Lecture 2. Diode Models and Circuits (Part 2)

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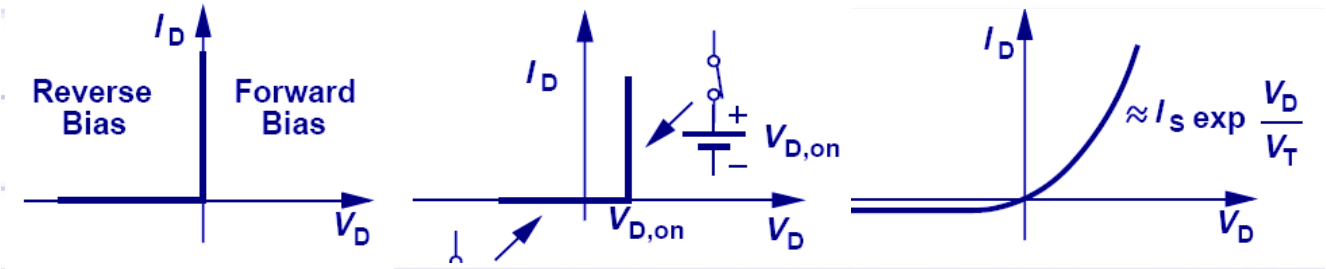
Design of Diode Circuits

- The ideal diode model is usually sufficient to design circuits and understand functionalities
- Use more detailed models for analyzing their limitations in reality

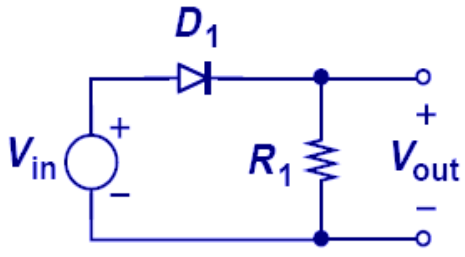


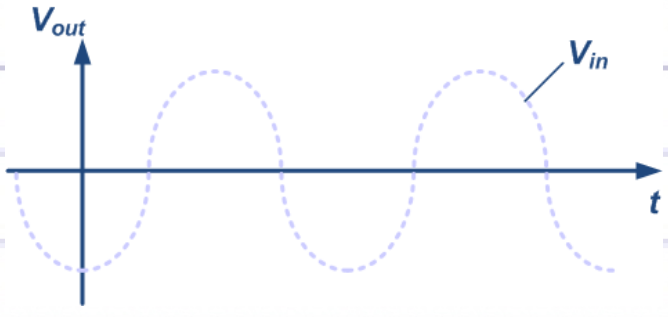
Applications of Diode

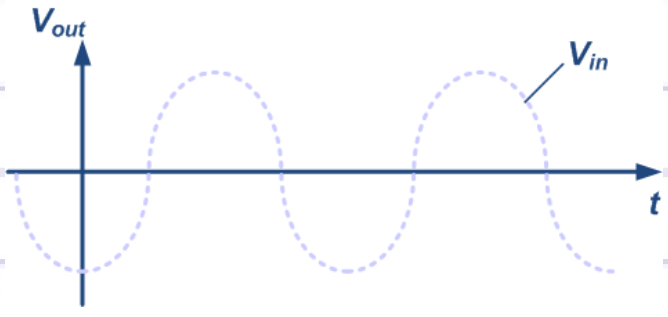
- Rectifiers
- Limiting/clamping circuits
- Level shifters
- Track-and-hold switches

Half-Wave Rectifier with R Load

- Draw V_{out} waveforms assuming ideal and constant-voltage models:

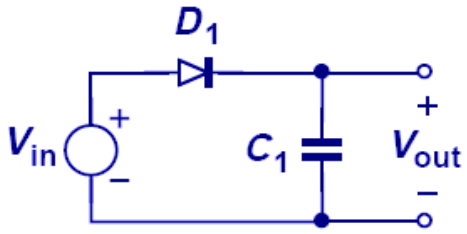


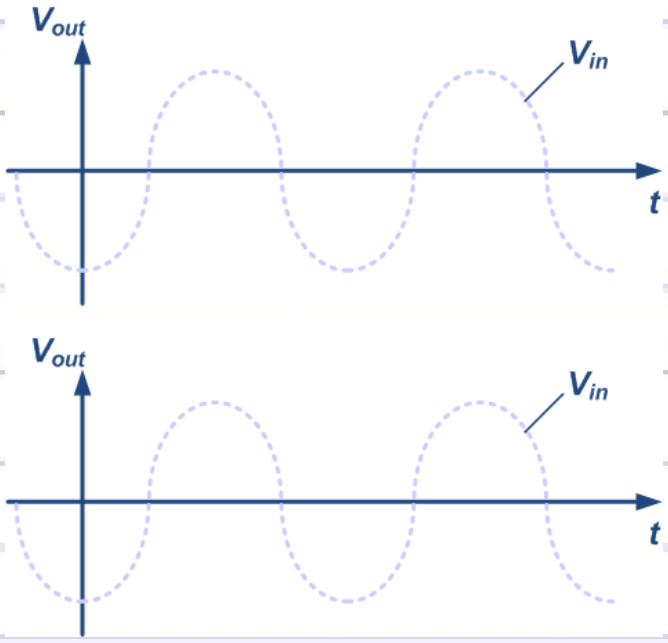




Half-Wave Rectifier with C Load

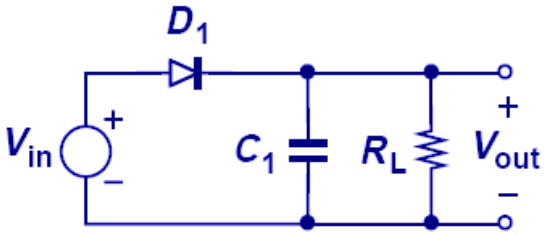
- Repeat for a diode driving a capacitor instead of a resistor:

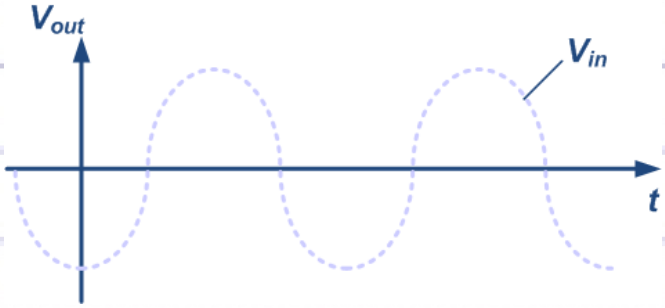




Half-Wave Rectifier with R+C Load

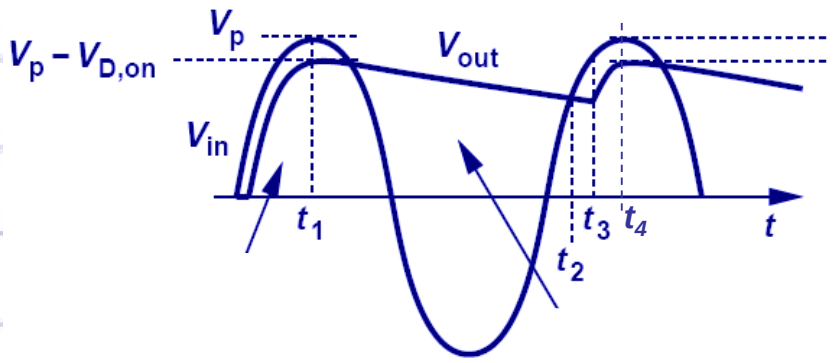
- What about when R_L is of finite value?





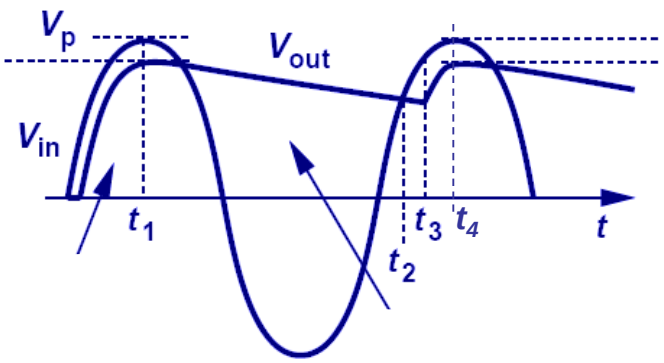
Half-Wave Rectifier Questions

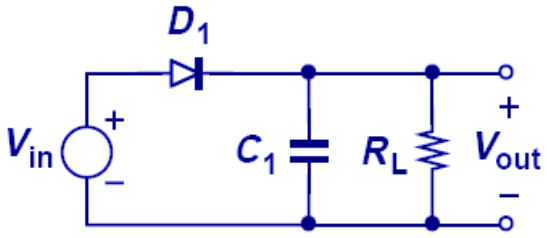
- During which interval the diode is conducting?
- What is the amount of V_{out} discharge (=voltage ripple)?
- When does the diode current reach its maximum?



Half-Wave Rectifier Questions (2)

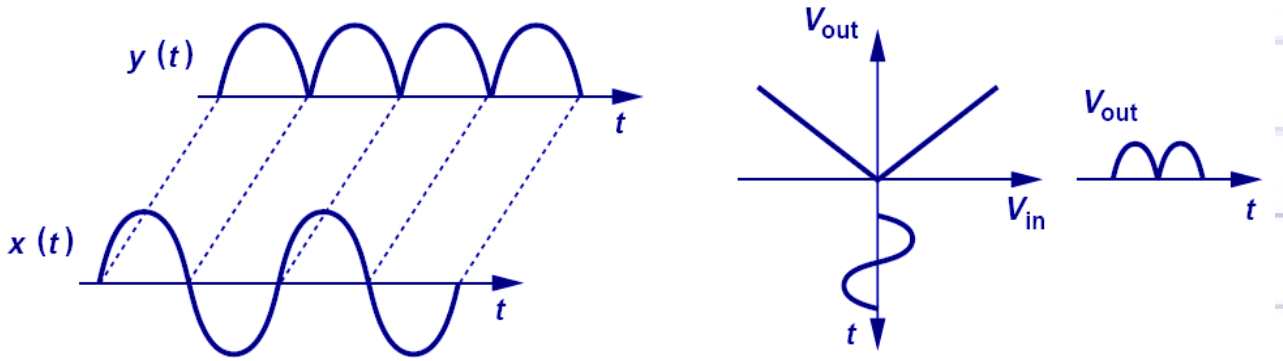
- When does the diode current reach its maximum?



