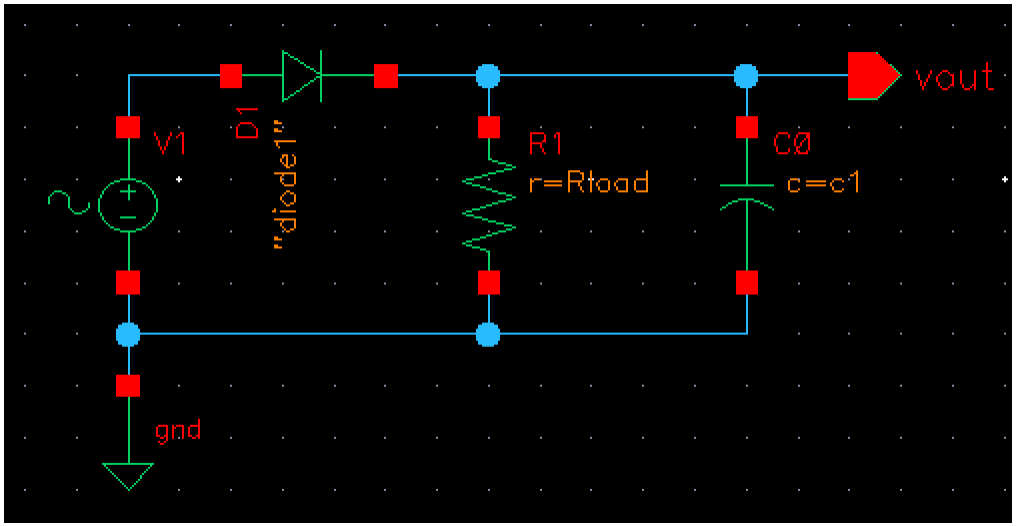
- To see the effect of the diode capacitance, you can charge it with a constant current *icharge*.
  - Make sure the polarity is such that the diode is in reverse bias
  - You can define the start voltage with a very small (1 fF) capacitor in parallel to the diode with an initial condition.



- Find a good value for *icharge* for your transient simulation
- Observe how the diode voltage increases with time. From the slope (calculator tool!), determine the capacitance
- Observe how the capacitance varies with voltage (time)
- Compare to what you expect from the model

4: A Simple Rectifier

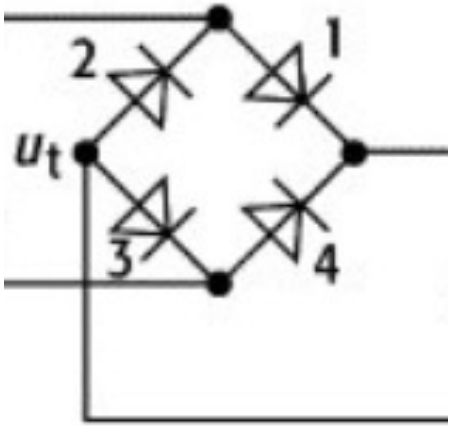
- Alternating voltages can be converted to ‘dc’ with a ‘rectifier’:

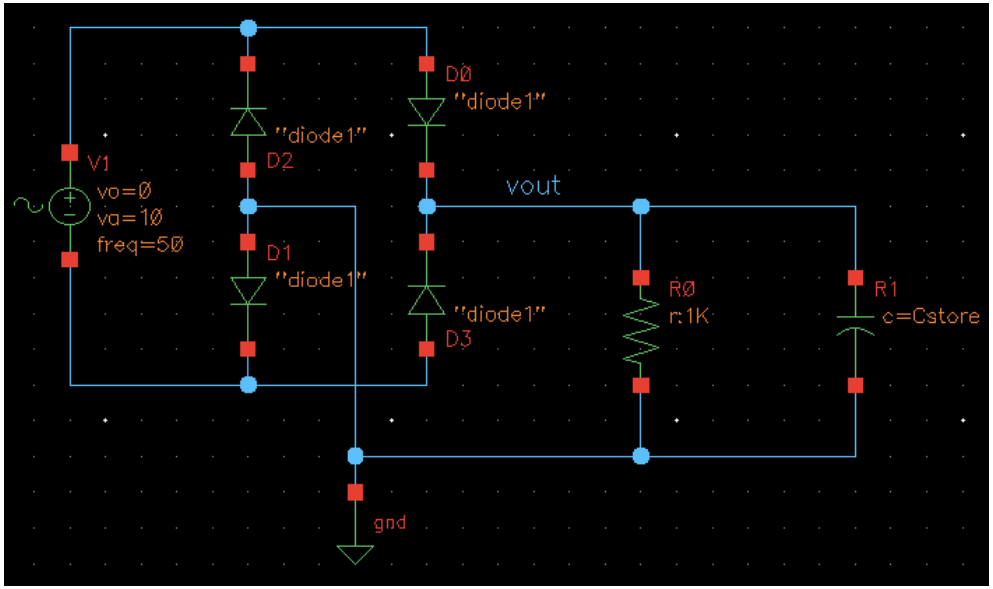


- Make a transient simulation (50 Hz, 10 V, R_{load}=1kΩ, C1=0)
  - Compare `vin` and `vout`. Observe the small difference in voltage. Where does it come from? How does that change with `Rload`?
  - Now set `C1` to 1 µF. Observe how `vout` stays positive even in the negative phases of `vin`. How does this work?
  - What are the effects of changing `Rload` and changing `c1`?
  - Which C is needed to keep V_{out} > 8V for R_{load}=1kΩ? Calculate!

5: Full Wave Rectifier

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

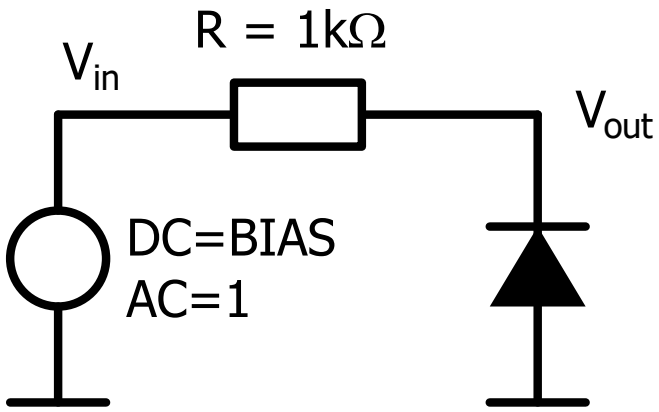




- How does V_{out} look like for C_{store} = 0
- How does the circuit work?
- What is the peak amplitude? Why?
- What C_{load} do you need to guarantee V_{out} > 8V? Calculate!

Exercise 6: Operation Point

- 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'?