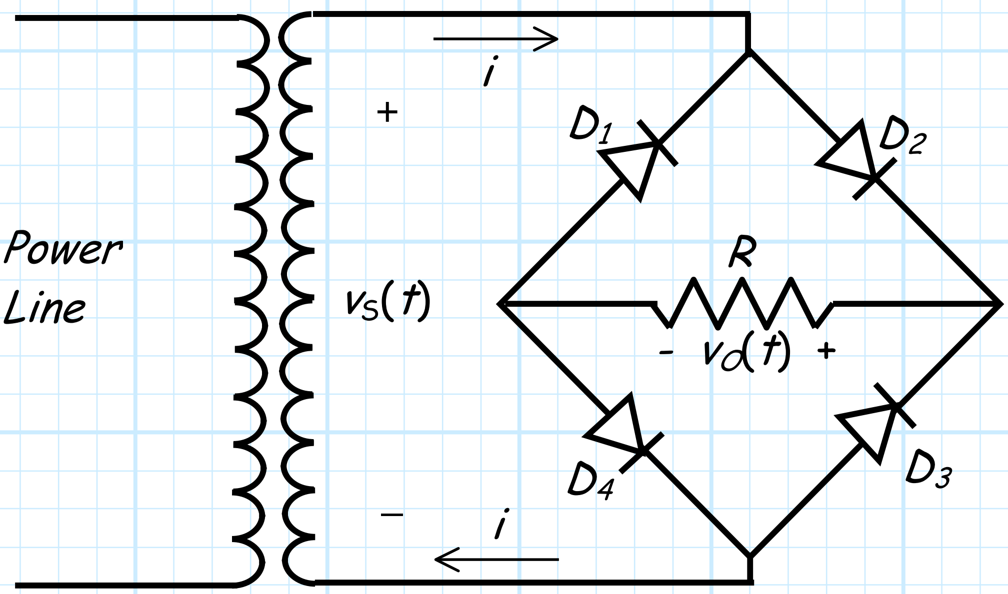
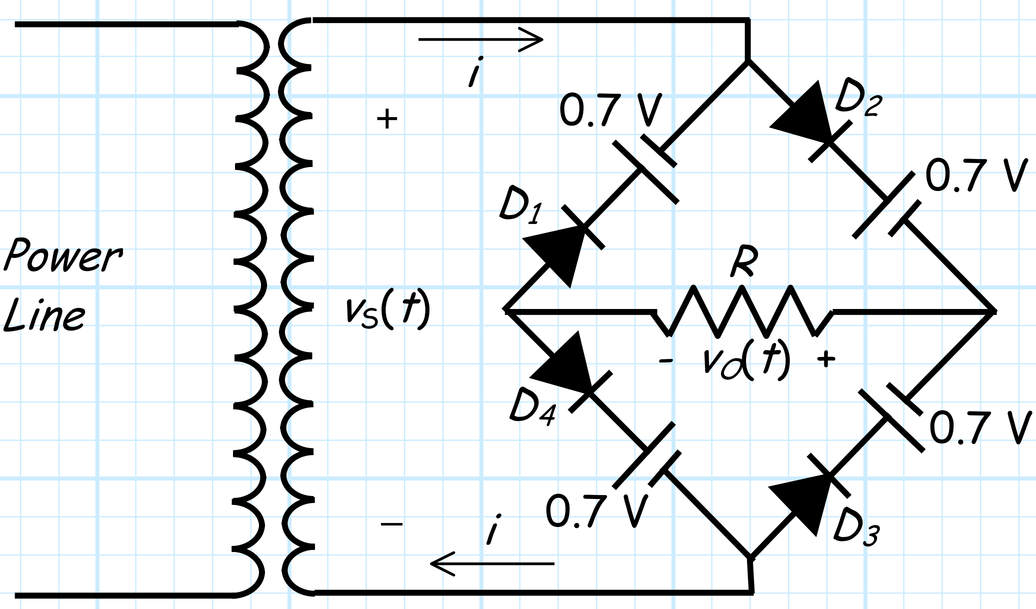
The Bridge Rectifier

Now consider this **junction diode** rectifier circuit:



We call this circuit the **bridge rectifier**. Let's **analyze** it and see what it does!

