Digital Electronics

Computer and Electronics Engineering

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Objectives:

The objectives of this module are to:

- Become familiar with basic electrical concepts
- Understand and use digital AND and OR logic functions
- Test circuits using circuit simulation software

To accomplish the objectives, we will give you a short overview of electrical and digital logic concepts. You will then work with a partner to build circuits described later in the handout using the Electronic Workbench simulation program. A variety of circuits are described; however, you may not have time to complete the simulation of all of them.

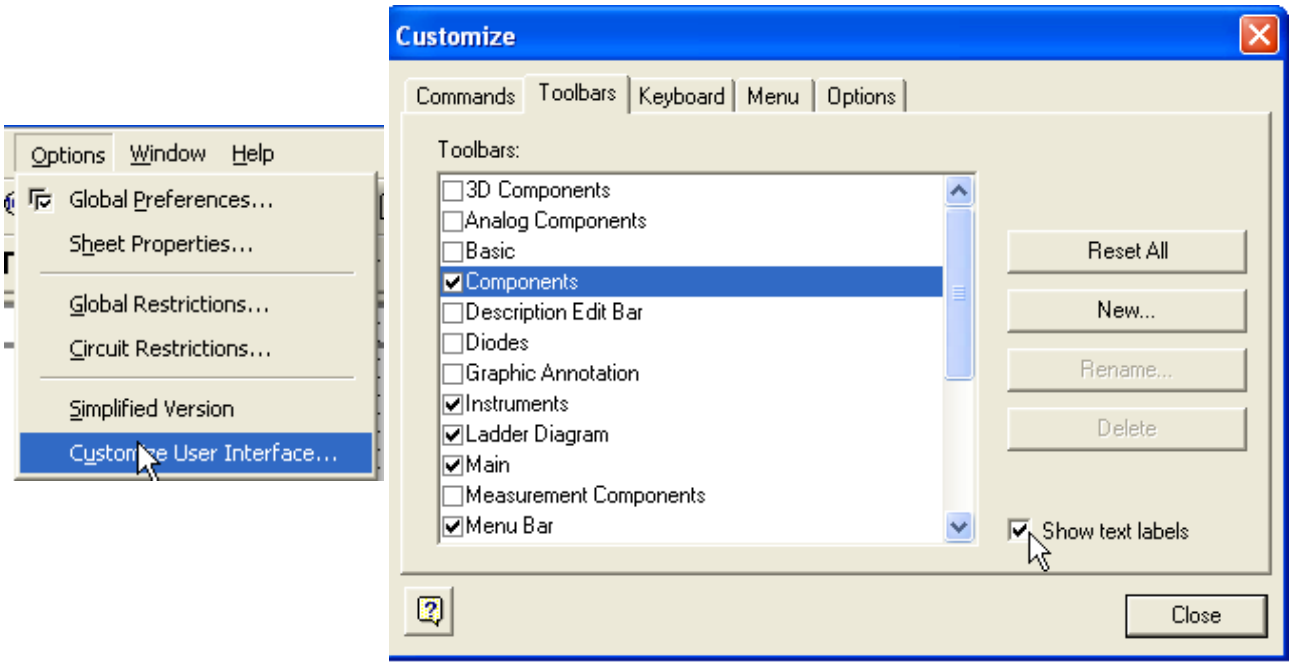
The simulation program we will be using is MultiSim 8 by Electronics Workbench. www.electronicsworkbench.com. It is a user-friendly program which a user can create and test circuits in a relatively short time. It has a variety of components listed in a series of menus. One of the initial difficulties is finding the component you want. The circuits we are going to build start on page 13.

How to Find Components

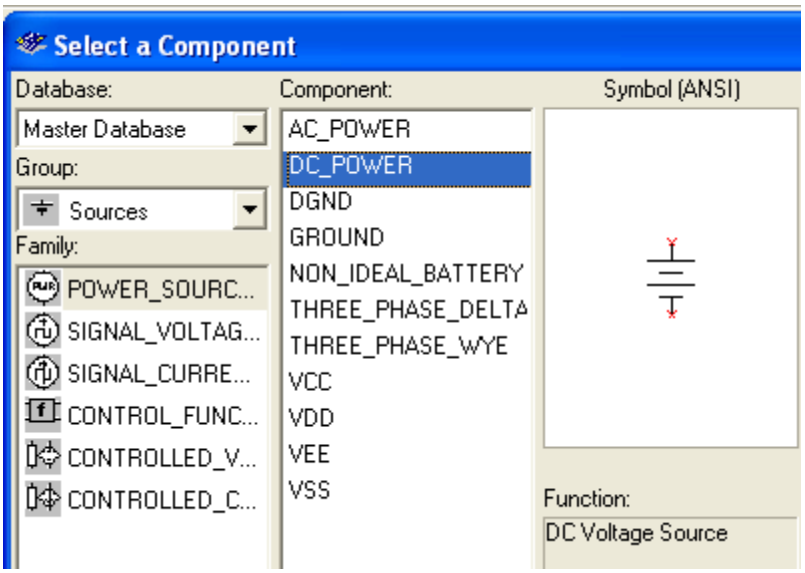
A list of component icons is shown along with the menu selections used to access them. The order of presentation is the same as the order in which you will be constructing the circuits.

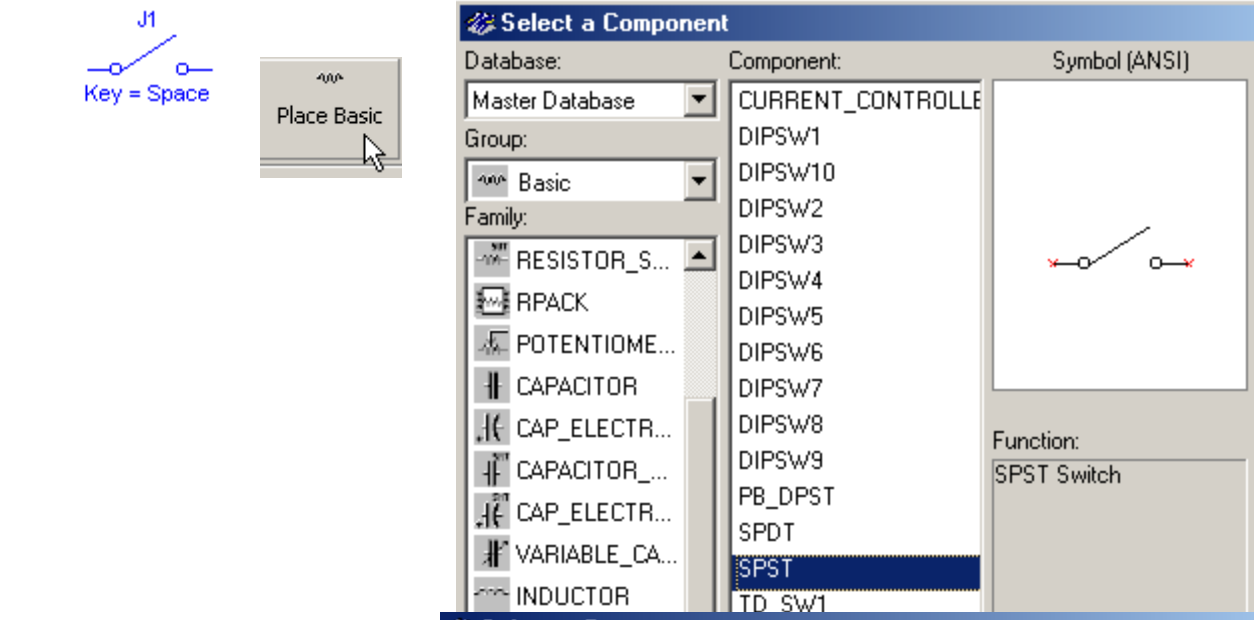
If your menu toolbar only shows icons without the text which identifies them, you need to turn on the text so the toolbar is as shown below:

