

Analog Electronics

Computer and Electronics Engineering

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Analog Electronics

Objectives:

The objectives of this module are to:

- Become familiar with basic electrical concepts
- Understand series connections and parallel connections
- Test circuits using circuit simulation software

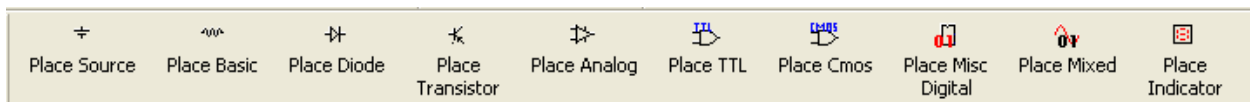
To accomplish the objectives, we will give you a short overview of electrical concepts. You will then work with a partner to build circuits described later in the handout using the Electronic Workbench simulation program

The simulation program we will be using is MultiSim 8 by Electronics Workbench. www.electronicworkbench.com. It is a user-friendly program which a user can create and test circuits in a relatively short time. It has a variety of components listed in a series of menus. One of the initial difficulties is finding the component you want.

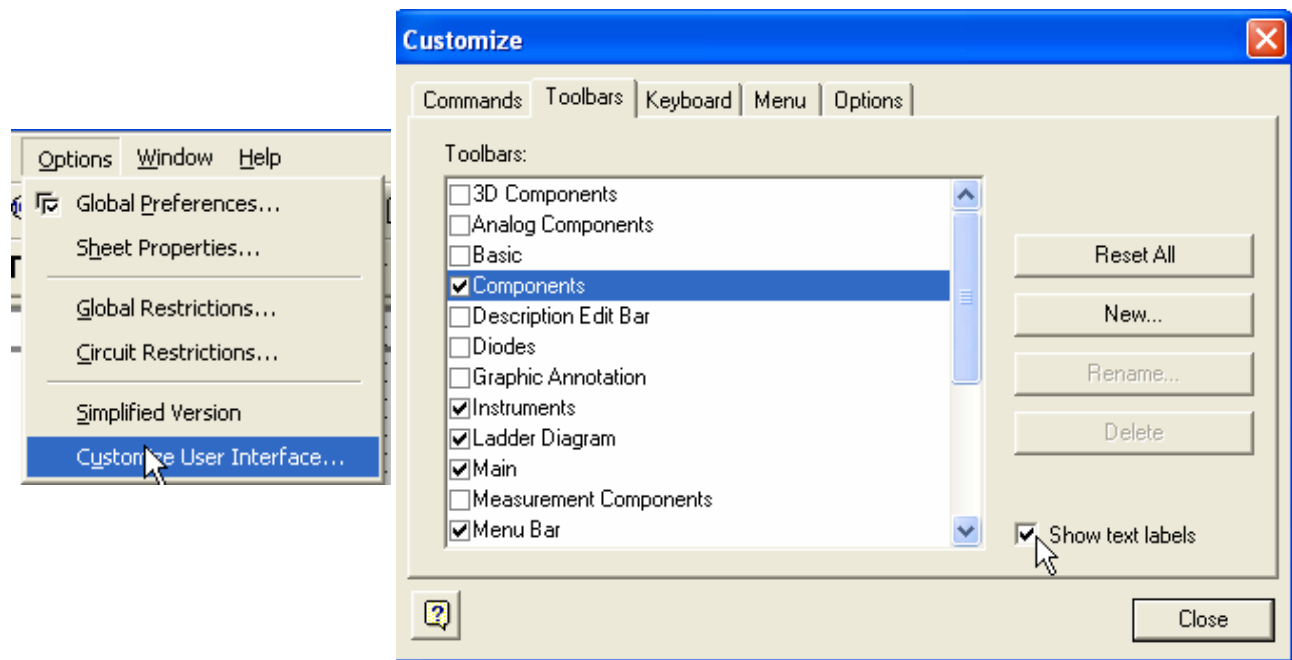
How to Find Components

A list of component icons is shown along with the menu selections used to access them. The order of presentation is the same as the order in which you will be constructing the circuits.

If your menu toolbar only shows icons without the text which identifies them, you need to turn on the text so the toolbar is as shown below:



How to turn on the Toolbar text

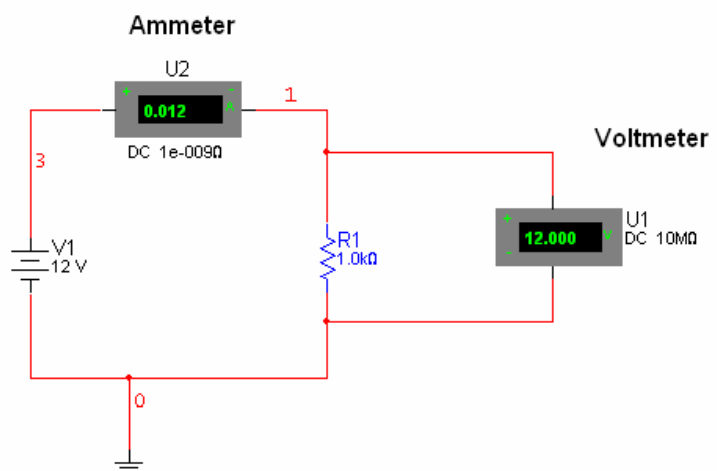


Theory

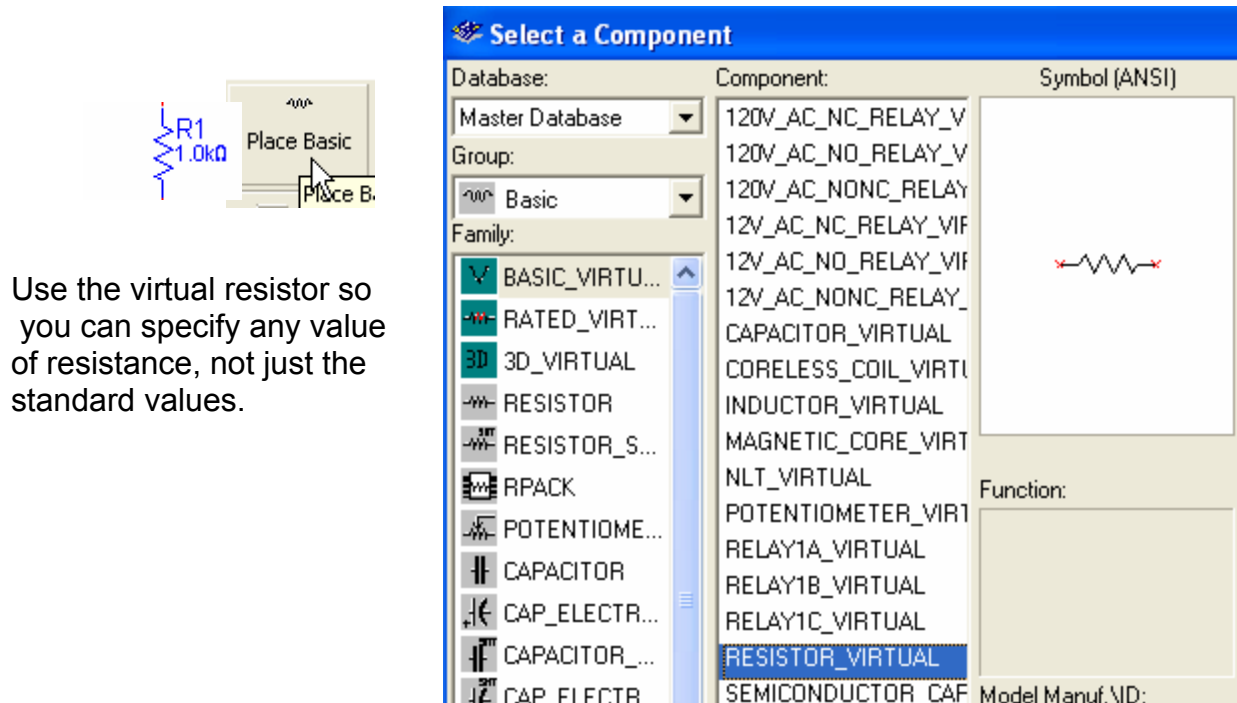
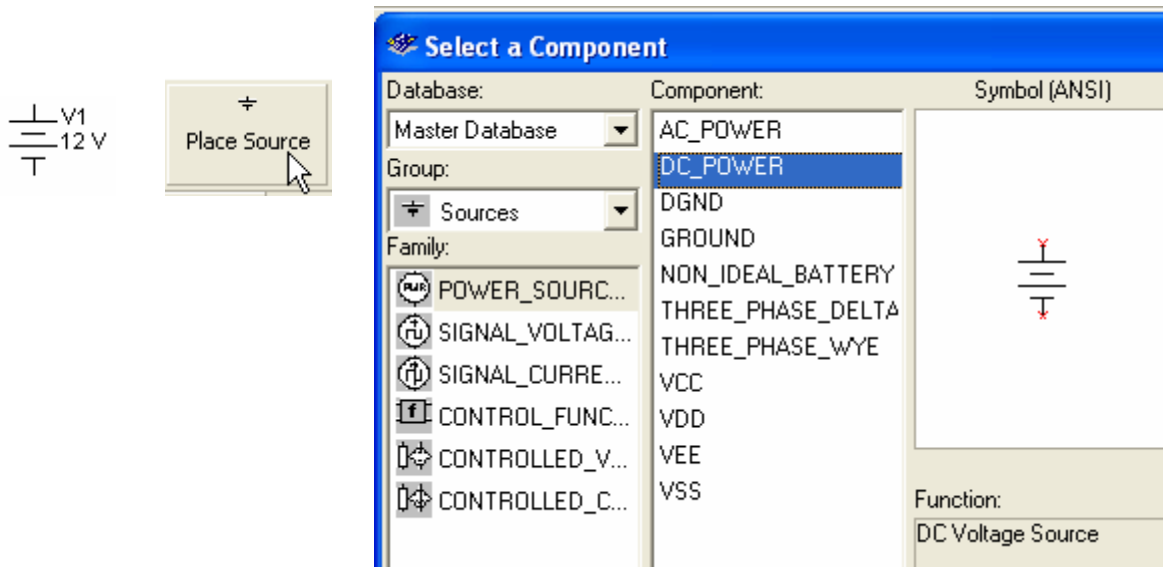
Ohm's Law give the relationship between voltage, current and resistance. The three ways it can be stated in an equation are:

$V=I \cdot R$, $I=V/R$, and $R=V/I$
where V is volts, I is current in amps, and R is resistance in Ohms.

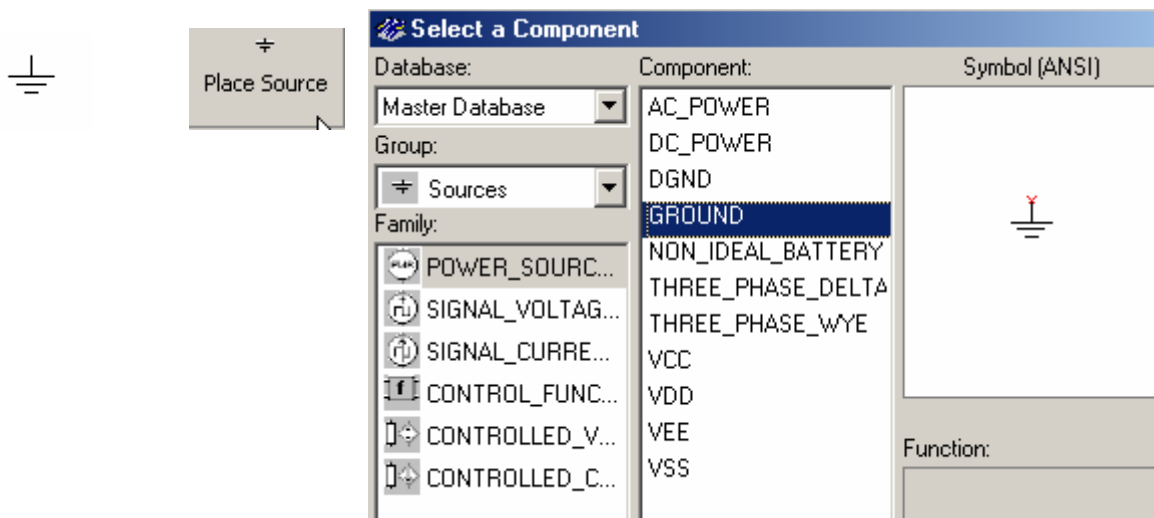
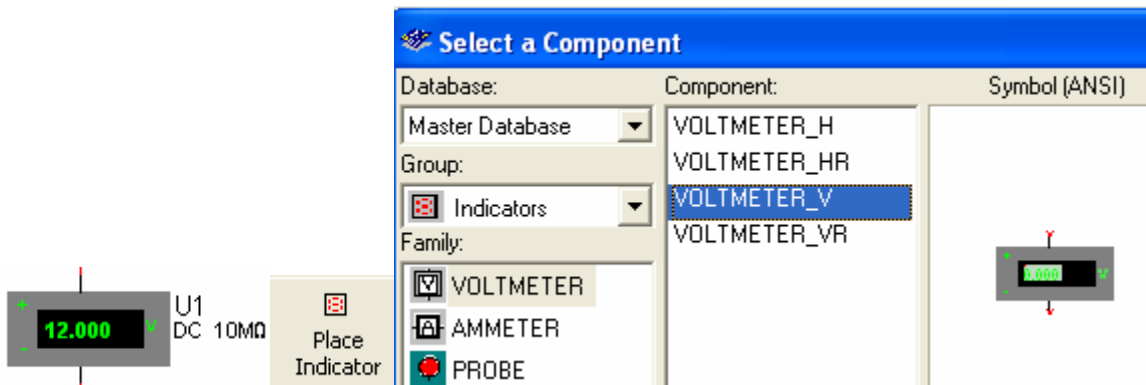
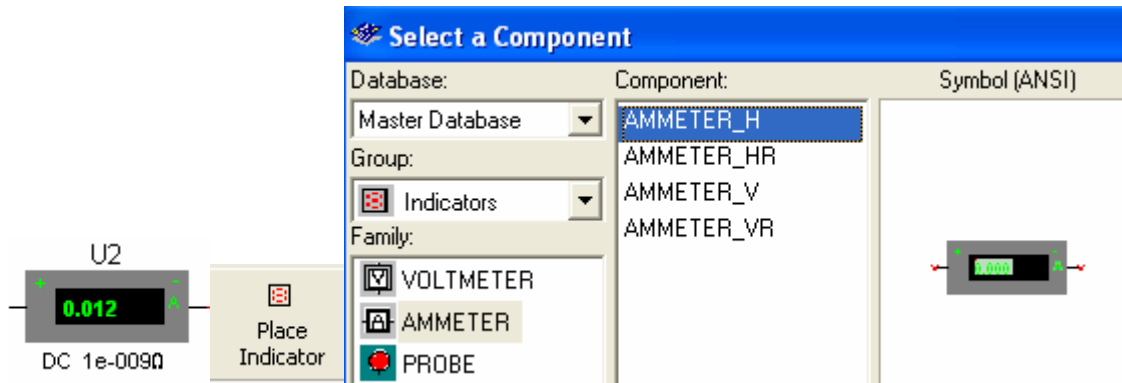
The circuit on the right is the first you will construct and simulate.