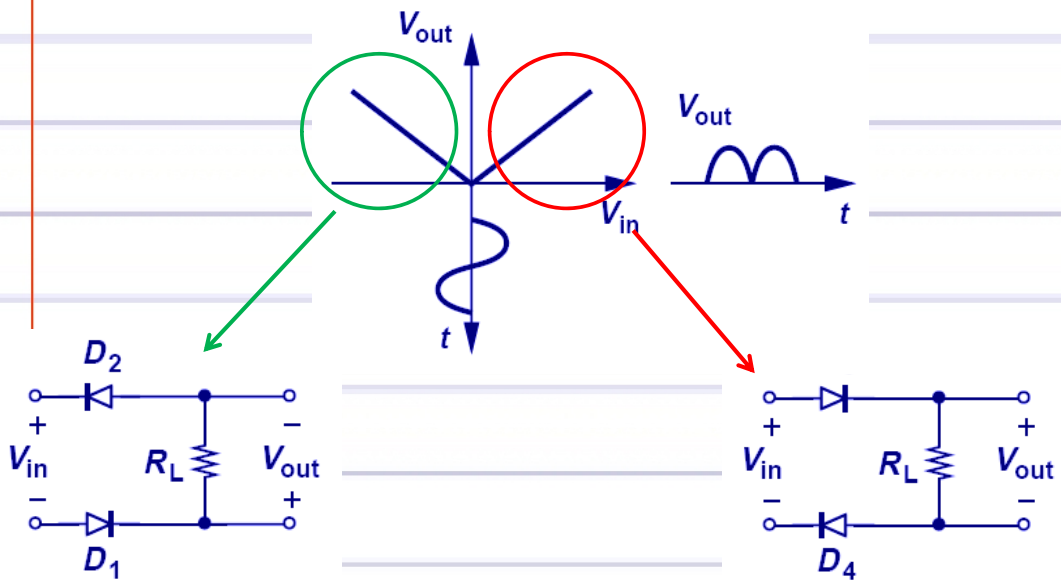


Full-Wave Rectifier

- Throwing out a half of the input energy seems wasteful; can we realize a I/O-curve like below?

