Lecture 15

Diode Circuits

Today we will analyze a variety of diode circuits that are used for different purposes.

Different Model, Different Result

We will compare the results obtained using up to 3 different diode models: ideal model, large-signal model, and small-signal model.

- ❖ If we skip analysis using a particular model due to time constraints, do the analysis at home for practice!

What Happens When Diode Direction is Reversed?

Each circuit behaves somewhat differently when the diode's polarity is reversed.

- ❖ Practice these analyses for each circuit, reversing the directions of the diodes.

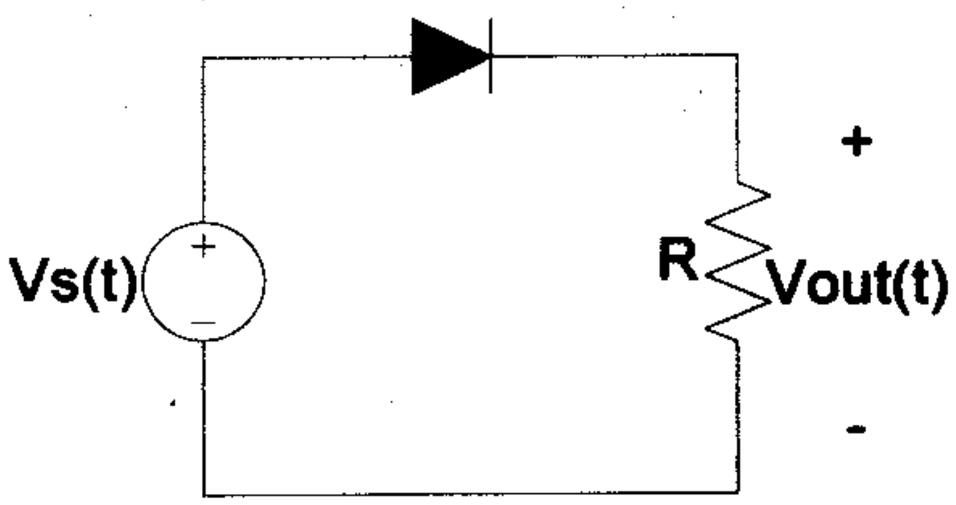
Model Parameters

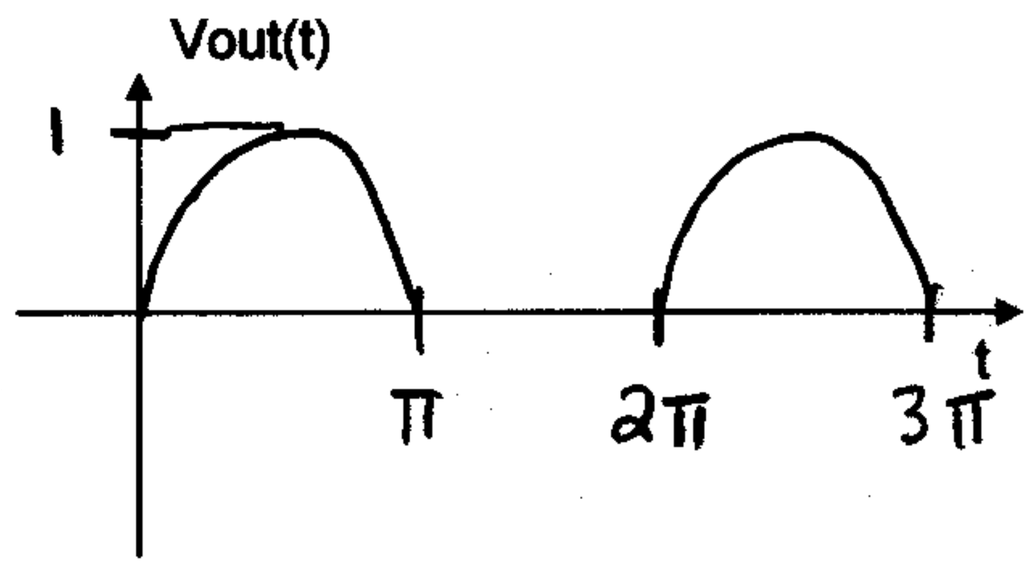
For the analyses to follow, we will assume $V_F = 0.7$ V and $R_D = 20\ \Omega$.