First, we **replace** the junction diodes with the **CVD model**:



Q: *__Four__ gul-durn ideal diodes! That means __16__ sets of dad-gum assumptions!*

A: True! However, there are only **three** of these sets of assumptions are actually **possible**!

Consider the **current** i flowing through the rectifier. This current of course can be positive, negative, or zero. It turns out that there is only **one** set of diode assumptions that would result in positive current i, **one** set of diode assumptions that would lead to negative current i, and **one** set that would lead to zero current i.

Q: *But what about the remaining __13__ sets of dog gone diode assumptions?*

A: **Regardless** of the value of source v_S, the remaining 13 sets of diode assumptions simply **cannot occur** for this particular circuit design!

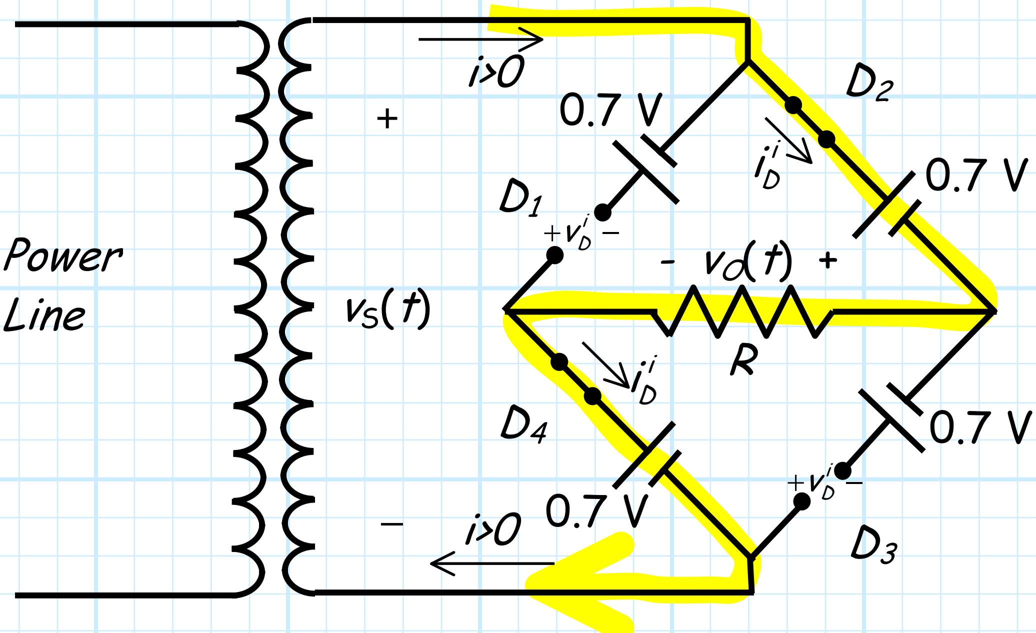
Let's look at the **three** possible sets of assumptions:

$i > 0$

The rectifier current i can be **positive** only **if** these assumptions are true:

D_1 and D_3 are reverse biased.

D_2 and D_4 are forward biased.