The following shows how to find the components you want for this circuit. On the left is the desired component symbol. Next is the menu icon to click, and on the right is window which opens. The entries which you select are shown greyed. On the first one, the entry “POWER SOURCE” is selected and “DC_POWER” is selected. On the right is the symbol which will be placed on your workspace.



Use the virtual resistor so you can specify any value of resistance, not just the standard values.

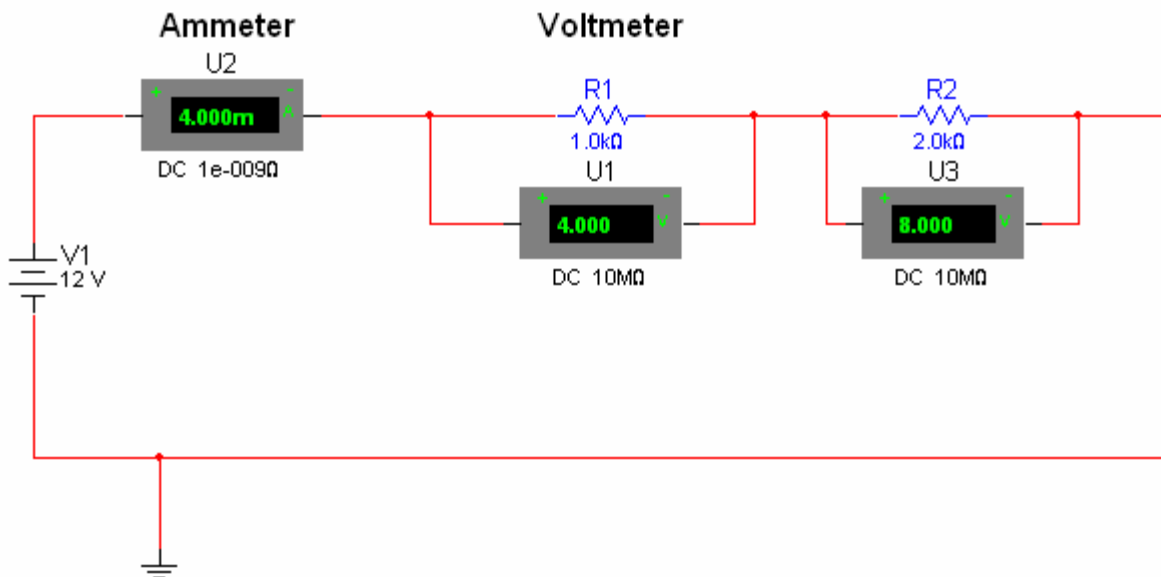


Ohm's Law says the current in this circuit should be $V/R = 12/1000 = 0.012$ amps = 12 milliamps (ma)

Theory: Components in Series

Components are in series if the current in one component is the same as the current in a component connected to it. In the first circuit, the battery and resistor are in series because the same current flows through both components.

If two or more resistors are connected in series, the equivalent resistance is the sum of the individual resistors. Construct and simulate the following circuit.



What is the total resistance? _____

From Ohm's Law, what is the total current? _____

Knowing the current in R1 and R2 (since they are in series they have the same current), what is the voltage across each resistor? _____

Theory: Kirchhoff's Voltage Law.

The sum of voltage changes due to sources (batteries) equals the sum of voltage drops due to resistors around any closed path.

In the previous circuit, the voltage due to sources is 12 volts. What is the sum of voltage drops due to resistors? _____. Does this follow Kirchhoff's Voltage Law? _____ i

Theory: Power

Power in circuit components can be computed by $P=V \cdot I$ (voltage times current). Typically, power is delivered by batteries and absorbed by resistors (and given off as heat). By using Ohm's Law and substituting in the power equation, we get several forms of the power equation:

$$P = V \cdot I = V^2/R = I^2 \cdot R$$

From the above circuit compute battery power by $V \cdot I$ _____.

Compute resistor power by $I^2 \cdot R$ _____.