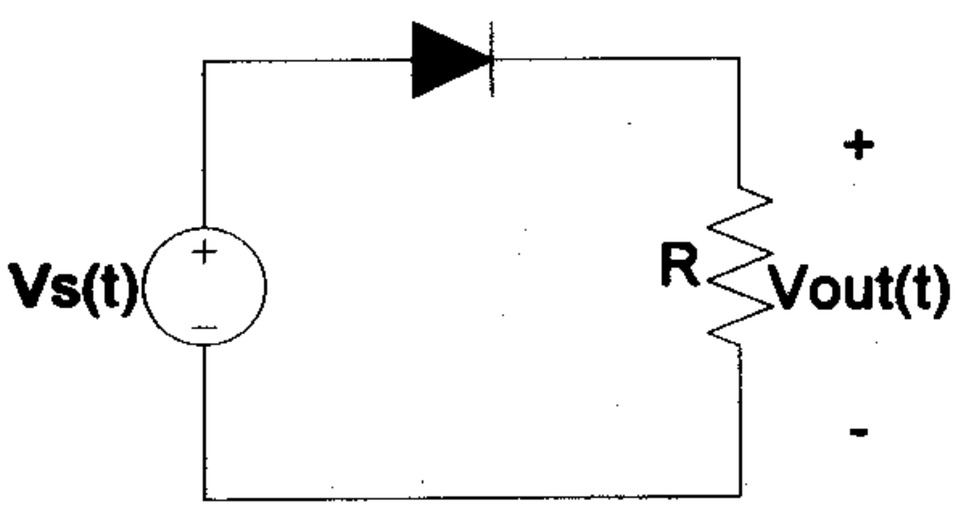
Circuit 1: Half-Wave Rectifier

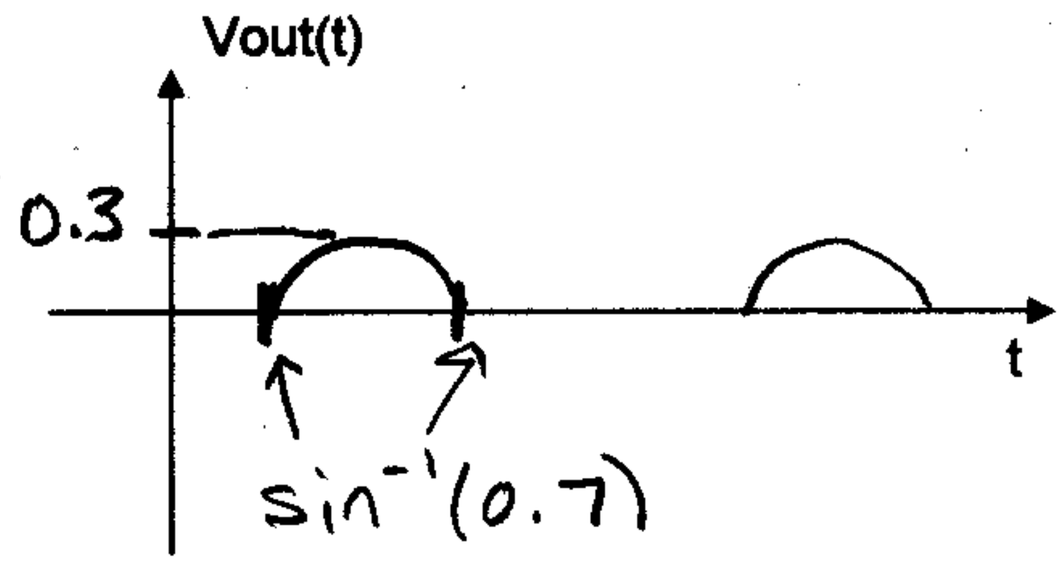
Let Vs(t) = sin(t), R = 20 Ω.

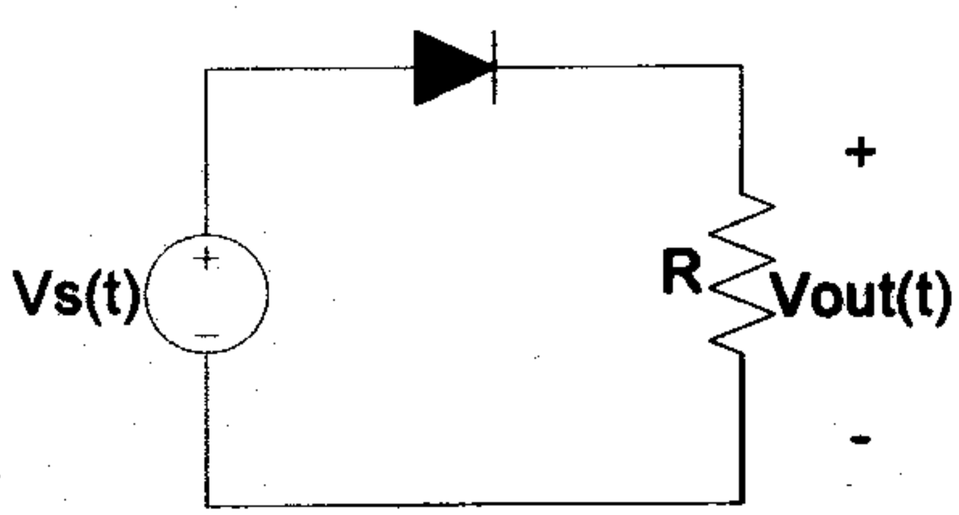
Sketch Vout(t) for the ideal diode model, large-signal model, and small-signal model.