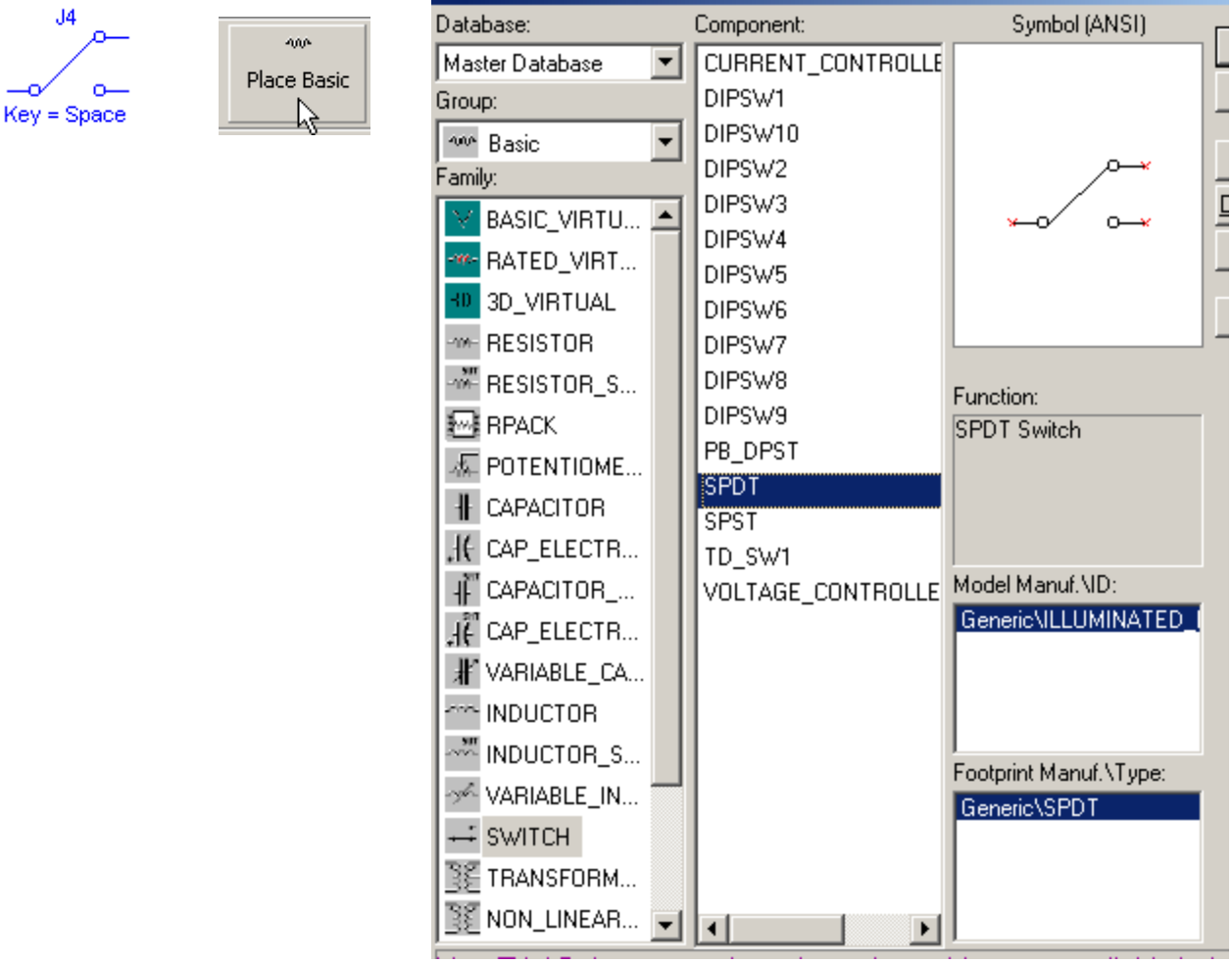
How to turn on the Toolbar text

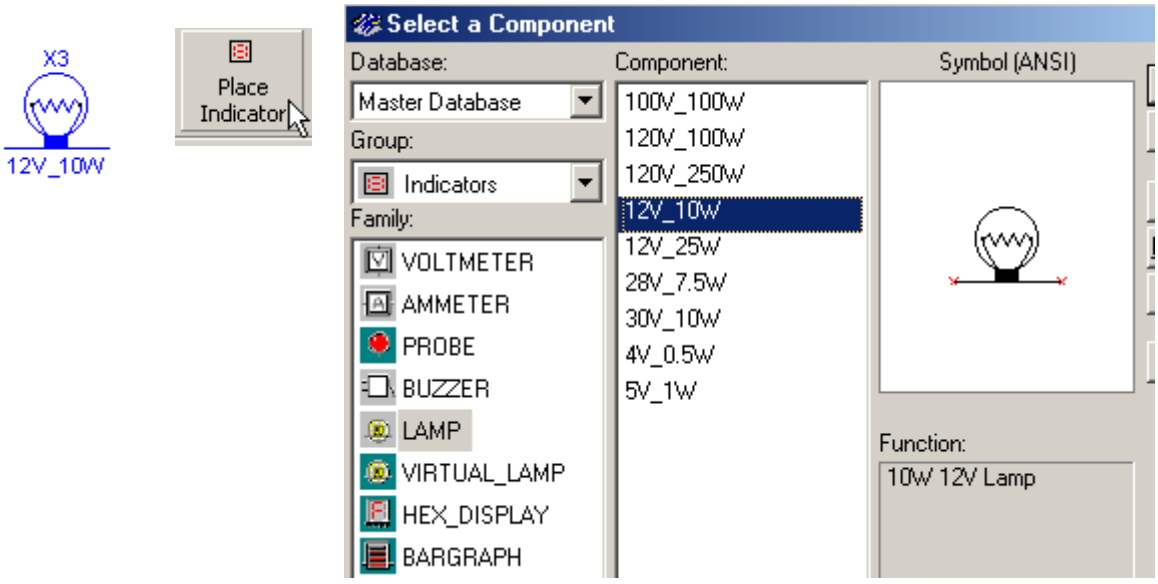


Circuit 1:

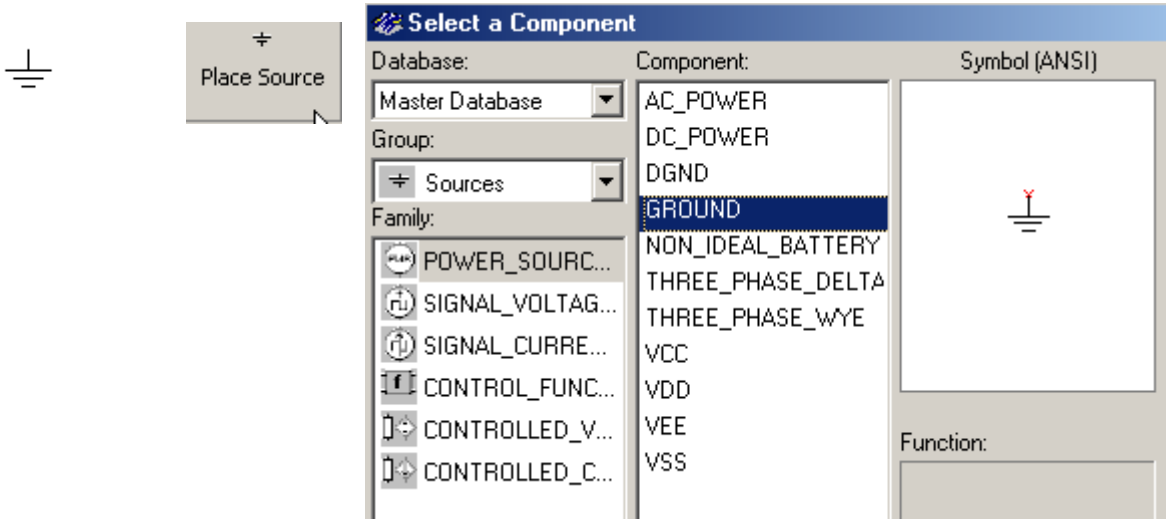


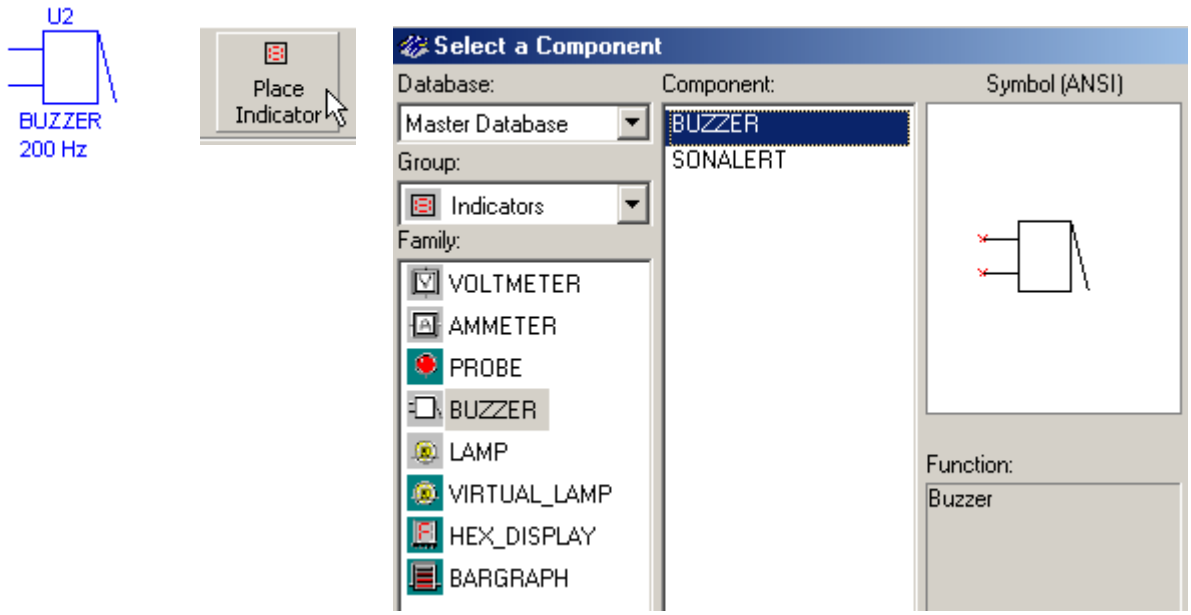

J1
Key = Space
Place Basic
Select a Component
Database:
Master Database
Group:
Basic
Family:
RESISTOR_S...
RPACK
POTENTIOME...
CAPACITOR
CAP_ELECTR...
CAPACITOR_...
CAP_ELECTR...
VARIABLE_CA...
INDUCTOR
Component:
CURRENT_CONTROLLE
DIPSW1
DIPSW10
DIPSW2
DIPSW3
DIPSW4
DIPSW5
DIPSW6
DIPSW7
DIPSW8
DIPSW9
PB_DPST
SPDT
SPST
Symbol (ANSI)
Function:
SPST Switch


J4
Key = Space
Place Basic
Select a Component
Database:
Master Database
Group:
Basic
Family:
BASIC_VIRTU...
RATED_VIRT...
3D_VIRTUAL
RESISTOR
RESISTOR_S...
RPACK
POTENTIOME...
CAPACITOR
CAP_ELECTR...
CAPACITOR_...
CAP_ELECTR...
VARIABLE_CA...
INDUCTOR
INDUCTOR_S...
VARIABLE_IN...
SWITCH
TRANSFORM...
NON_LINEAR...
Component:
CURRENT_CONTROLLE
DIPSW1
DIPSW10
DIPSW2
DIPSW3
DIPSW4
DIPSW5
DIPSW6
DIPSW7
DIPSW8
DIPSW9
PB_DPST
SPDT
SPST
TD_SW1
VOLTAGE_CONTROLLE
Symbol (ANSI)
Function:
SPDT Switch
Model Manuf.\ID:
Generic\ILLUMINATED_
Footprint Manuf.\Type:
Generic\SPDT

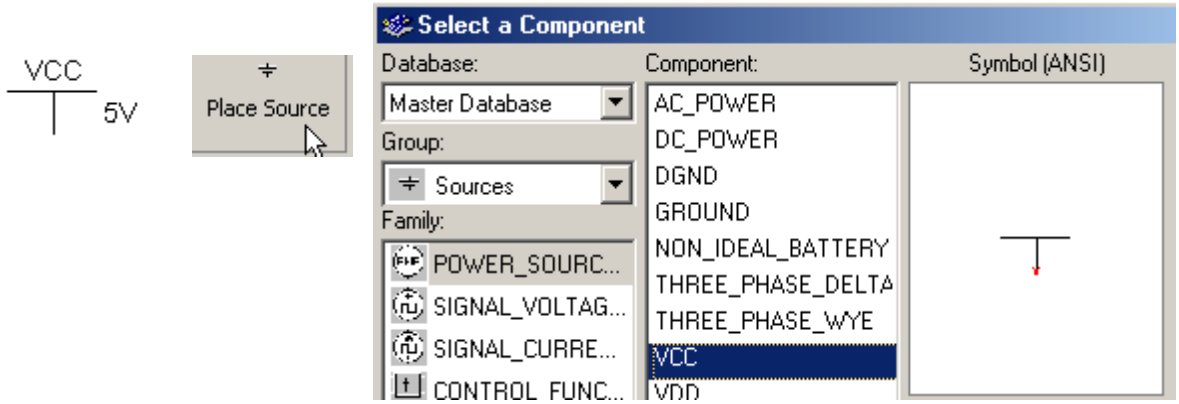

X3
12V_10W
Place Indicator
Select a Component
Database:
Master Database
Group:
Indicators
Family:
VOLTMETER
AMMETER
PROBE
BUZZER
LAMP
VIRTUAL_LAMP
HEX_DISPLAY
BARGRAPH
Component:
100V_100W
120V_100W
120V_250W
12V_10W
12V_25W
28V_7.5W
30V_10W
4V_0.5W
5V_1W
Symbol (ANSI)
Function:
10W 12V Lamp