Analyzing this circuit, we find that the **output voltage** is:

$$v_O = v_S - 1.4 \text{ V}$$

and the f.b. **ideal diode currents** are:

$$i = i_D^i = \frac{v_S - 1.4}{R}$$

and, finally the r.b. **ideal diode voltages** are:

$$v_D^i = -v_S$$

Thus, $i_D^i > 0$ when:

$$\frac{v_S - 1.4}{R} > 0$$

$$v_S - 1.4 > 0$$

$$v_S > 1.4 \text{ V}$$

and $v_D^i < 0$ when:

$$-v_S < 0$$

$$v_S > 0$$

Therefore, we **find** that for this circuit:

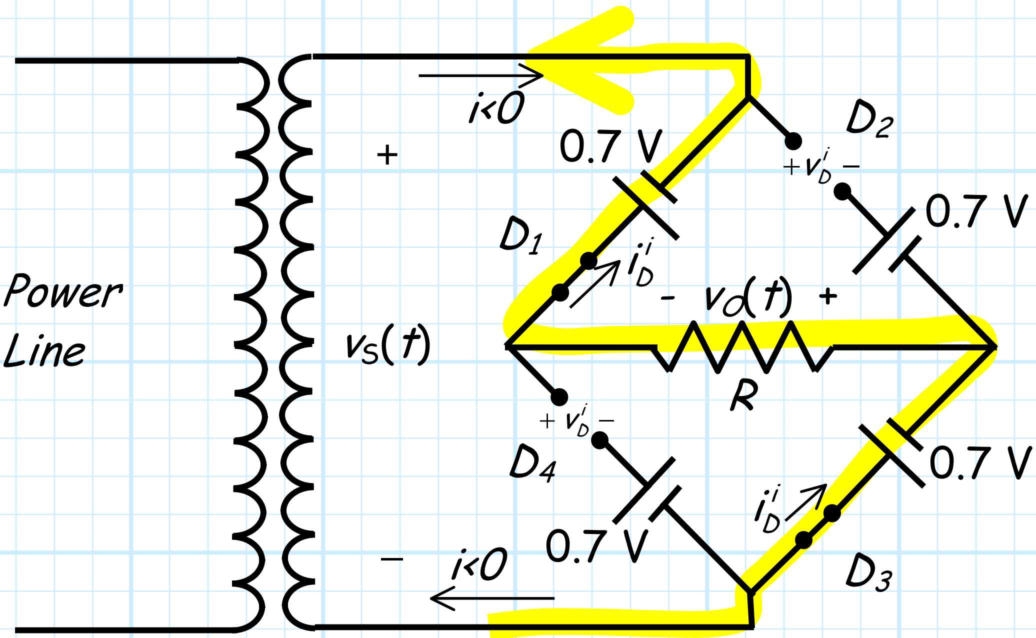
$$v_O = v_S - 1.4 \text{ V} \quad \text{when} \quad v_S > 1.4 \text{ V}$$

i <0

The rectifier current i can be **negative** only **if** these assumptions are true:

D_1 and D_3 are forward biased.

D_2 and D_4 are reverse biased.



Analyzing this circuit, we find that the **output voltage** is:

$$v_O = -v_S - 1.4 \text{ V}$$

while the f.b. **ideal diode currents** are both
:

$$-i = i_D^i = \frac{-v_S - 1.4}{R}$$

and the r.b. **ideal diode voltages** are both:

$$v_D^i = v_S$$

Thus, $i_D^i > 0$ when:

$$\frac{-v_S - 1.4}{R} > 0$$

$$-v_S - 1.4 > 0$$

$$-v_S > 1.4 \text{ V}$$

$$v_S < -1.4 \text{ V}$$

and, $v_D^i < 0$ when:

$$v_S < 0$$

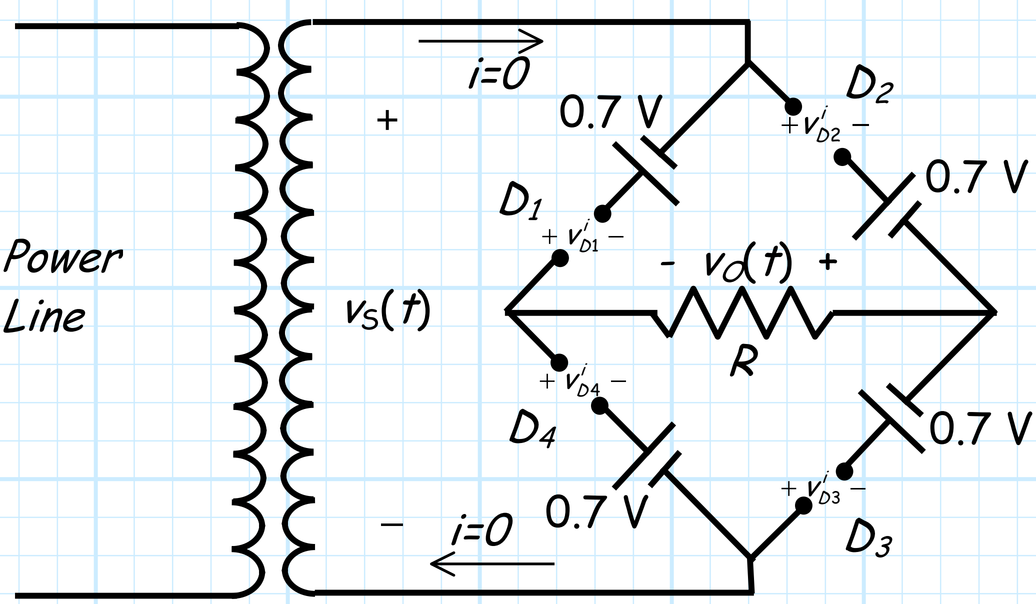
Therefore, we likewise **find** for this circuit:

$$v_O = -v_S - 1.4 \text{ V} \quad \text{when} \quad v_S < -1.4 \text{ V}$$

***i* =0**

The rectifier current *i* can be **zero** only **if** these assumptions are true:

All ideal diodes are **reverse** biased!



Analyzing this circuit, we find that the **output voltage** is:

$$v_O = R\,i = 0$$

while the **ideal diode voltages** of D_2 and D_4 are each:

$$v_{D2}^{i} = \frac{v_S - 1.4}{2} = v_{D4}^{i}$$

and the **ideal diode voltages** of D_1 and D_3 are each:

$$v_{D1}^{i} = \frac{-v_S - 1.4}{2} = v_{D3}^{i}$$

Thus, $v_{D2}^{i} < 0$ when:

$$\frac{v_S - 1.4}{2} < 0$$

$$v_S - 1.4 < 0$$

$$v_S < 1.4$$

and, $v_{D1}^{i} < 0$ when:

$$\frac{-v_S - 1.4}{2} < 0$$

$$-v_S - 1.4 < 0$$

$$-v_S < 1.4$$

$$v_S > -1.4$$

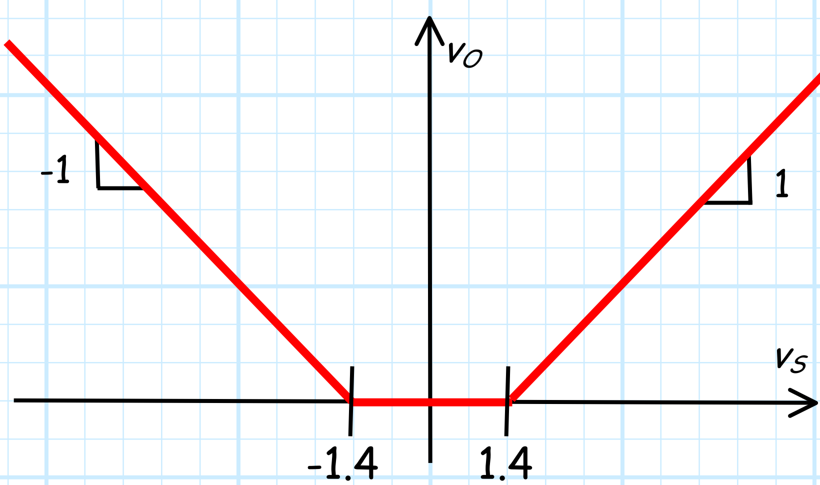
Therefore, we also **find** for this circuit that:

$v_O = 0$ when both $v_S < 1.4\,V$ and $v_S > -1.4\,V$ $(-1.4 < v_S < 1.4\,V)$

Q: *You know, that dang **Mizzou** grad said we only needed to consider these **three** sets of diode assumptions, yet I am **still** concerned about the other 13. How can we be **sure** that we have analyzed every **possible** set of **valid** diode assumptions?*

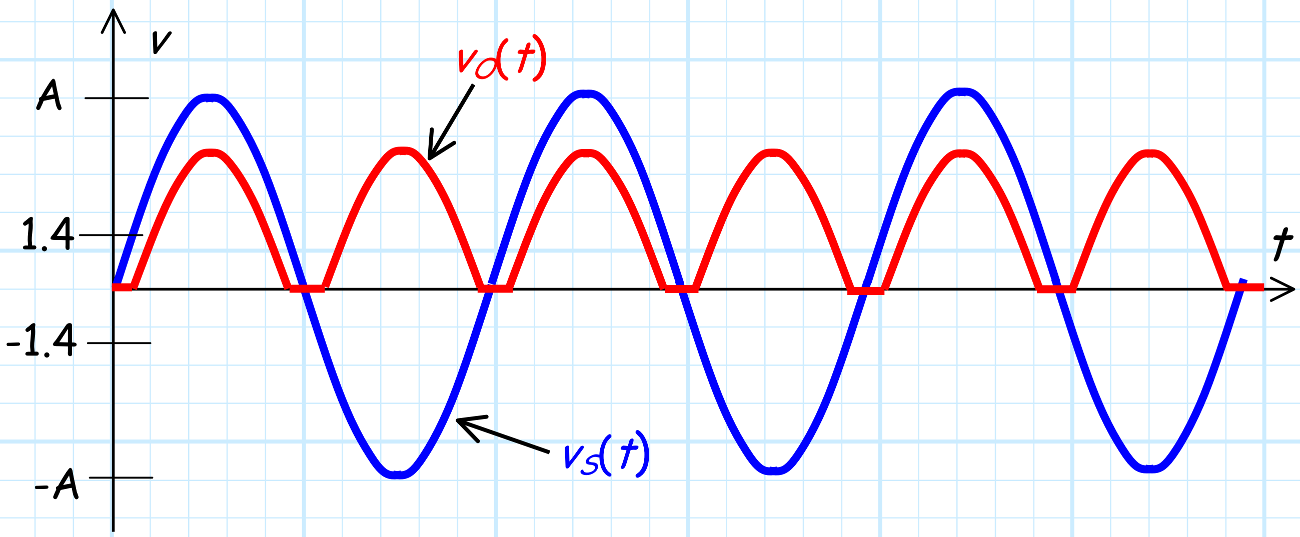
A: We know that we have considered **every** possible case, because when we combine the three results we find that we have a piece-wise linear **function**! I.E.,:

$$v_O = \begin{cases} -v_S - 1.4\text{ V} & \text{if} \quad v_S < -1.4\text{ V} \\ 0 & \text{if} \quad -1.4 < v_S < 1.4\text{ V} \\ v_S - 1.4\text{ V} & \text{if} \quad v_S > 1.4\text{ V} \end{cases}$$



Note that the **bridge** rectifier is a **full-wave** rectifier!

If the input to this rectifier is a **sine wave**, we find that the **output** is approximately that of an ideal **full-wave rectifier**:



We see that the junction diode bridge rectifier output is **very close** to ideal. In fact, if A>>1.4 V, the **DC component** of this junction diode bridge rectifier is approximately:

$$V_o \approx \frac{2A}{\pi} - 1.4 \text{ V}$$

Just 1.4 V less than the **ideal** full-wave rectifier DC component!