From conservation of energy power delivered should equal power dissipated. Does it? _____

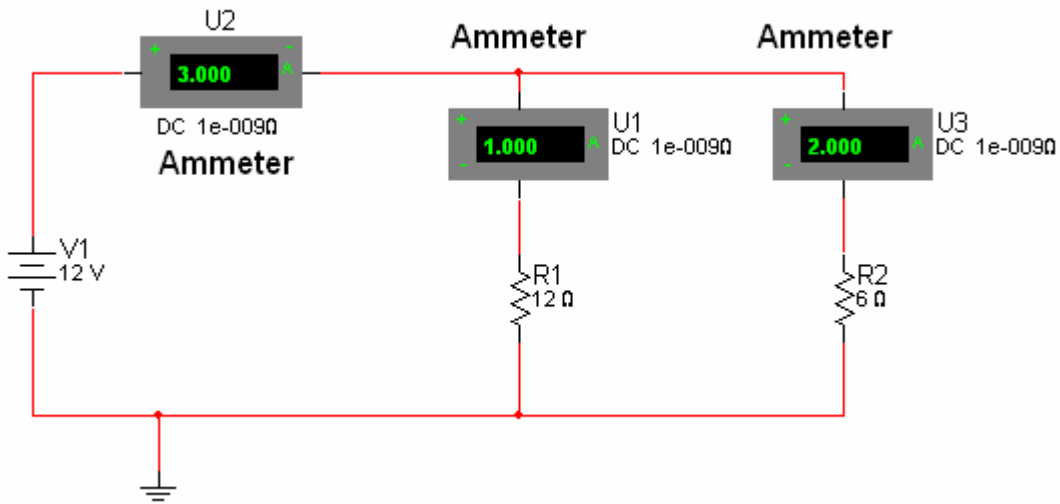
Theory: Components in Parallel

Two components are in parallel if two of their leads are connected to a common point and their other two leads are connected to another common point.

If two or more resistors are in parallel, their equivalent resistance is given by:

$$1/R_T = 1/R_1 + 1/R_2 + \dots$$

Construct and simulate the following circuit



What is the total resistance? _____ (4 ohms)

What is the current from the battery? _____

What is the voltage across each resistor? _____ (12 V because both are connected to the 12V battery)

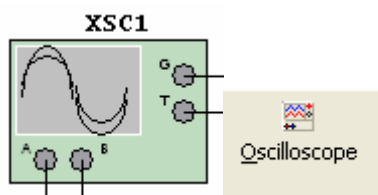
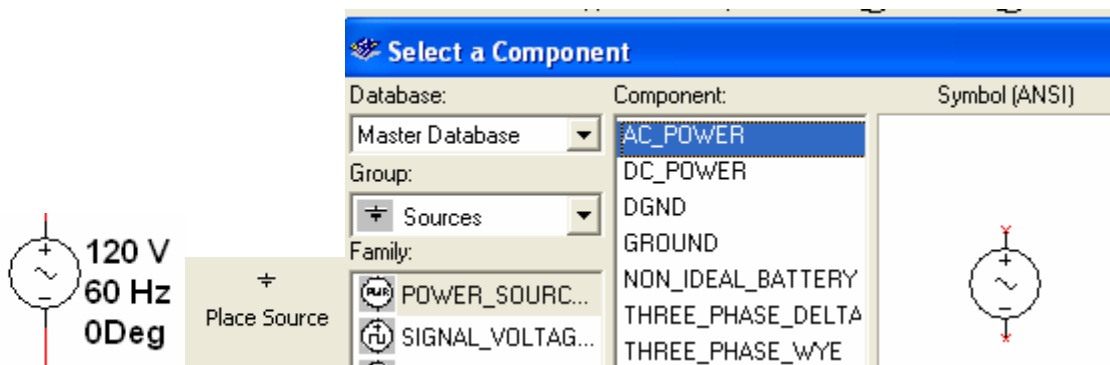
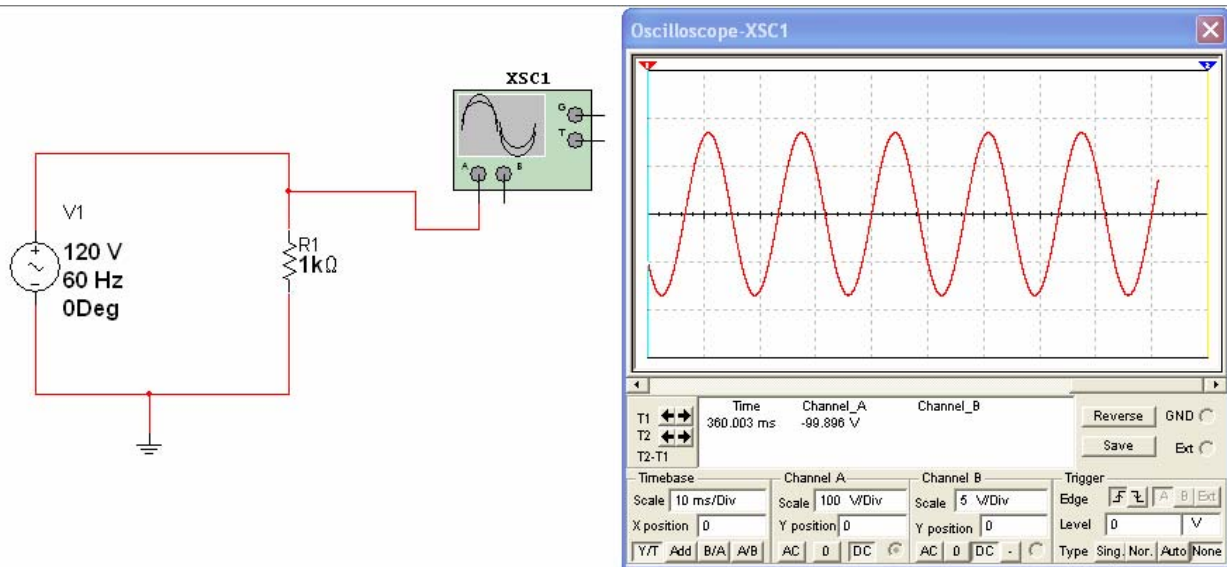
Theory: Kirchhoff's Current Law

Kirchhoff's Current Law states that current entering a junction has to equal the current leaving the junction. In the previous circuit there are 3 amps entering the junction of the two resistors and 1 amp + 2 amps leaving through the two resistors.

Note that in all the above circuits if the battery orientation were reversed, the current would flow the opposite direction but would have the same magnitude (value).

Sine Wave Sources

Construct the following circuit.