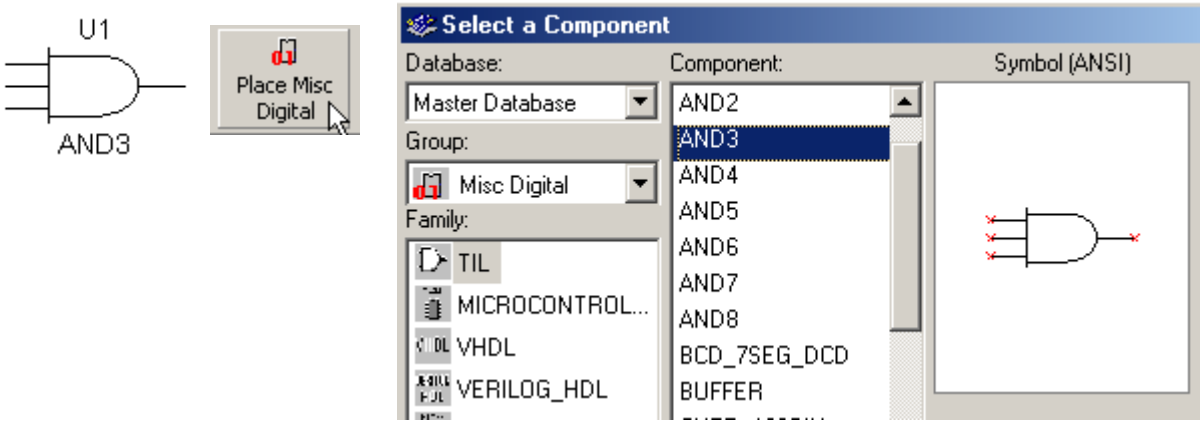
Circuit 3:

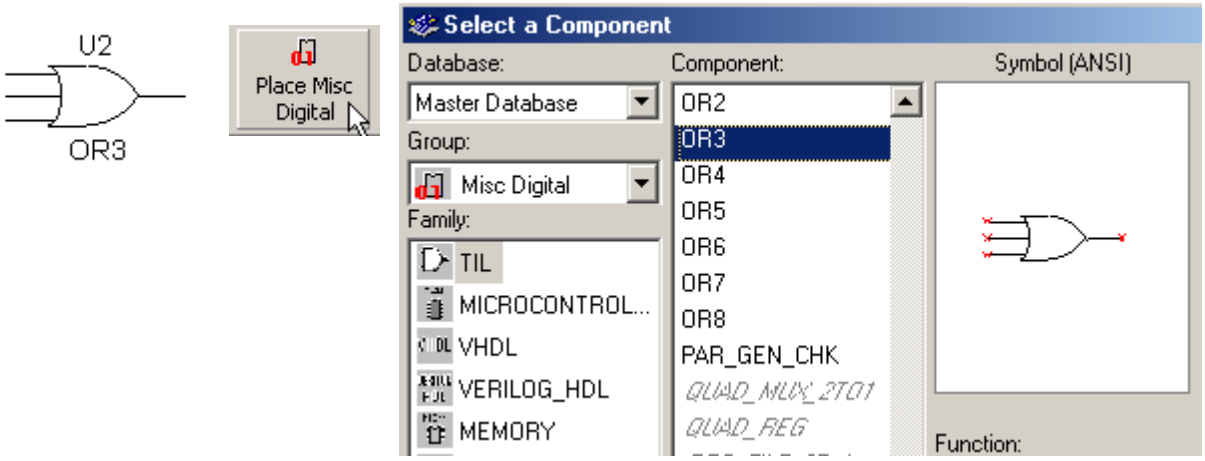

Place Source
Select a Component
Database:
Master Database
Group:
Sources
Family:
POWER_SOURC...
SIGNAL_VOLTAG...
SIGNAL_CURRE...
CONTROL_FUNC...
CONTROLLED_V...
CONTROLLED_C...
Component:
AC_POWER
DC_POWER
DGND
GROUND
NON_IDEAL_BATTERY
THREE_PHASE_DELTA
THREE_PHASE_WYE
VCC
VDD
VEE
VSS
Symbol (ANSI)
Function:

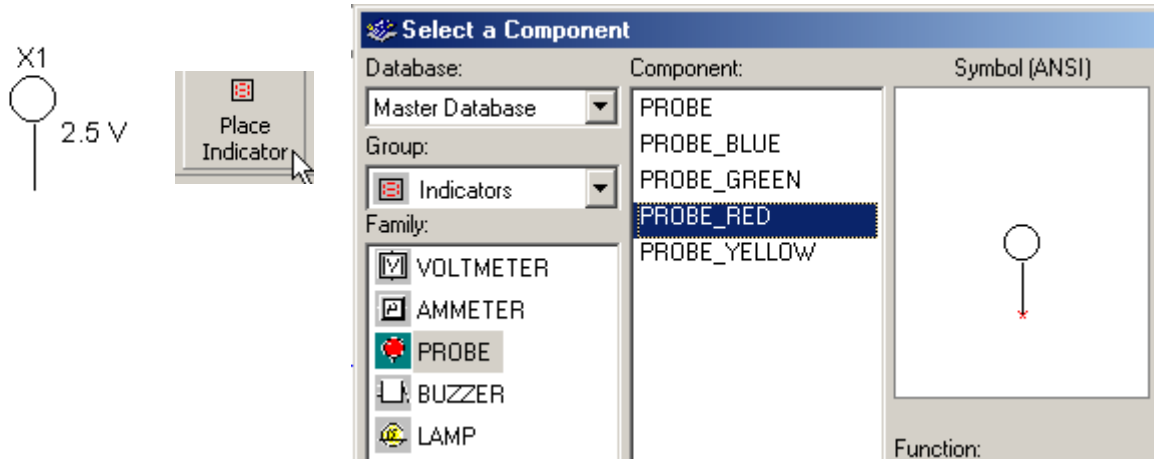

U2
BUZZER
200 Hz
Place Indicator
Select a Component
Database:
Master Database
Group:
Indicators
Family:
VOLTMETER
AMMETER
PROBE
BUZZER
LAMP
VIRTUAL_LAMP
HEX_DISPLAY
BARGRAPH
Component:
BUZZER
SONALERT
Symbol (ANSI)
Function:
Buzzer

Circuit 4:

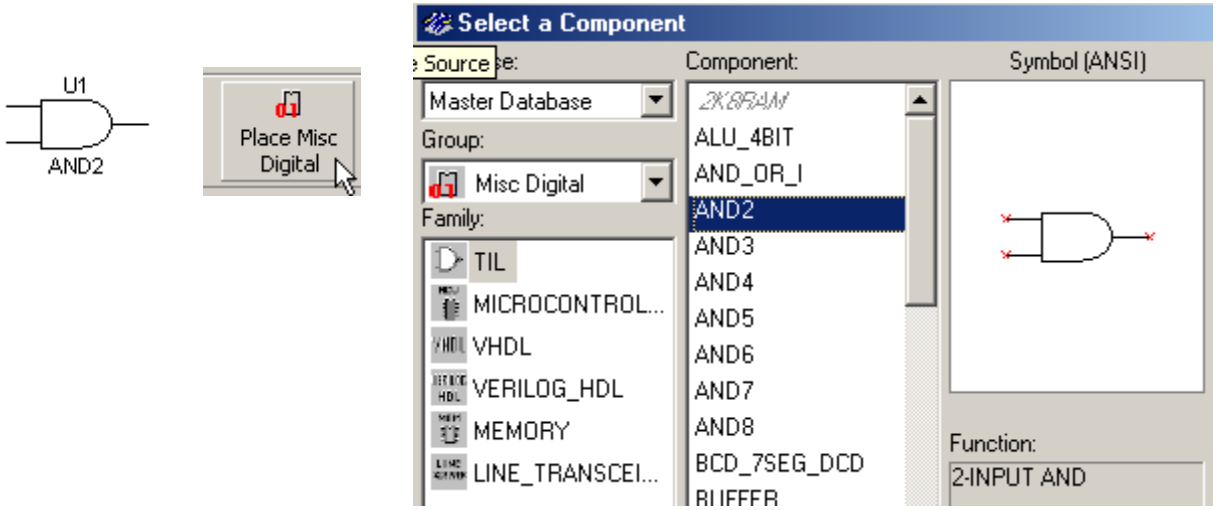

VCC
5V
Place Source
Select a Component
Database:
Master Database
Group:
Sources
Family:
POWER_SOURC...
SIGNAL_VOLTAG...
SIGNAL_CURRE...
CONTROL_FUNC...
Component:
AC_POWER
DC_POWER
DGND
GROUND
NON_IDEAL_BATTERY
THREE_PHASE_DELTA
THREE_PHASE_WYE
VCC
VDD
Symbol (ANSI)