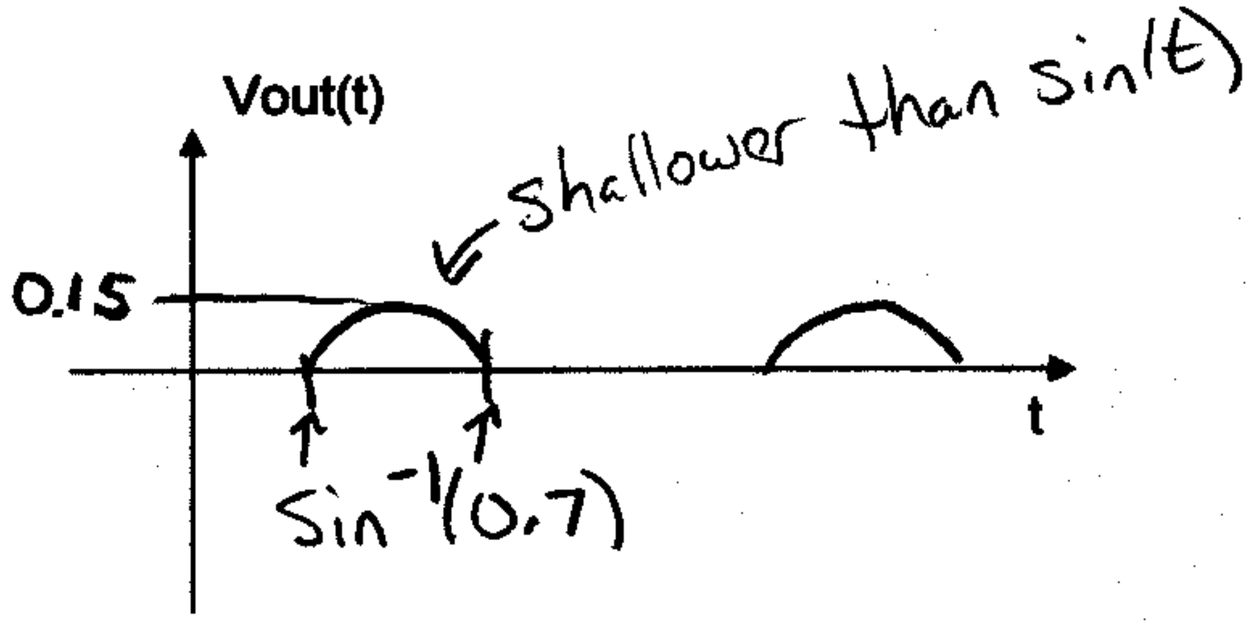








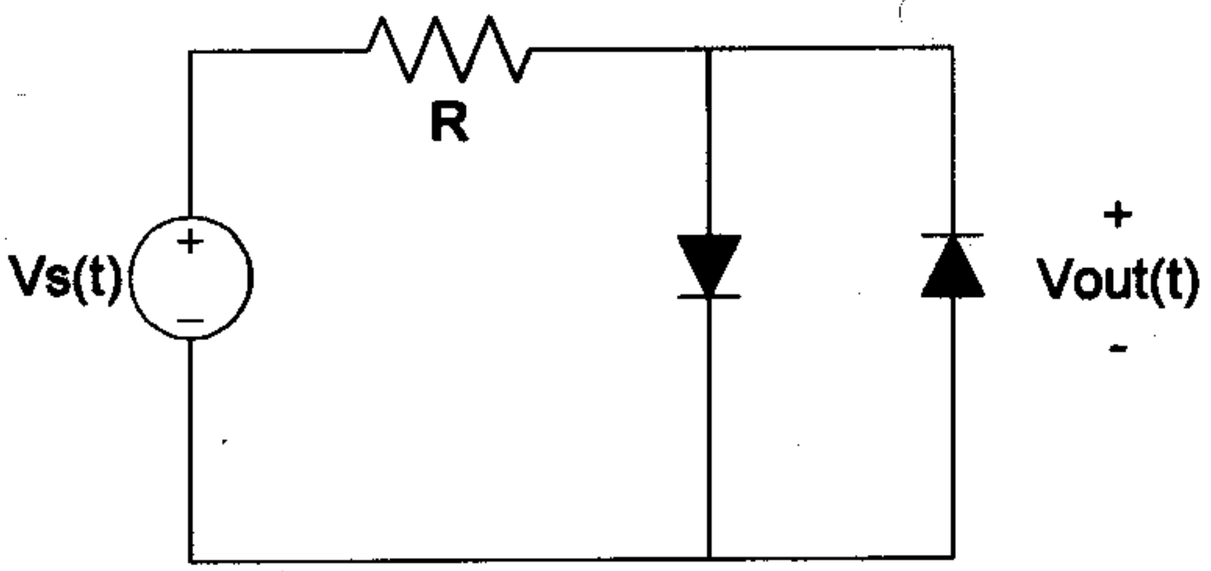


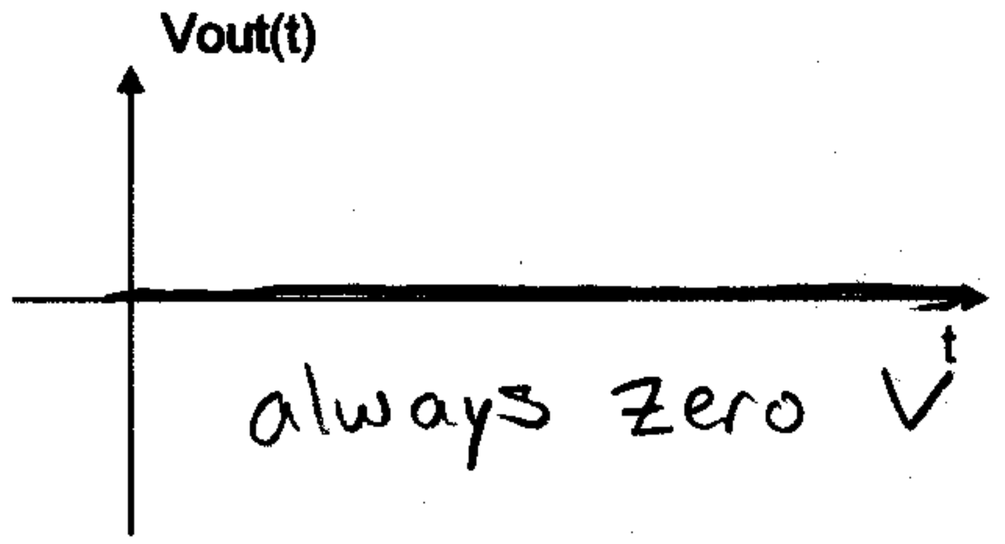


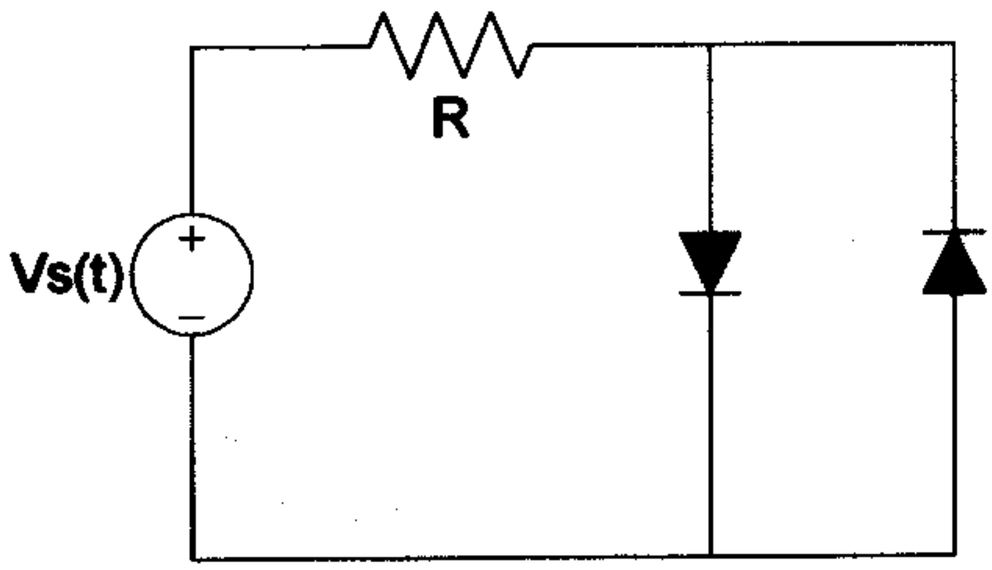
Circuit 2: Clipper