If this is not on the menu, select "view" "toolbars"

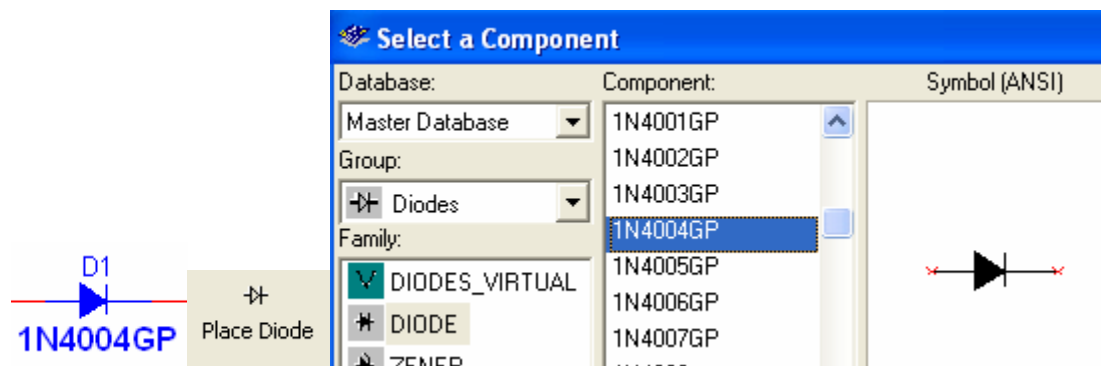
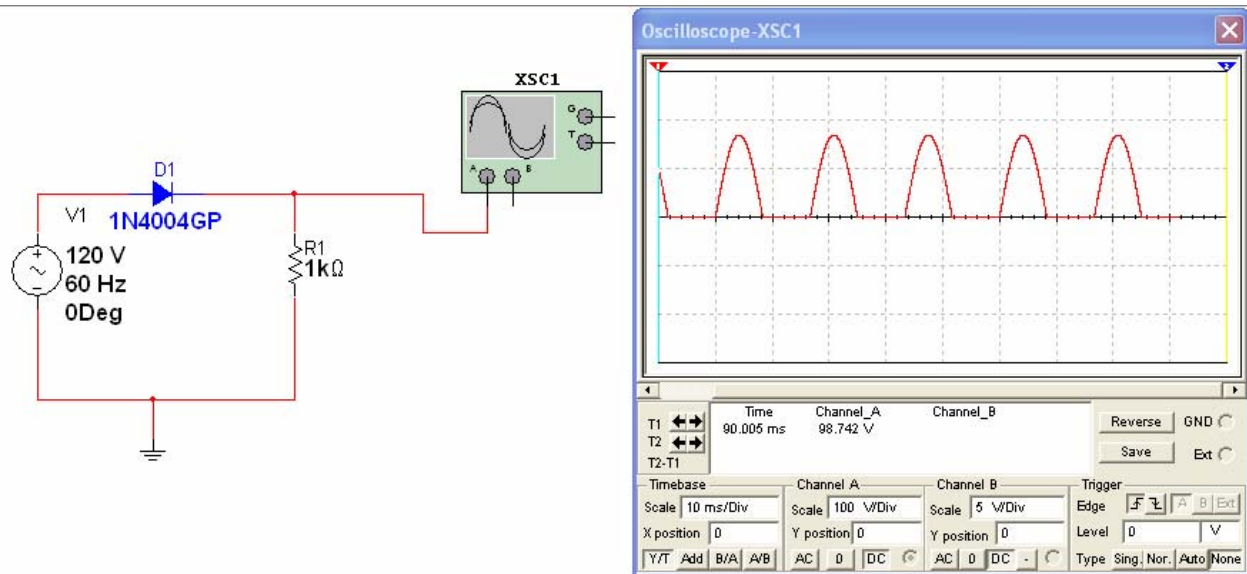
"instruments"

To get the oscilloscope display, double click the symbol.

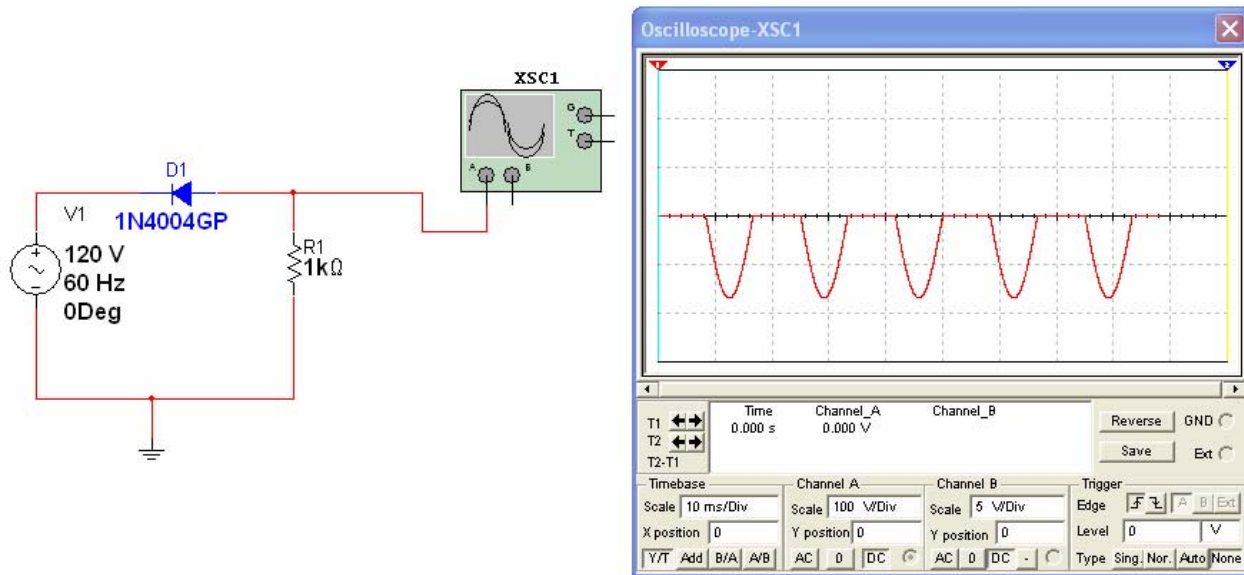
Set the oscilloscope display Timebase to 10ms/div and the Channel A Scale to 100 V/div.

Simulate. If the waveform is too fast or too slow, you can change the timebase. Note that the sine wave is negative for half of the time and makes current go the opposite direction (alternating current). Zero volts on the waveform is the center dark line.

Add a diode to the circuit and simulate.



Reverse the diode.