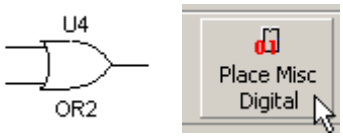

U1
AND3
Place Misc Digital
Select a Component
Database:
Master Database
Group:
Misc Digital
Family:
TIL
MICROCONTROL...
VHDL
VERILOG_HDL
Component:
AND2
AND3
AND4
AND5
AND6
AND7
AND8
BCD_7SEG_DCD
BUFFER
Symbol (ANSI)

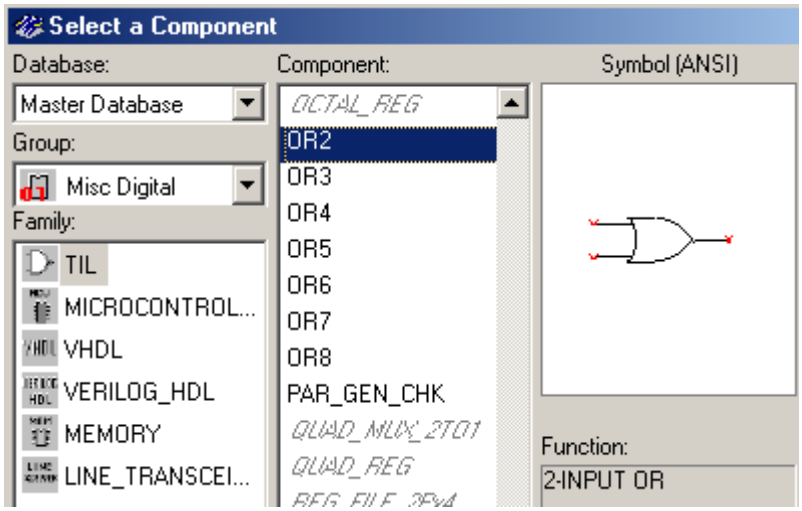

U2
OR3
Place Misc Digital
Select a Component
Database:
Master Database
Component:
OR2
OR3
OR4
OR5
OR6
OR7
OR8
PAR_GEN_CHK
Symbol (ANSI)
Group:
Misc Digital
Family:
TIL
MICROCONTROL...
VHDL
VERILOG_HDL
MEMORY
Function:


X1
2.5 V
Place Indicator
Select a Component
Database:
Master Database
Component:
PROBE
PROBE_BLUE
PROBE_GREEN
PROBE_RED
PROBE_YELLOW
Symbol (ANSI)
Group:
Indicators
Family:
VOLTMETER
AMMETER
PROBE
BUZZER
LAMP
Function:

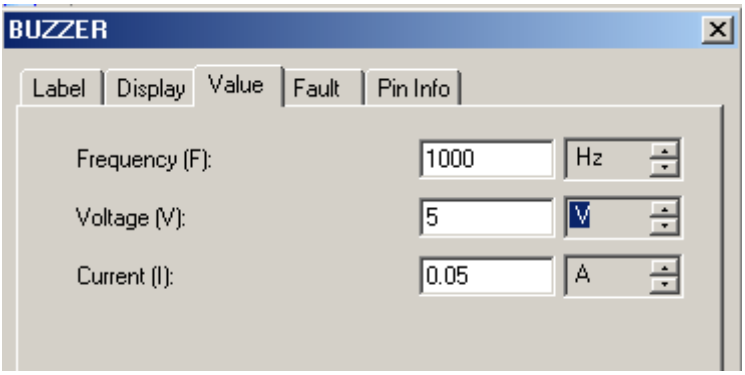
Circuit 5:


U1
AND2
Place Misc Digital
Select a Component
Source
Component:
Symbol (ANSI)
Master Database
ALU_4BIT
AND_OR_I
AND2
AND3
AND4
AND5
AND6
AND7
AND8
BCD_7SEG_DCD
Group:
Misc Digital
Family:
TIL
MICROCONTROL...
VHDL
VERILOG_HDL
MEMORY
LINE_TRANSCEI...
Function:
2-INPUT AND

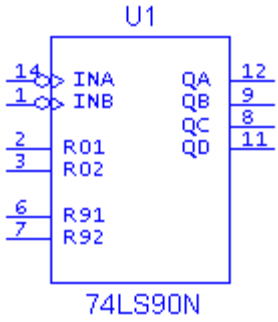


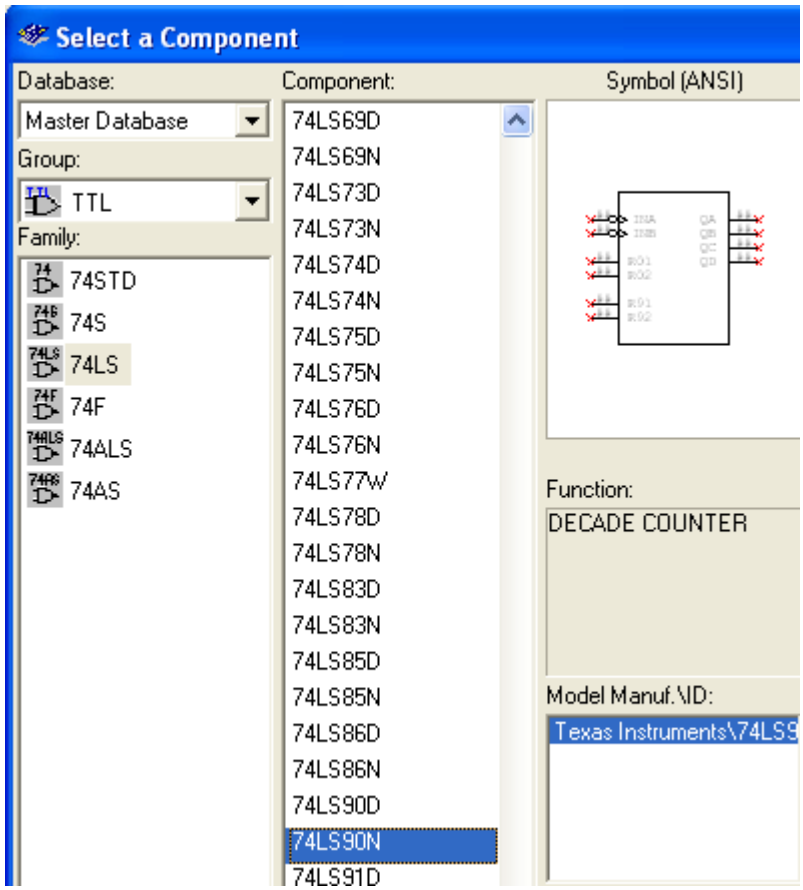


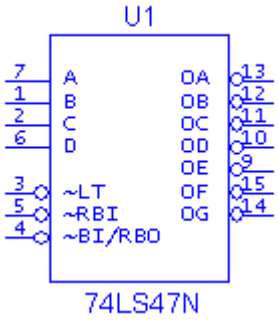
Double click the buzzer icon to change the buzzer to work with 5 volts.