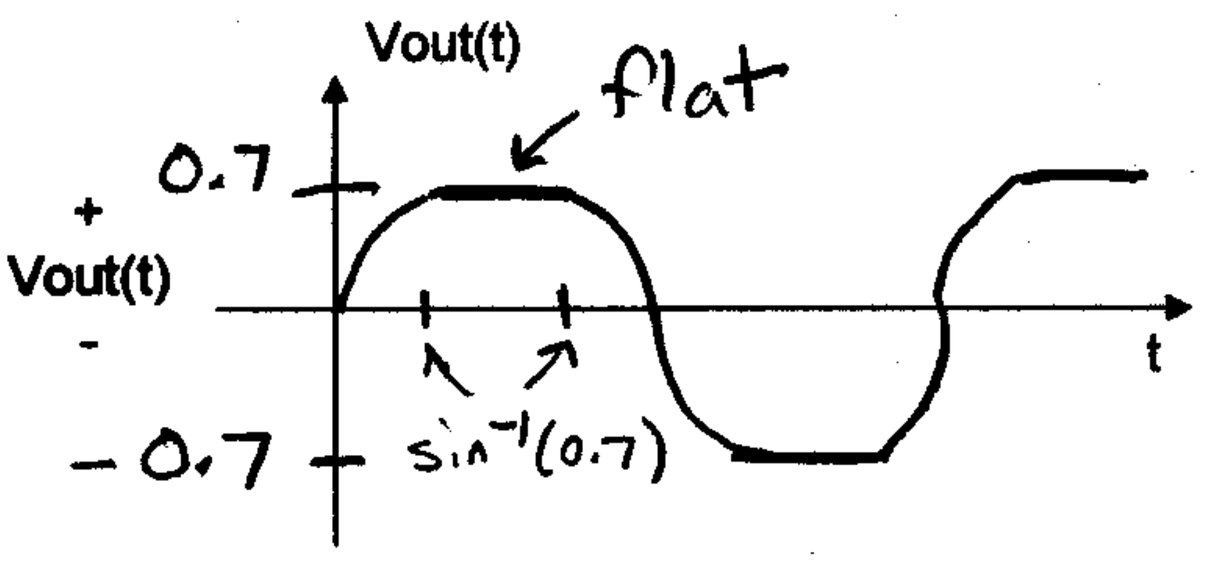
Let Vs(t) = sin(t), R = 20 Ω.

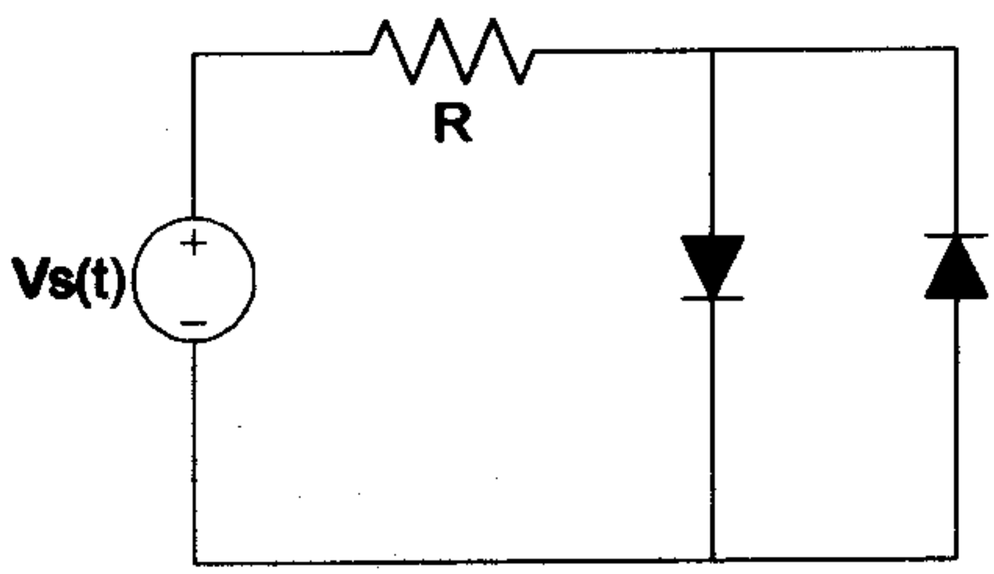
Sketch Vout(t) for the ideal diode model, large-signal model, and small-signal model.