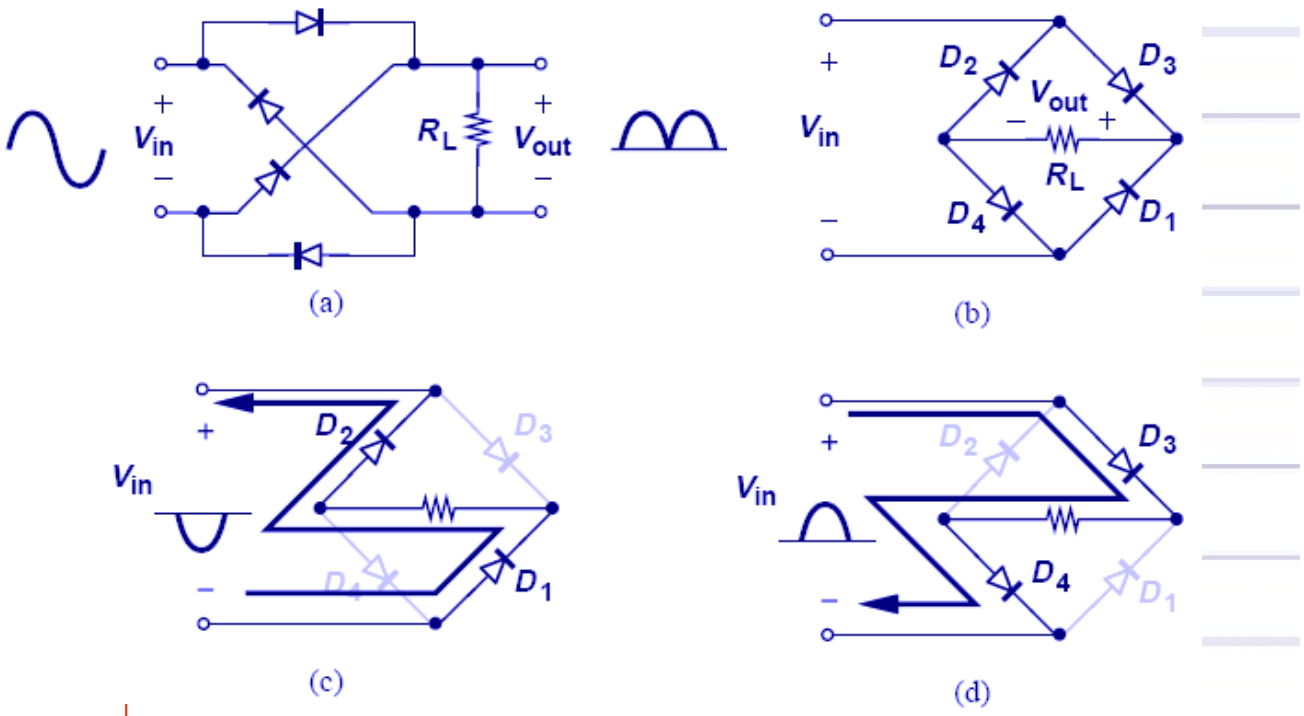


Full-Wave Rectifier



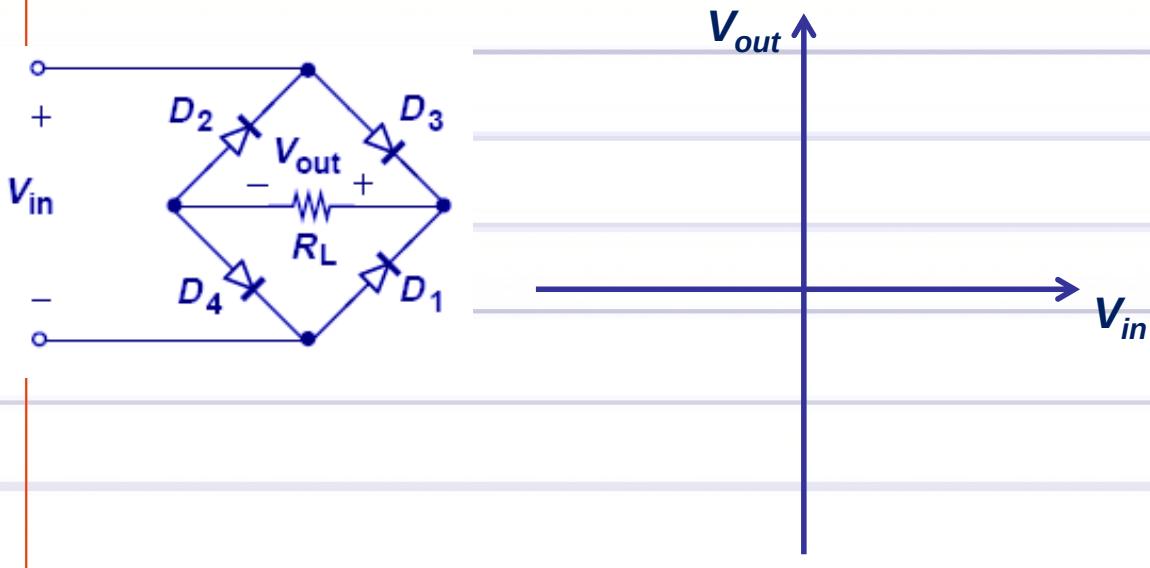
- Can we combine these two circuits into one?

Bridge Rectifier

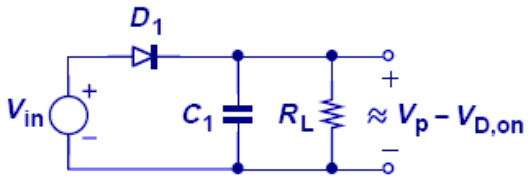


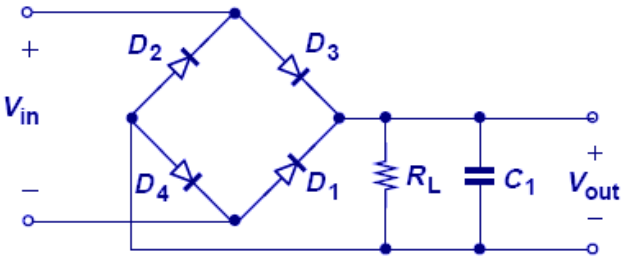
Example 3.29

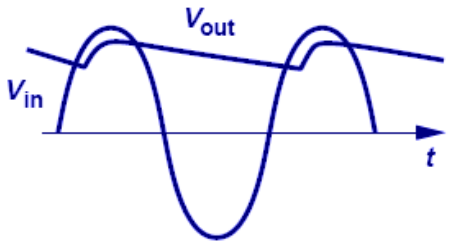
- Plot the I/O characteristic of a full-wave rectifier assuming a constant-voltage model