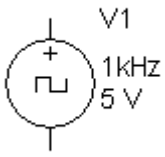
Circuit 6:

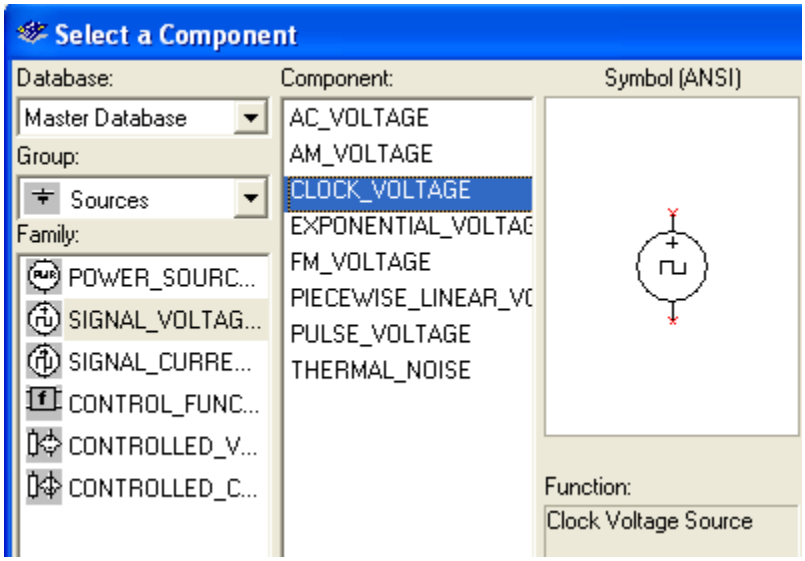






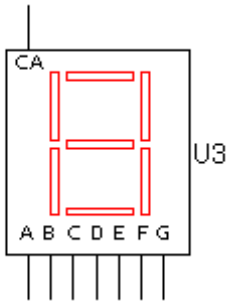
Same as the 74LS90N except select 74LS47N.

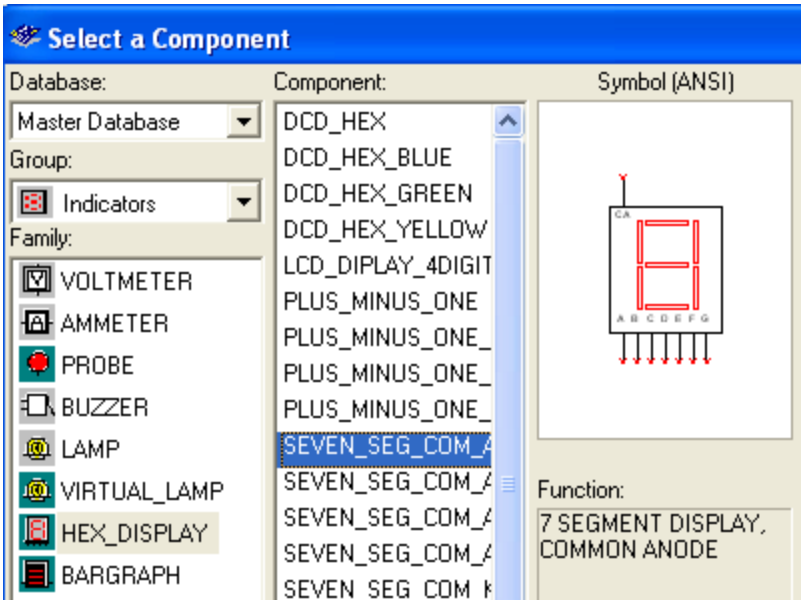




Double click on symbol
to set values on the device.

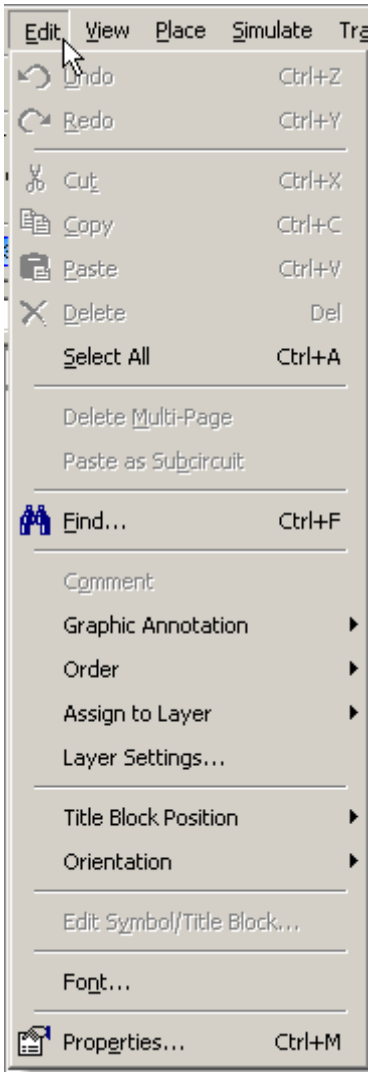
If the circuit is running when
You change its speed, you will
have to stop it and start it again
for the new value to be
recognized.