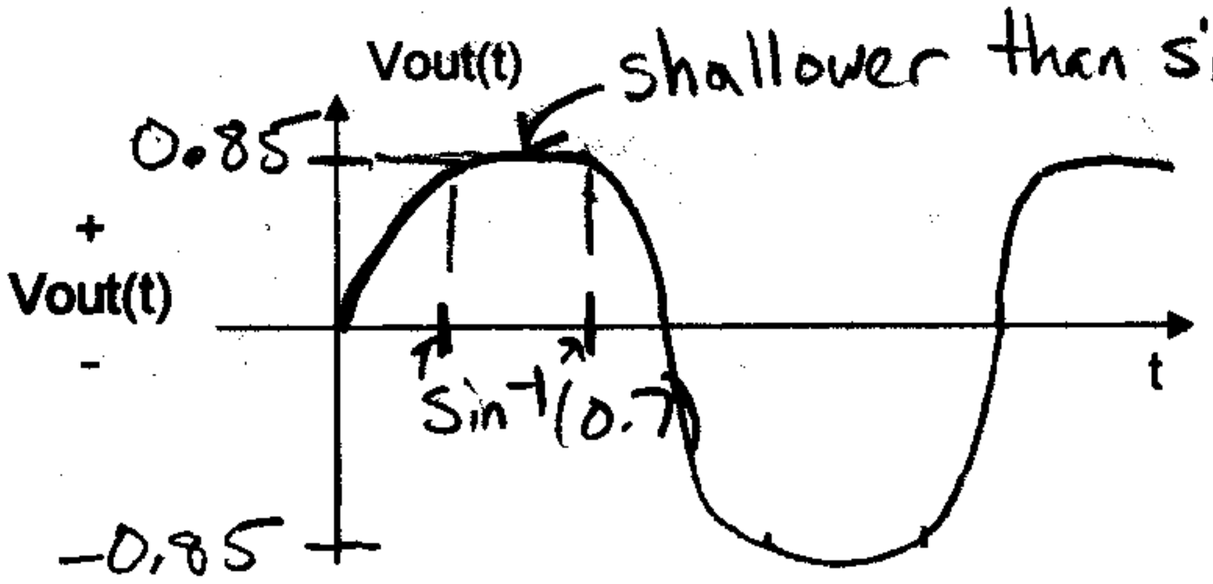








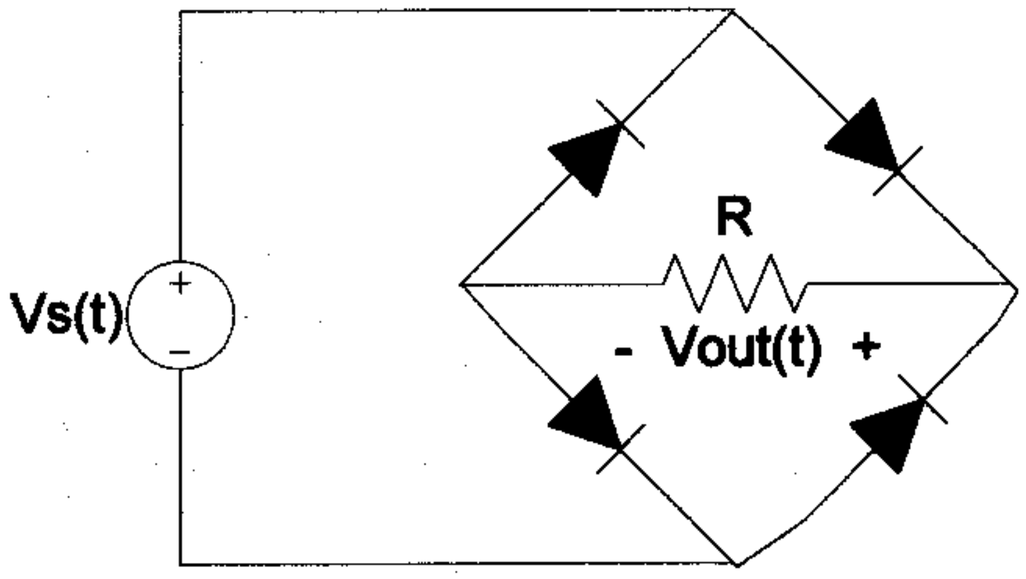


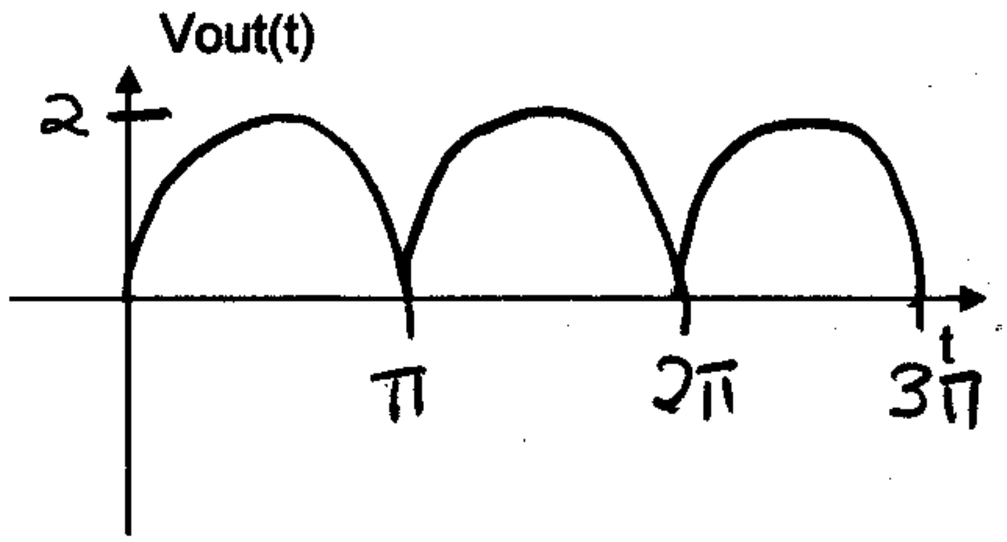


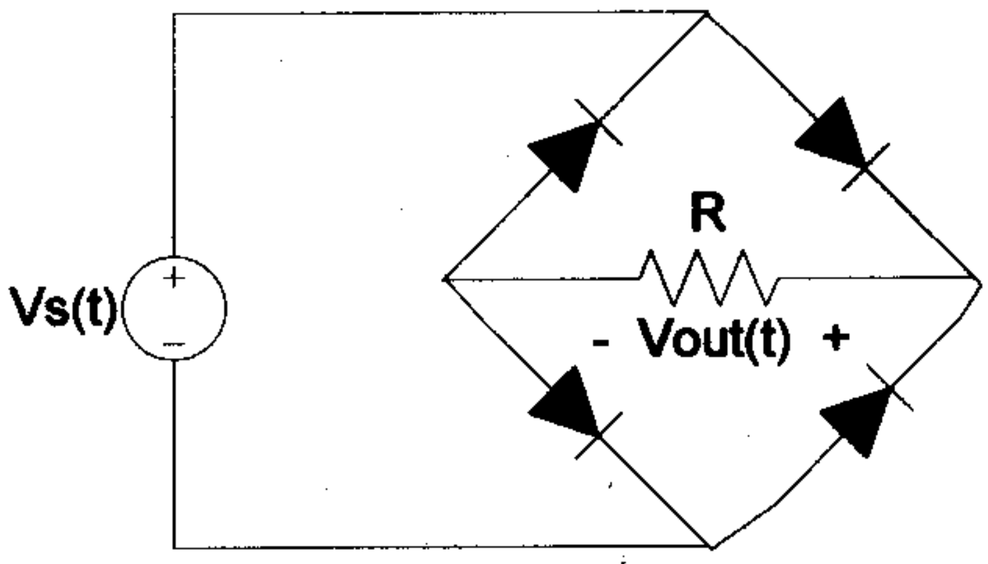
Circuit 3: Full-Wave Rectifier

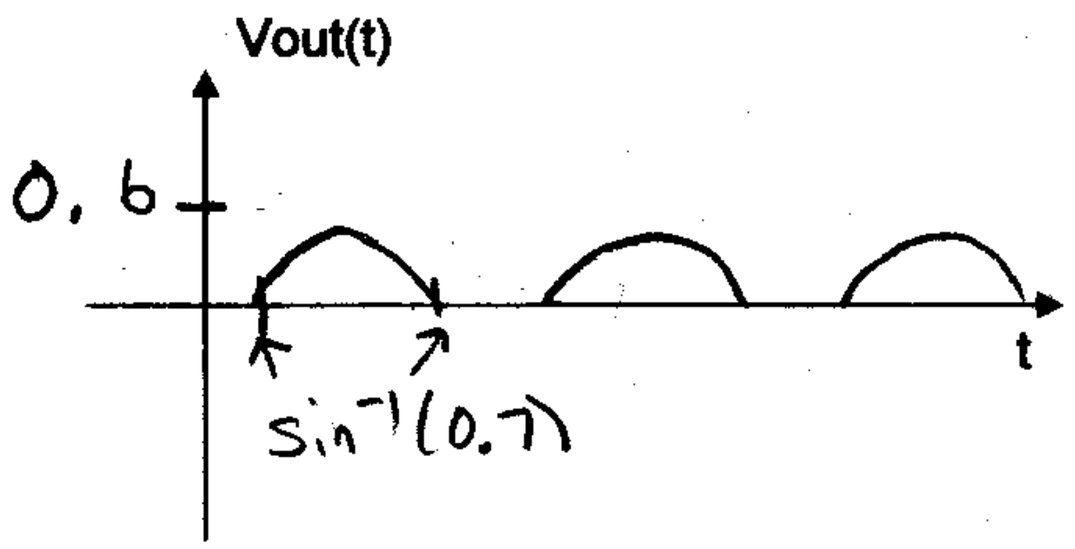
Let Vs(t) = 2 sin(t), R = 20 Ω.