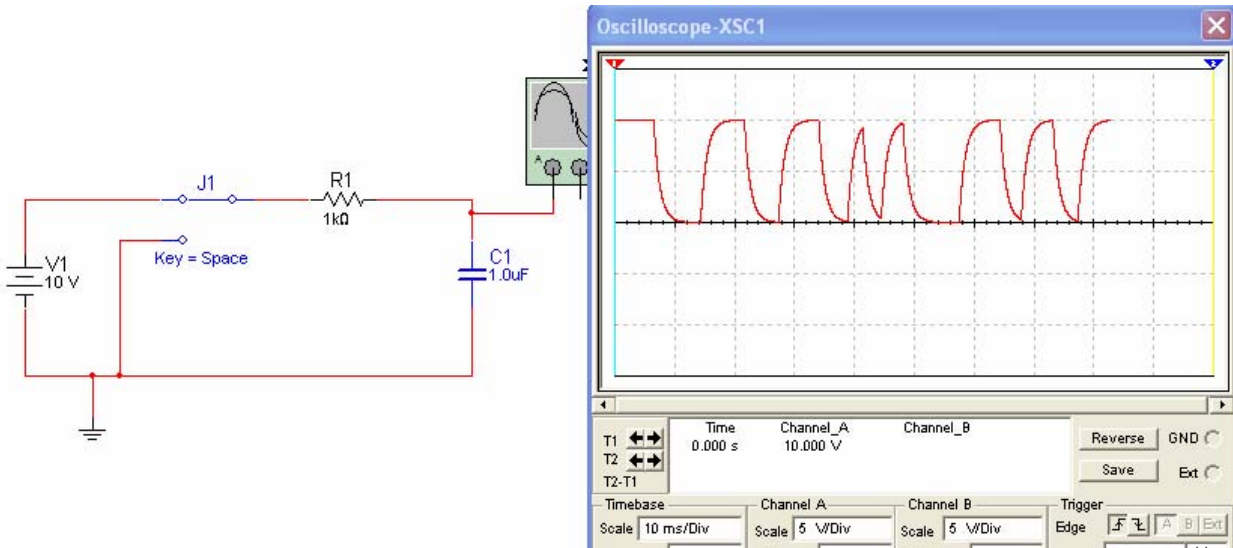
Theory: Capacitors

The basic capacitor is two parallel conduction plates which, when they have a voltage applied, will store electrons (charge)

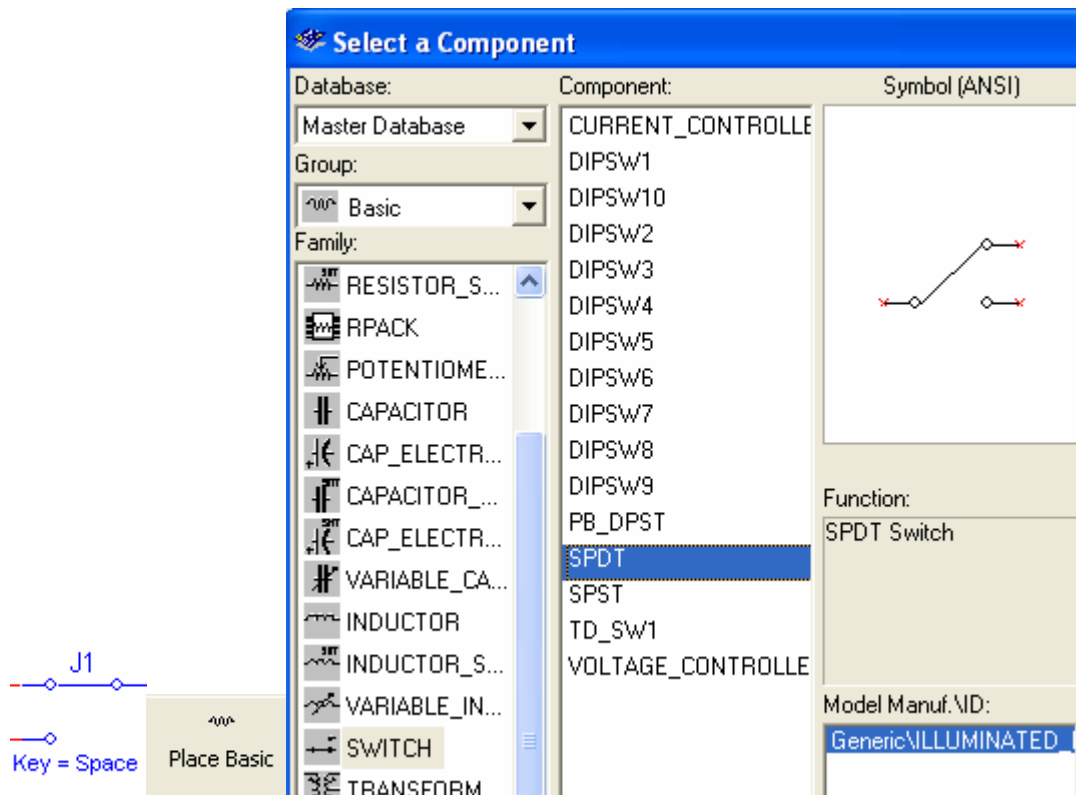
The defining equation for capacitance is $C = Q/V$ where C is capacitance in farads, Q is charge in coulombs, and V is voltage in volts.

The capacitance of parallel plates can be determined from their physical properties: $C = \epsilon (A/d)$ where C is capacitance in farads, ϵ is the permittivity of the material between the parallel plates, A is the area of the plates in square meters, and d is the separation of the plates in meters.

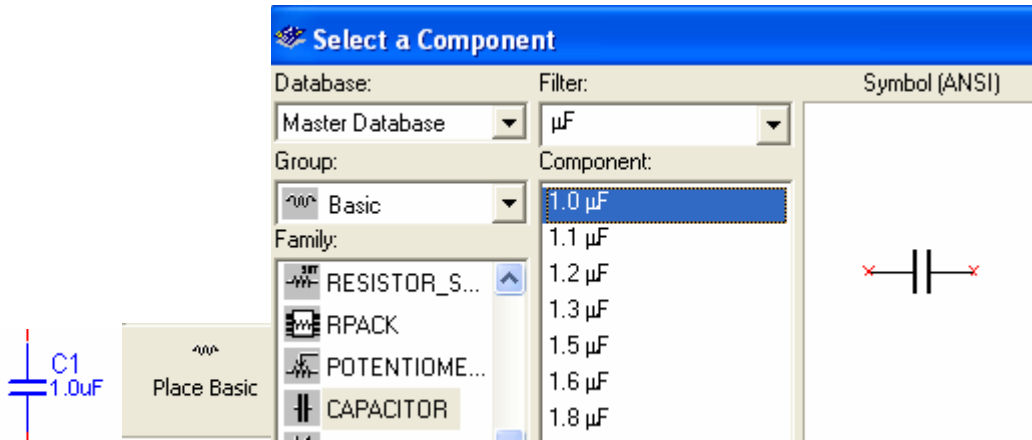
A capacitor can be considered a storage tank for electrons. A battery forces the electrons into the capacitor. This “charges” the capacitor. As more electrons are put in the capacitor, its voltage increases. ($V=Q/C$) A resistor “resists” the flow of electrons so the capacitor fills more slowly. If the battery is removed, the electrons leave the capacitor and it discharges. Construct the following circuit.