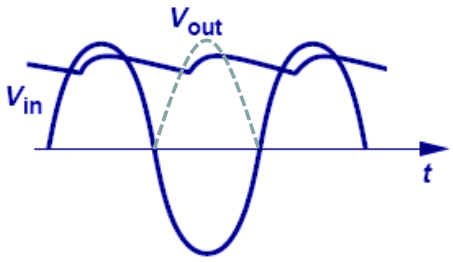
Half-Wave vs. Full-Wave Rectifiers







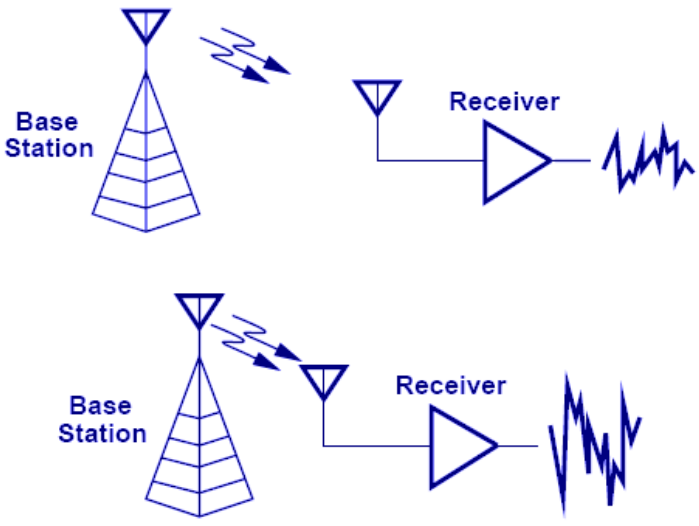
Reverse Bias $\approx 2V_p$



Reverse Bias $\approx V_p$

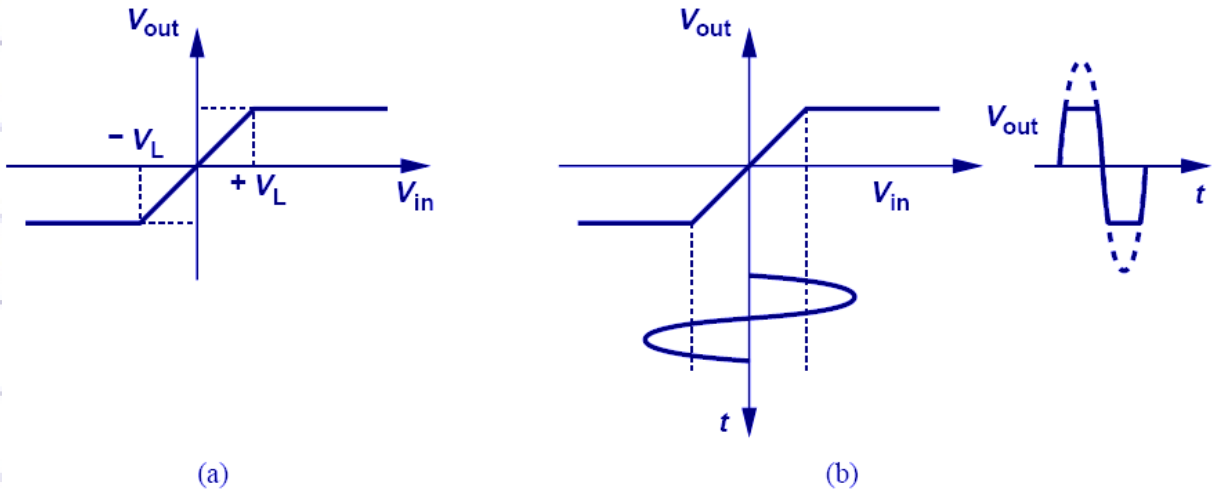
Limiting Circuits

- Sometimes, there is a need to limit the maximum amplitude of the input signal



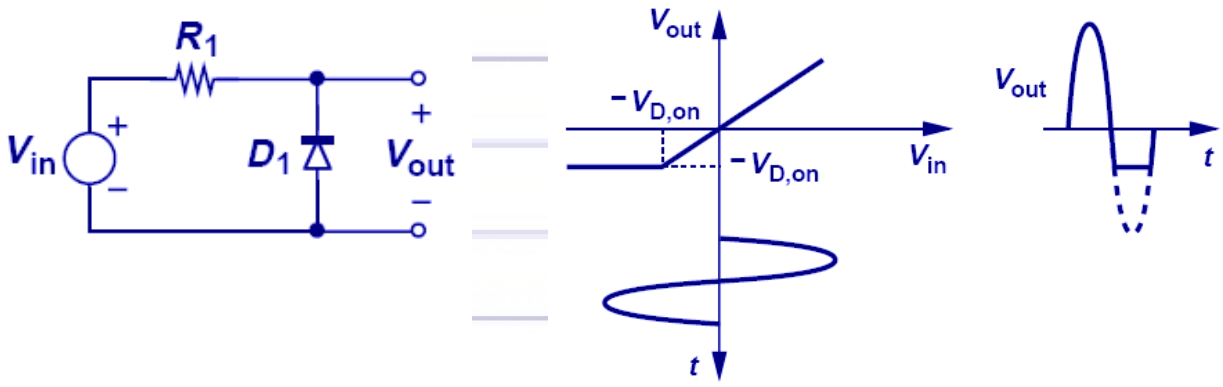
Desired I/O Characteristics

- How would you realize this with diodes?