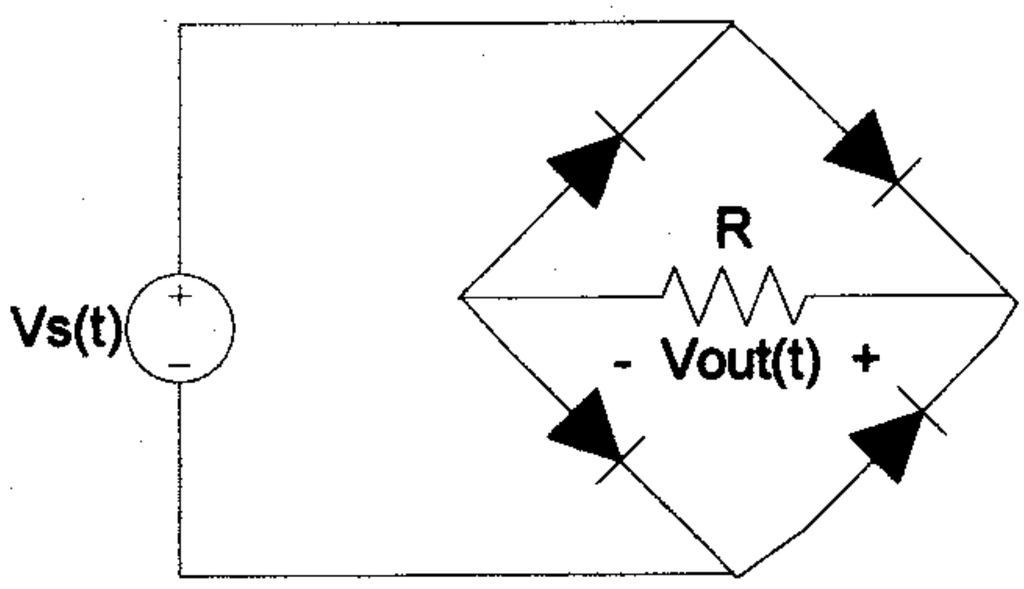
Sketch Vout(t) for the ideal diode model, large-signal model, and small-signal model.