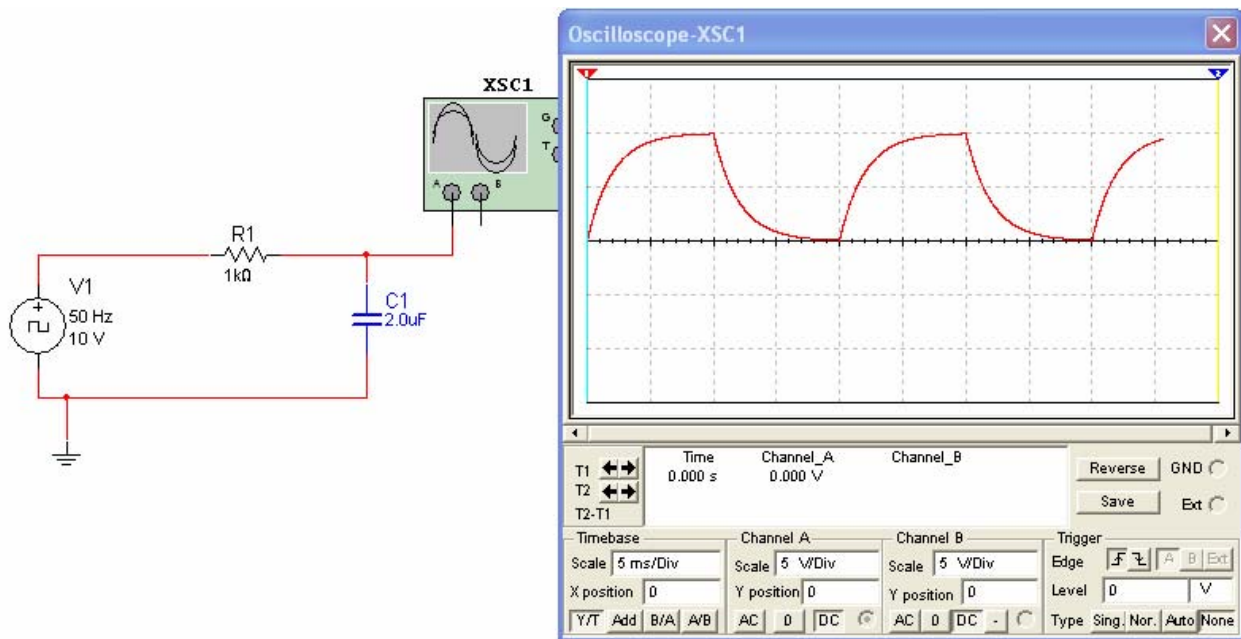
You change the switch position by pressing the space bar on the keyboard. You must have Electronic Workbench window active, not the Oscilloscope window to do this.

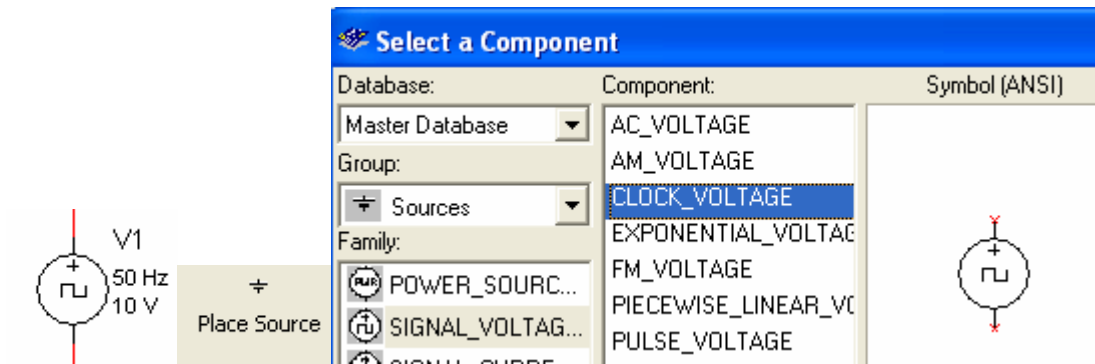


Note that you will have to rotate the switch to get the correct orientation.



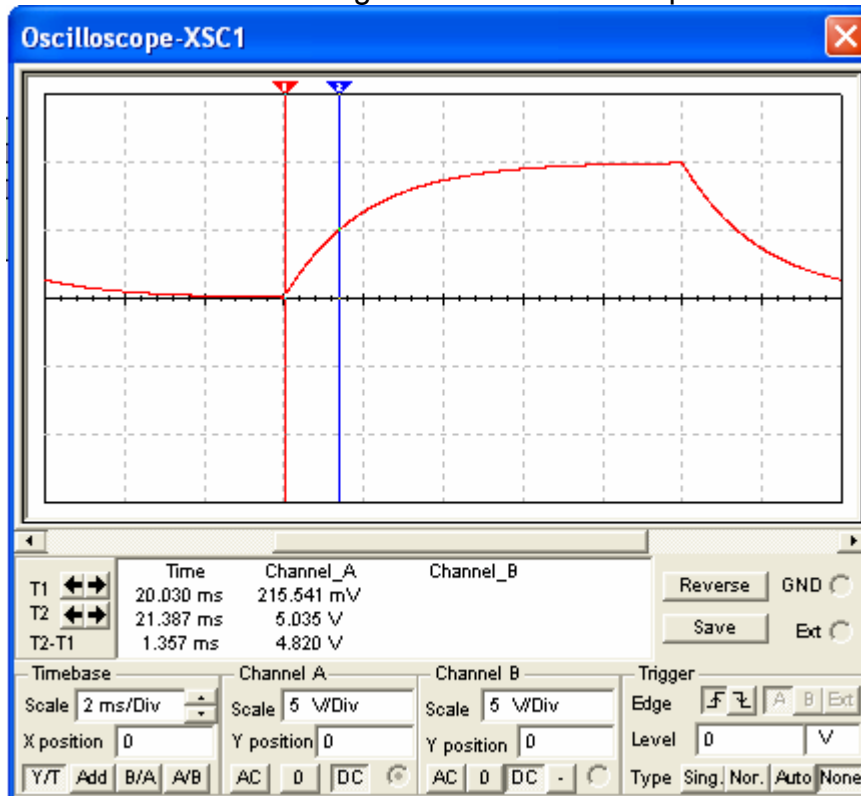
Construct the circuit which has a square wave input.