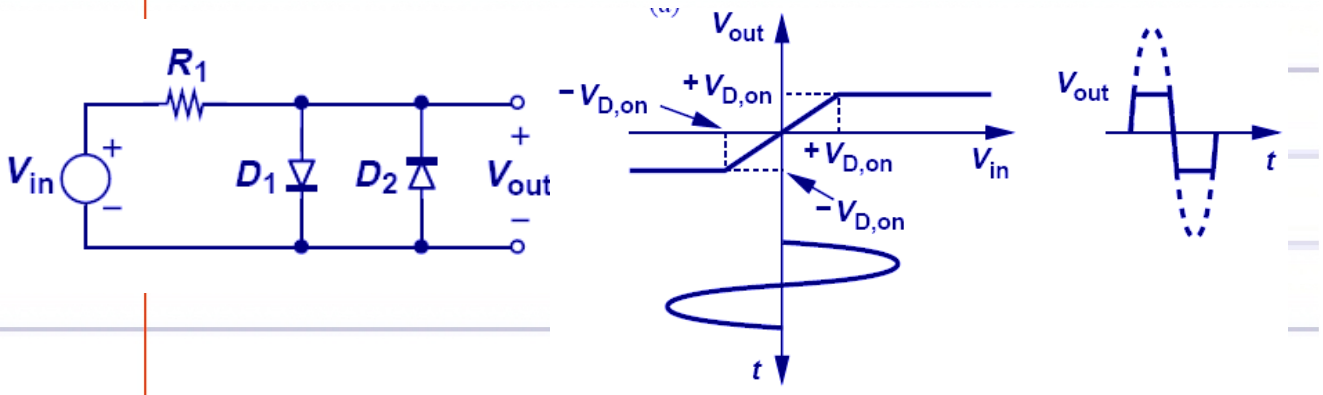
Limiting Circuit (1)

- Start with a negative-clipping circuit



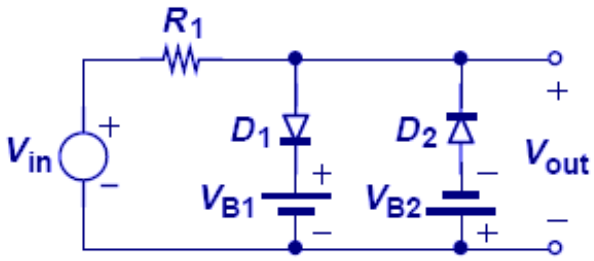
Limiting Circuit (2)

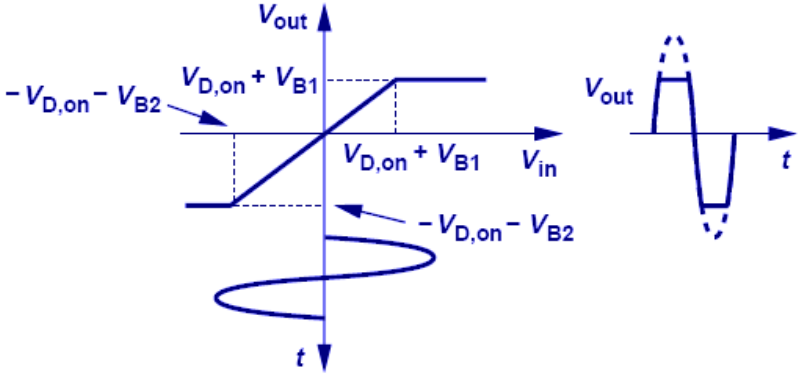
- And add a positive-clipping diode



- How can we change the voltage limits?

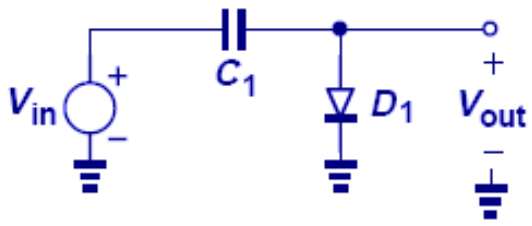
General Voltage Limiting Circuit

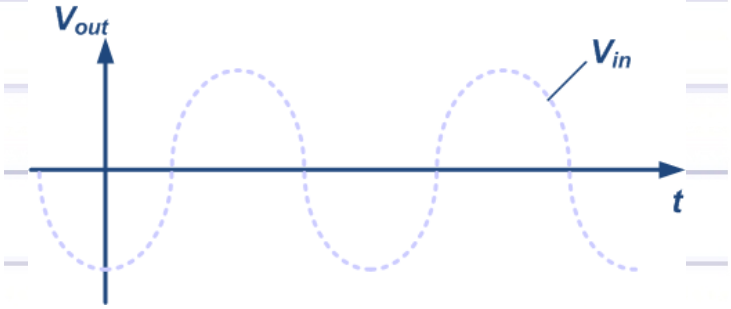




Waveform Shifter

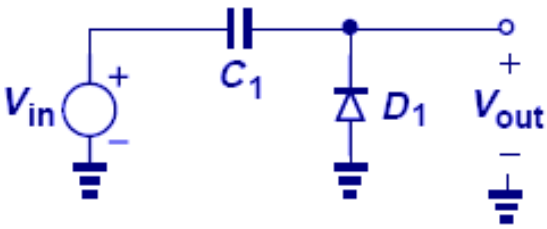
- For a sinusoidal V_{in} ($=V_p \cos\omega t$), what is the final voltage across C_1?
  - And, what is the relationship between V_{in} & V_{out}?