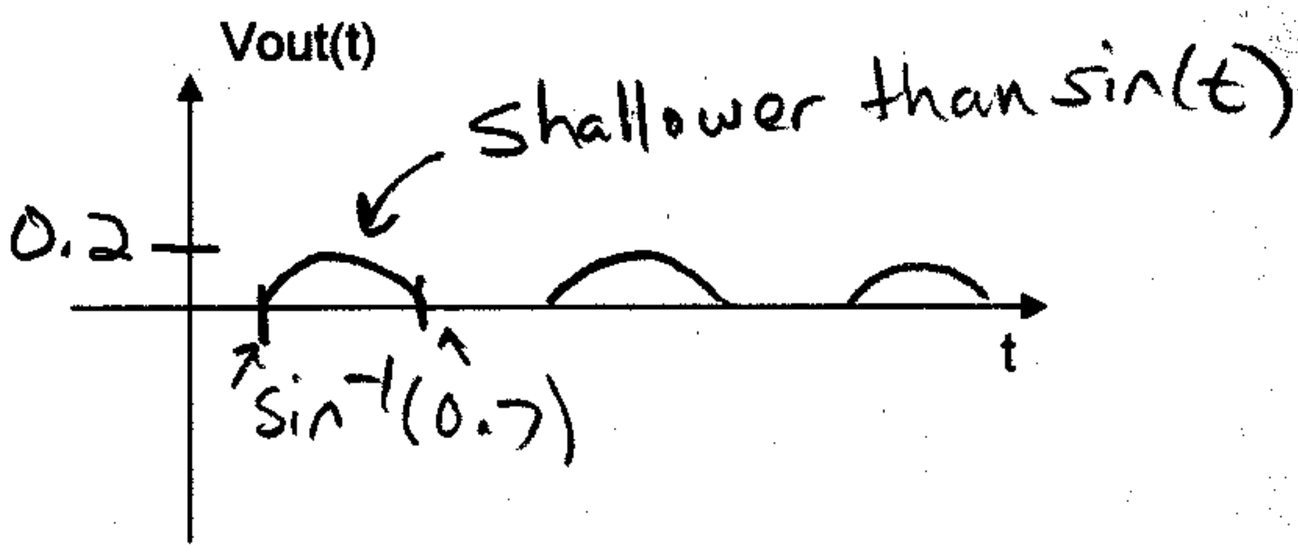








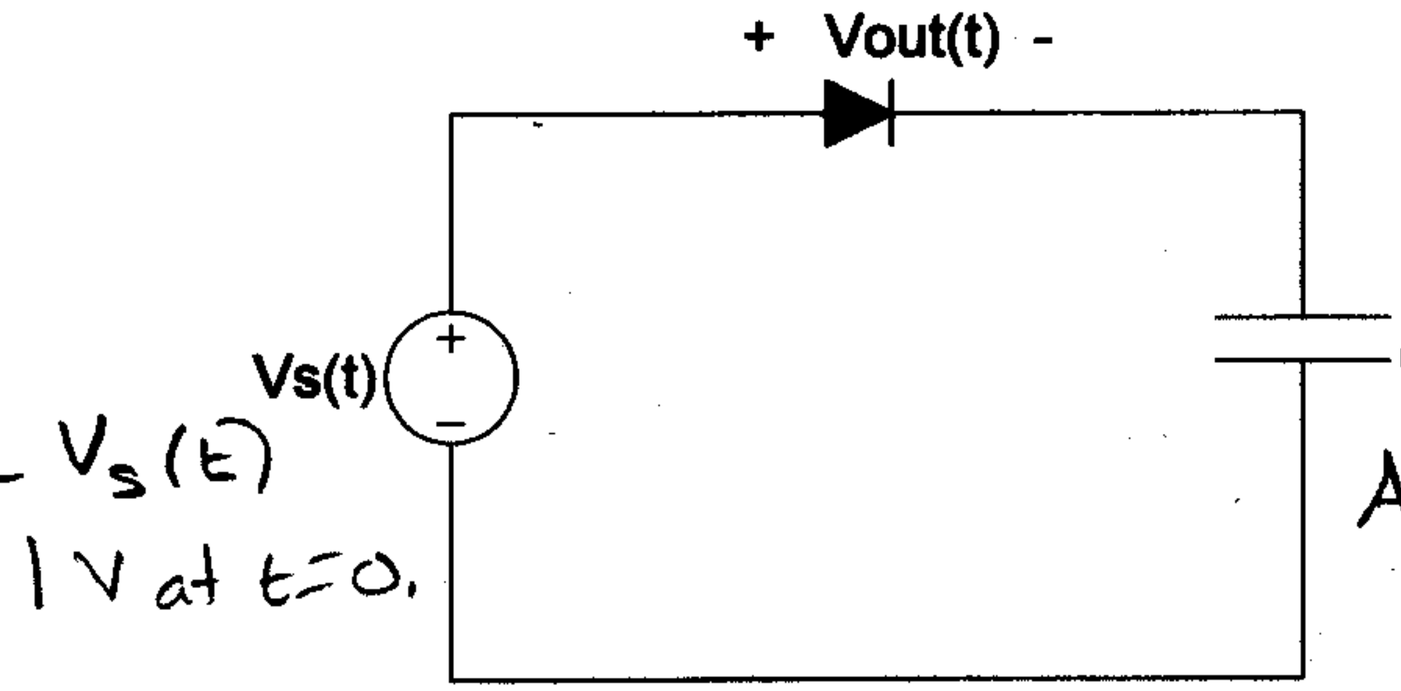




Circuit 4: Clamper (DC Restorer)

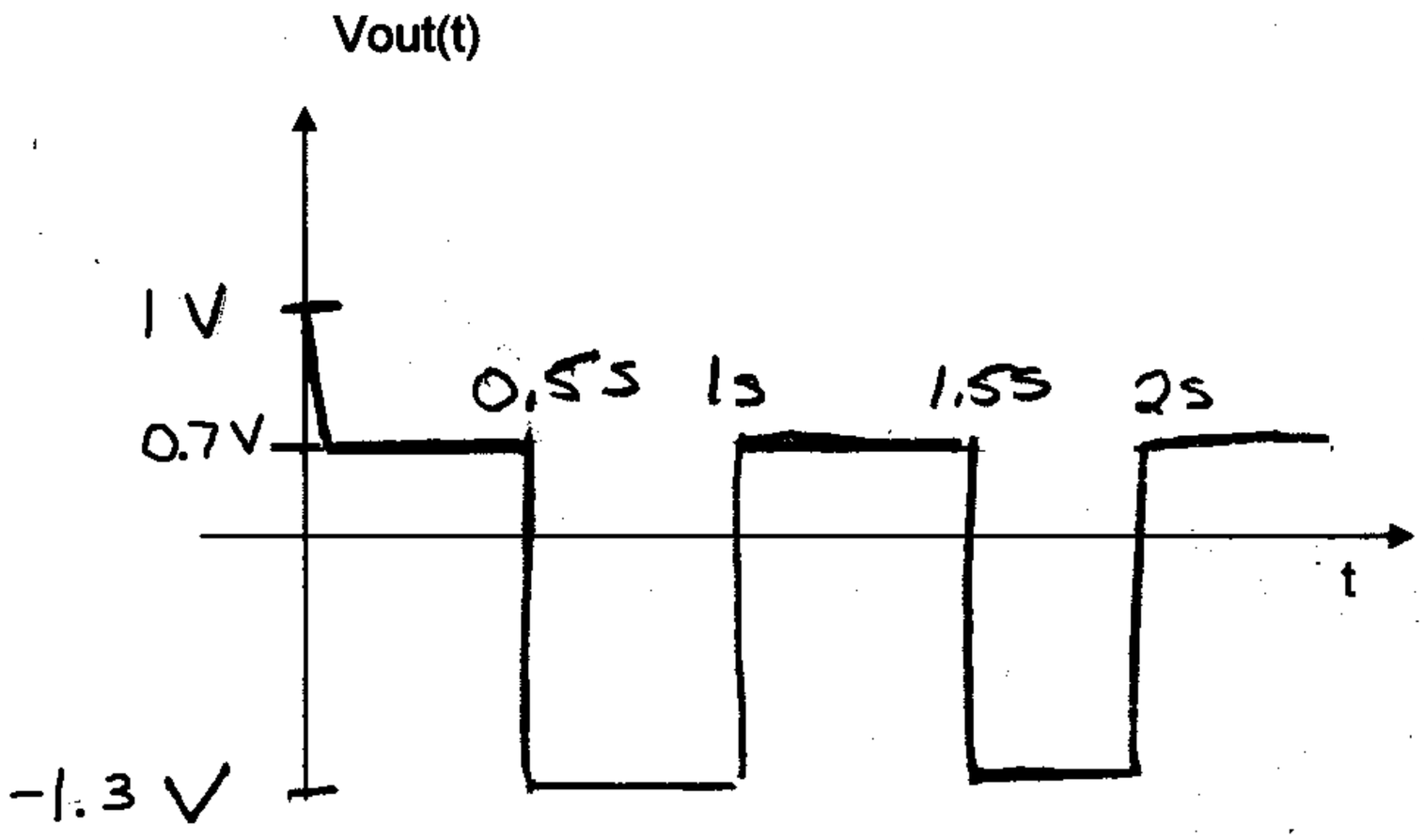
Let Vs(t) be a square wave with amplitude 1 V, period 1 s, duty cycle 50%, and DC offset 0 V.
Let C = 500 μF.

Sketch Vout(t) for the small-signal diode model.



Assume $V_s(t)$ goes to 1 V at t=0.

Assume $V_C(0) = 0$ V.



❖ What happens if the ideal or large signal diode model is used to analyze this circuit?