The square wave source works just like the switch in the previous circuit.

When you have the desired waveform, press the “OFF” switch to stop simulation. Move the cursors so the left is where the voltage starts to rise and the left is where the voltage is 5 volts. You can change the time base to expand the waveform if you desire.

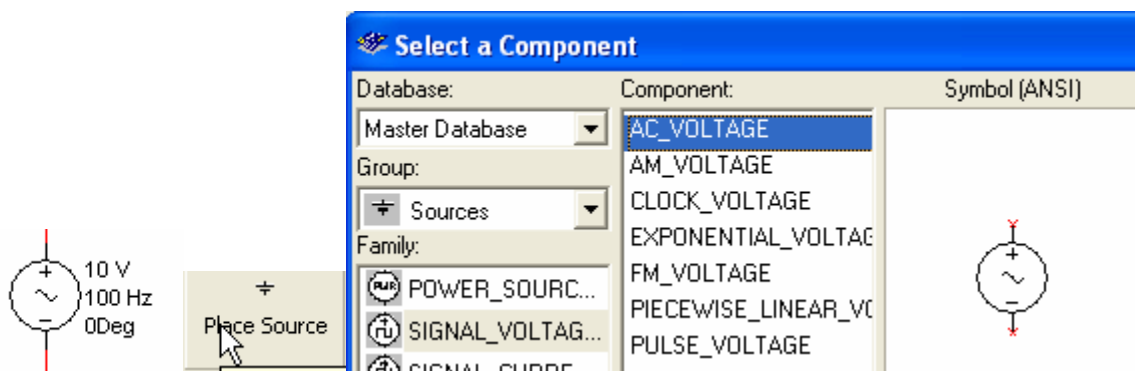
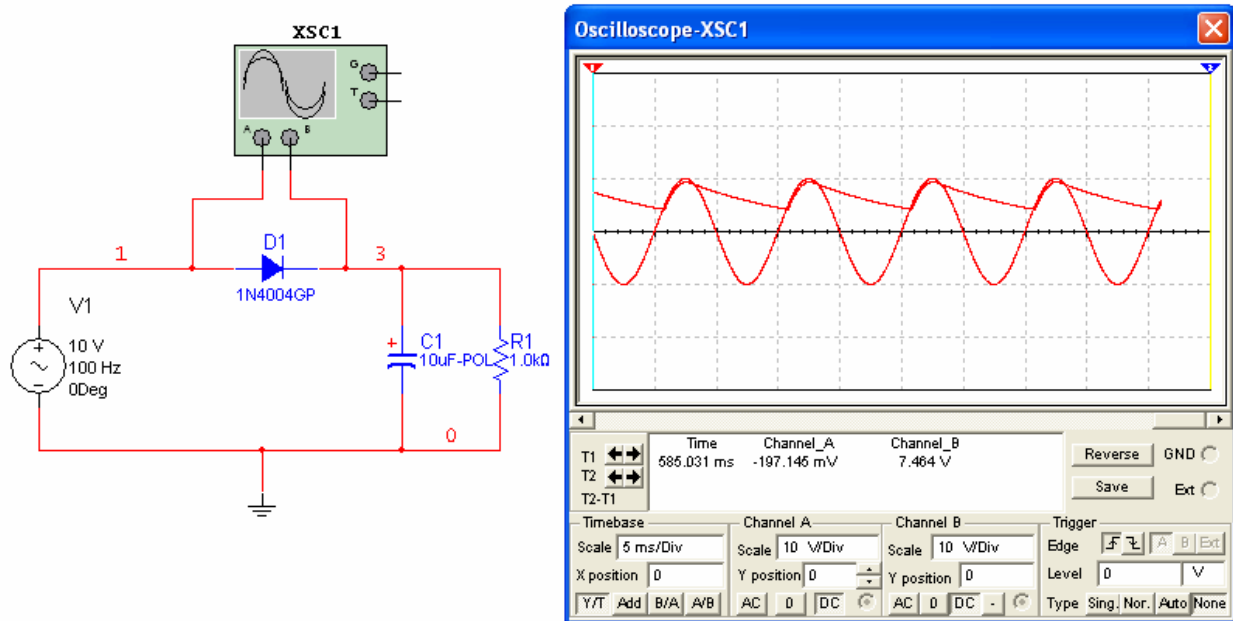


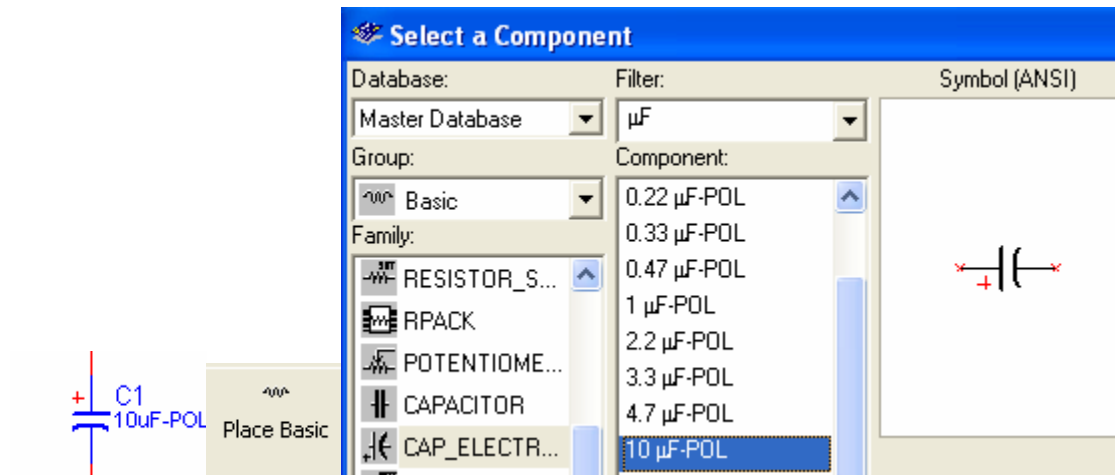
Note on the digital readout the Channel A voltage at T2 is 5.035V. The time it took to reach that value is $T2-T1 = 1.357$ ms.

Next construct a circuit similar to the one on page 8 but with a capacitor added. You will look at both the signal from the generator and the signal across the resistor. This is a simple direct current (DC) power supply.

You can right-click on one of the wires going into the oscilloscope and change its color which will change its color on the waveforms.

Make the capacitor value larger and smaller to observe the effect on the output waveform.





References:

Simulation Software:

Electronics Workbench USA
60 Industrial Park, #068
Cheektowaga, NY 14227

www.electronicworkbench.com