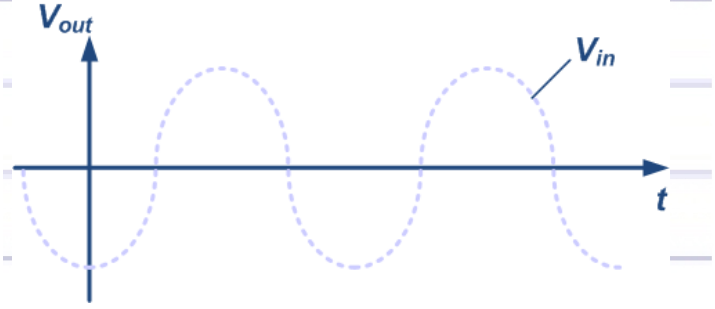




Waveform Shifter (2)

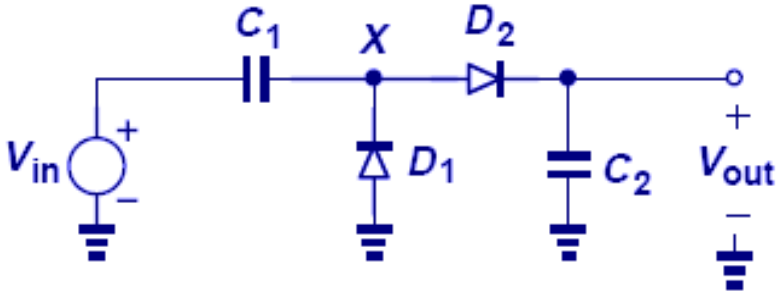
- What happens now when the diode is flipped?





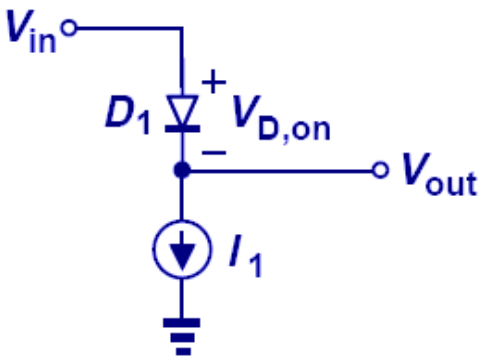
Voltage Doubler

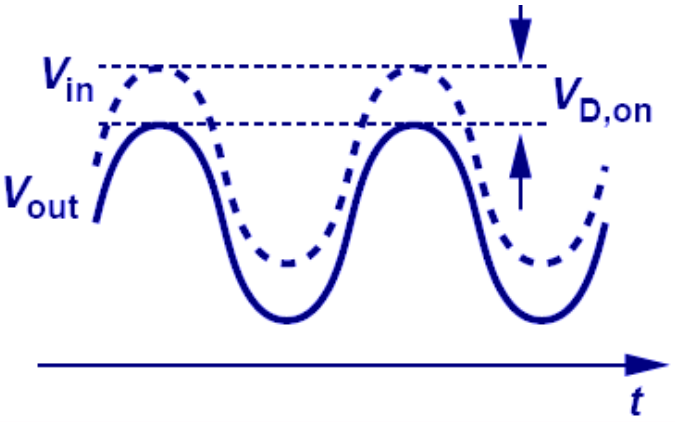
- $V_{in}=V_p\cos\omega t$, what is the final voltage for V_{out}?



- For details on transient behaviors, see the text

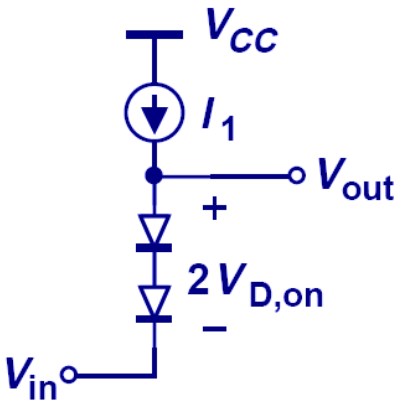
Voltage Shifter

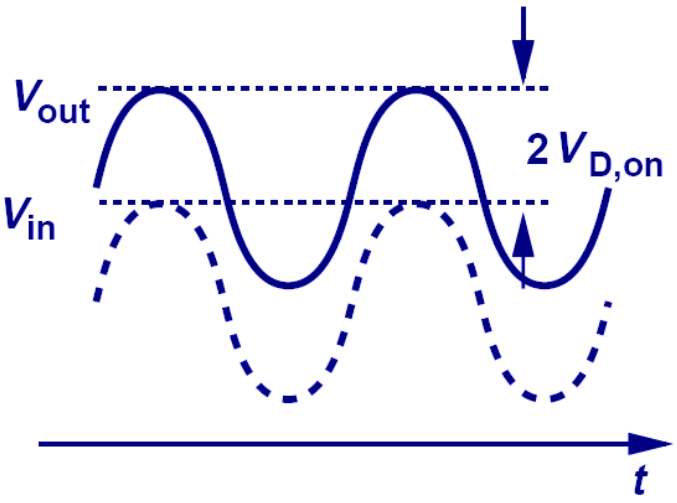




- What is the model that reflects the design intent?