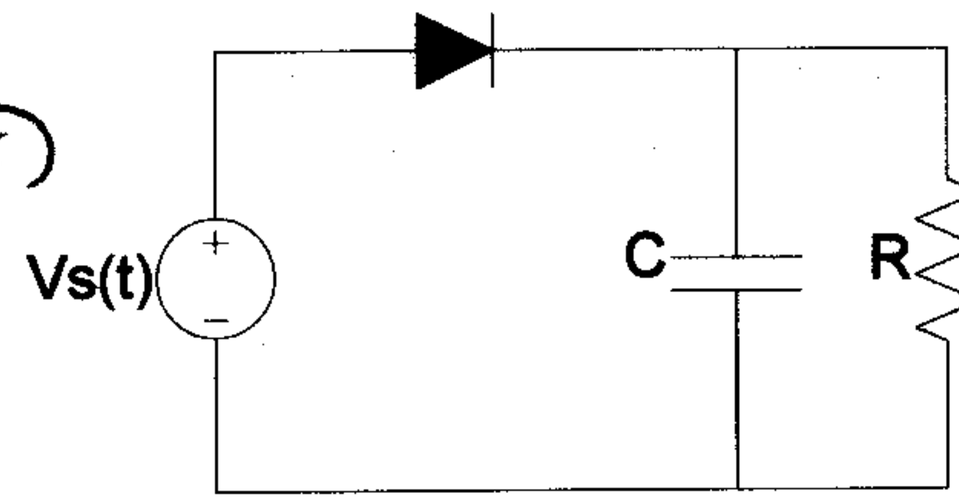
Capacitor voltage would be required to "jump" – can't happen

Circuit 5: Half-Wave Rectifier with Filter Capacitor (Peak or Envelope Detector)

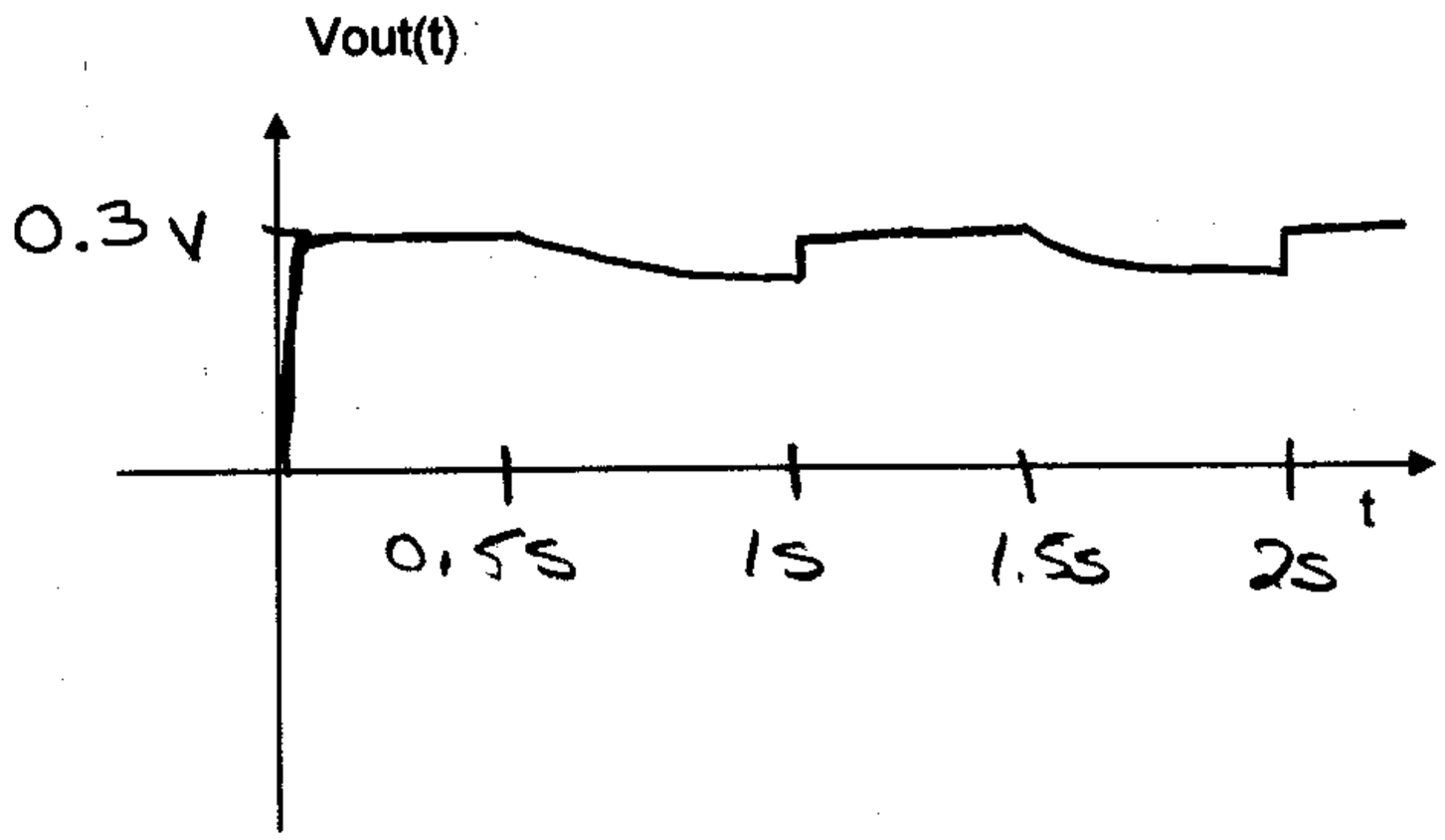
Let Vs(t) be a square wave with amplitude 1 V, period 1 s, duty cycle 50%, and DC offset 0 V.
Let C = 500 μF and R = 10 kΩ.

Sketch Vout(t) for the small-signal diode model.

Assume Vs(t) goes to 1V at t=0



Assume $V_C(0) = 0$ V



- What happens if the ideal or large signal diode model is used to analyze this circuit?

Capacitor voltage would have to jump - it can't

- What values should R and C take to make the circuit function as a peak detector (Vout(t) is highest voltage achieved by Vs(t) up until that time t)?

Large R results in slow decay - good
"Reasonable" C which would still allow fast charging

- What values should R and C take to make the circuit function as an envelope detector (Vout(t) approximately connects the peaks of Vs(t))?

RC big enough to connect peaks
but not too big to miss small peaks