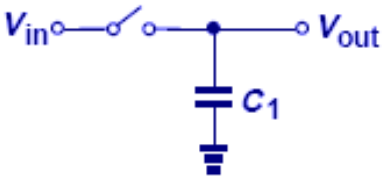
Voltage Shifter (2)





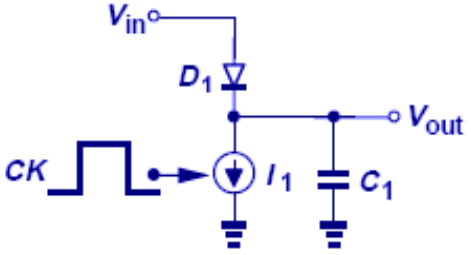
Diode as Switch

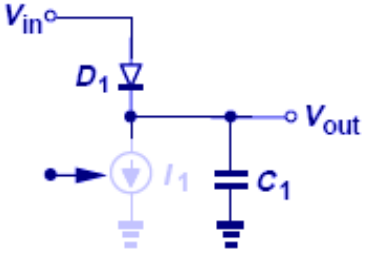
- Want to build this using diode:



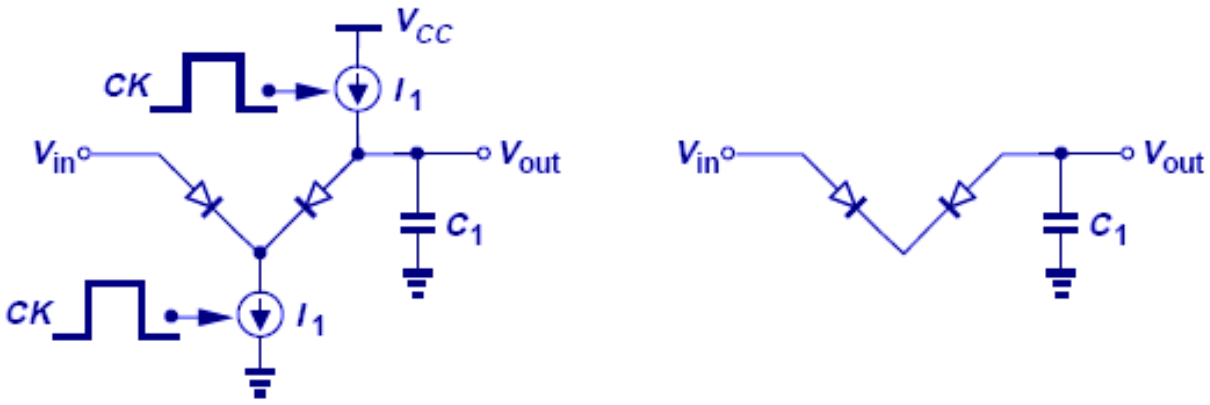
"Track-and-Hold"

- Will this circuit work?

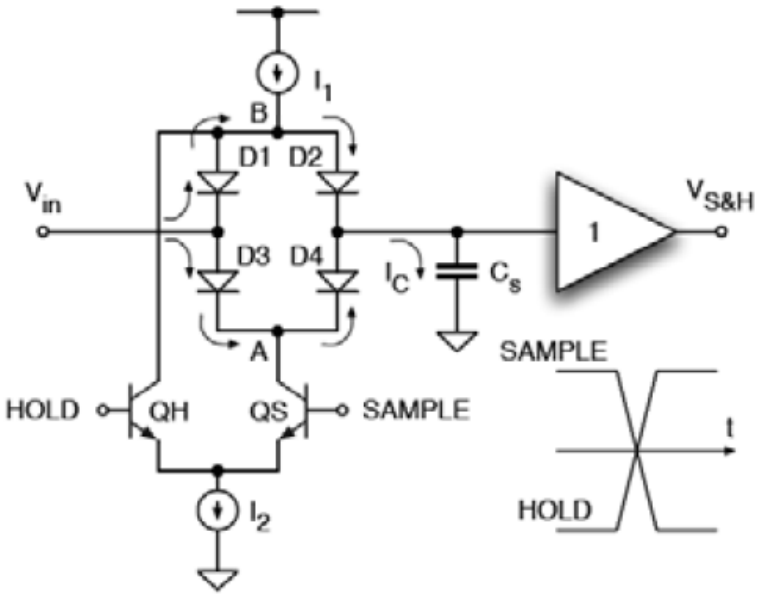




Diode as Switch (2)



Diode Bridge T&H Switch



- Used for multi-GHz sampling in BJT technologies