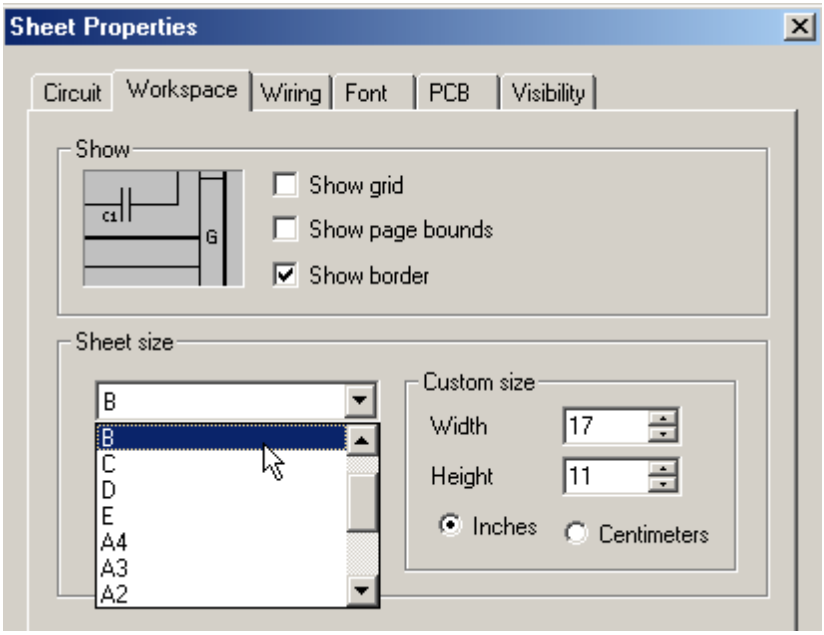




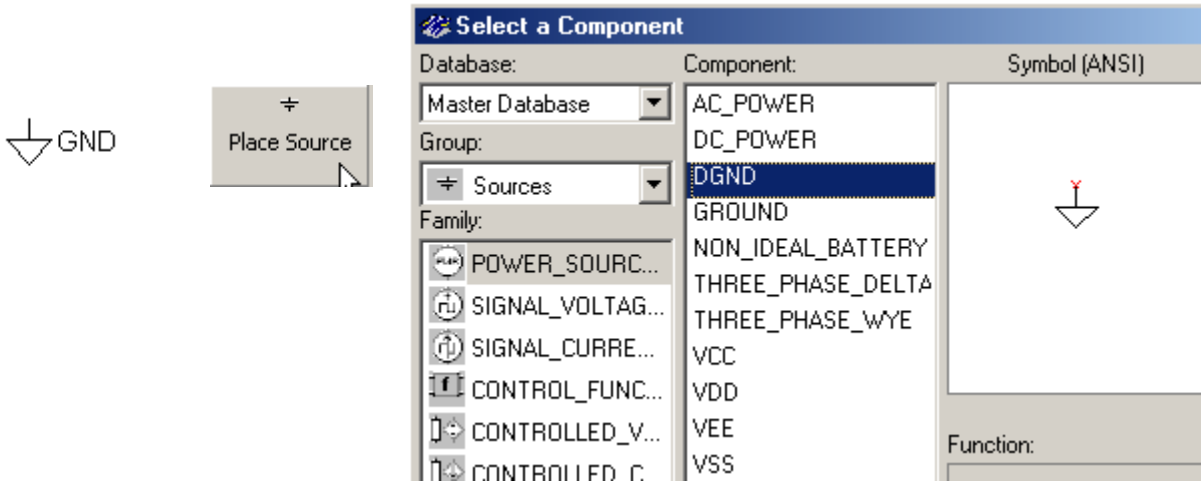
Circuit 7:

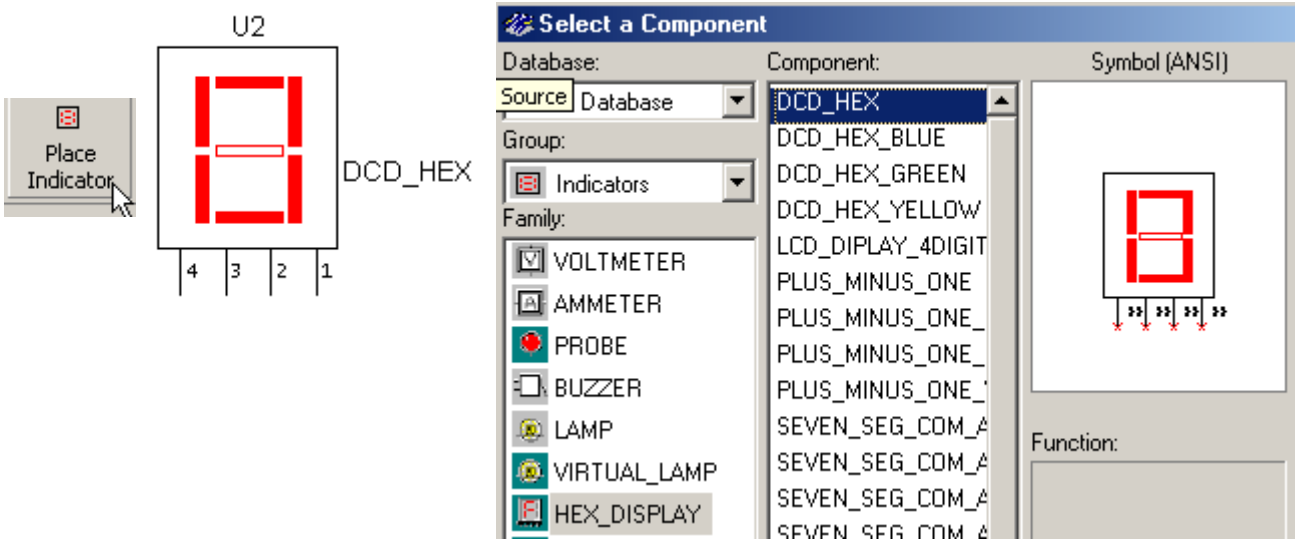
Changing Page Size: Edit | Properties |



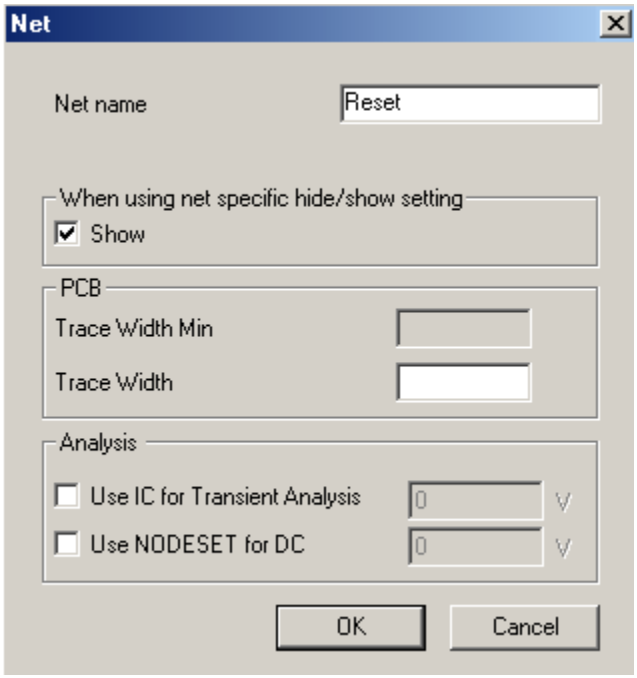


Circuit 8:

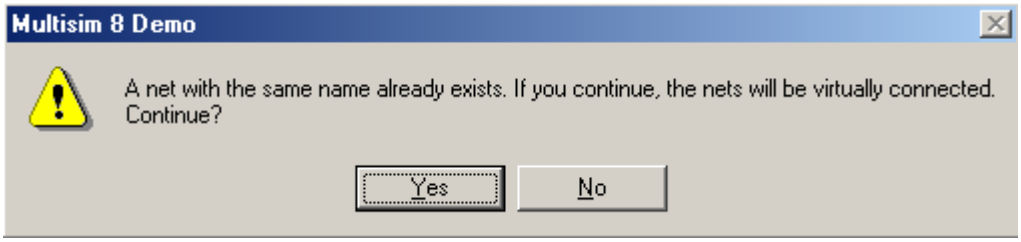

GND
Place Source
Select a Component
Database:
Master Database
Group:
Sources
Family:
POWER_SOURC...
SIGNAL_VOLTAG...
SIGNAL_CURRE...
CONTROL_FUNC...
CONTROLLED_V...
Component:
AC_POWER
DC_POWER
DGND
GROUND
NON_IDEAL_BATTERY
THREE_PHASE_DELTA
THREE_PHASE_WYE
VCC
VDD
VEE
VSS
Symbol (ANSI)
Function:


U2
Place Indicator
DCD_HEX
4
3
2
1
Select a Component
Database:
Source
Database
Group:
Indicators
Family:
VOLTMETER
AMMETER
PROBE
BUZZER
LAMP
VIRTUAL_LAMP
HEX_DISPLAY
Component:
DCD_HEX
DCD_HEX_BLUE
DCD_HEX_GREEN
DCD_HEX_YELLOW
LCD_DIPLAY_4DIGIT
PLUS_MINUS_ONE
PLUS_MINUS_ONE_
PLUS_MINUS_ONE_
PLUS_MINUS_ONE_
SEVEN_SEG_COM_A
SEVEN_SEG_COM_A
SEVEN_SEG_COM_A
Symbol (ANSI)
Function:

Naming a Wire

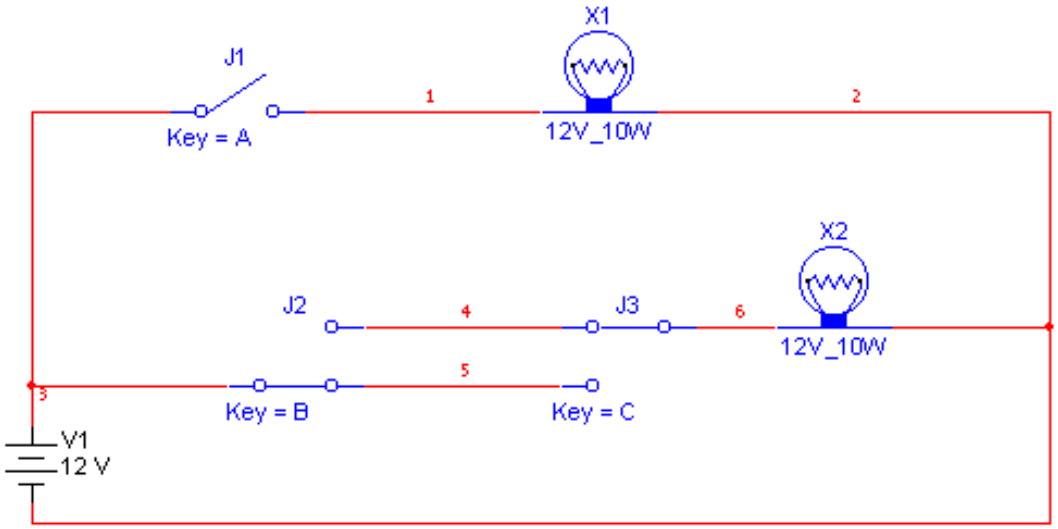


A warning you get if you have previously used the same name.



Simulating Circuits

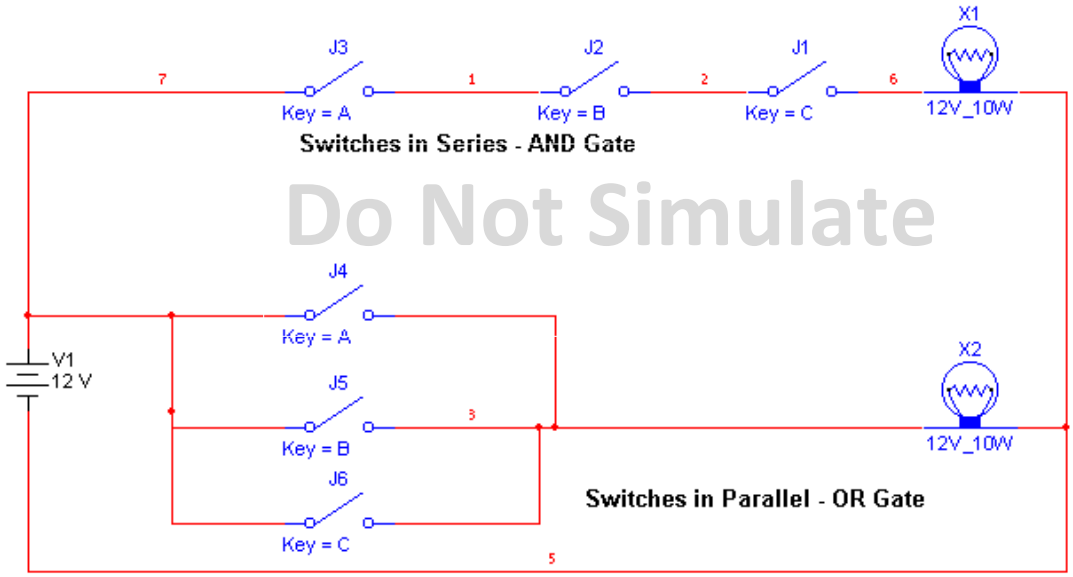
The circuits which we will construct and simulate are digital. In a digital circuit we are only concerned if a signal is present or not. A switch is an example of a digital circuit. It is either on or off. Terms used for the presence of a signal are **on**, **high**, **true**, and **one**. Terms used for the absence of a signal are **off**, **low**, **false** and **zero**. The following circuit shows how switches are wired in homes to make a one-way switch circuit and a three-way switch circuit.



Circuit 1 – Wiring Residential Switches

This circuit shows how typical “one-way” and “three-way” switches are wired. Switch A is wired as a one-way switch. Switches B and C are wired as three-way switches.

Digital circuits are constructed so that they perform logic functions. The two most basic logic functions are the AND and OR. An AND circuit gives an output signal if all of its inputs (switches) are true (on). An OR circuit gives an output signal if at least one of its inputs is on. The following circuit shows how switches are wired to implement these functions.



Circuit 2 - Switches as Logic Elements

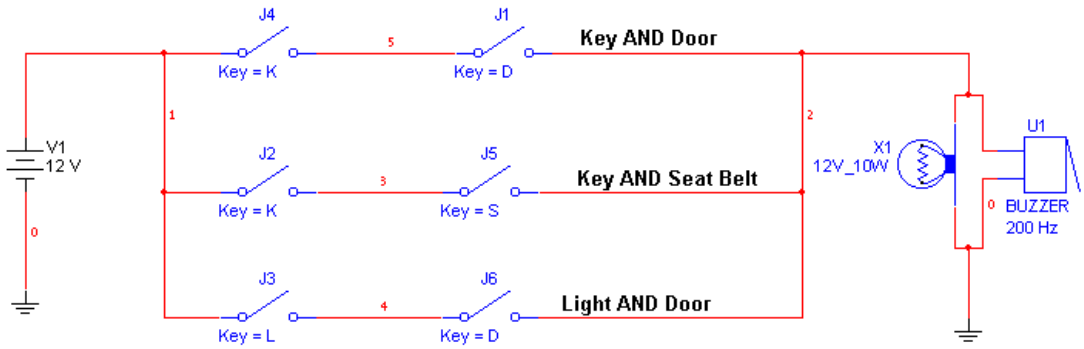
The upper switches which are in a row (series) implement an AND gate. Switches A AND B AND C must be closed to light the light.

The lower switches which are in parallel implement an OR gate. Switch A OR switch B OR switch C must be closed to light the light.

The following example shows how switches can be combined to make a “real” circuit. This implements a simple "Idiot Buzzer" system on an automobile.
The buzzer will sound if:

the key is in the ignition AND the door is open
OR the key is in the ignition AND the seat belts are not connected
OR the lights are on AND the door is open.

Note: A light is used in addition to the buzzer.



Circuit 3 – Automobile Buzzer System

Description of Switches

Key
Open: Key not in ignition
Closed: Key in the ignition

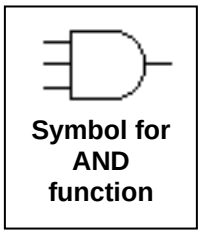
Lights
Open: Lights off
Closed: Lights on

Seatbelts
Open: Seatbelts connected
Closed: Seatbelts not connected

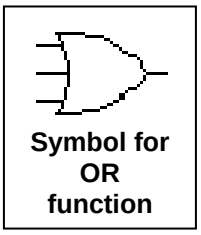
Door
Open: Door closed
Closed: Door open

This circuit uses the ground Symbol .  All parts of the circuit which have the ground symbol are physically connected together even though the schematic does not show it.

There are symbols to represent the logic functions. The input signals are on the left and the output is on the right. These symbols show three signals ANDed and Ored but there could be any number of inputs. These symbols are normally used when the logic function is built using integrated circuits.

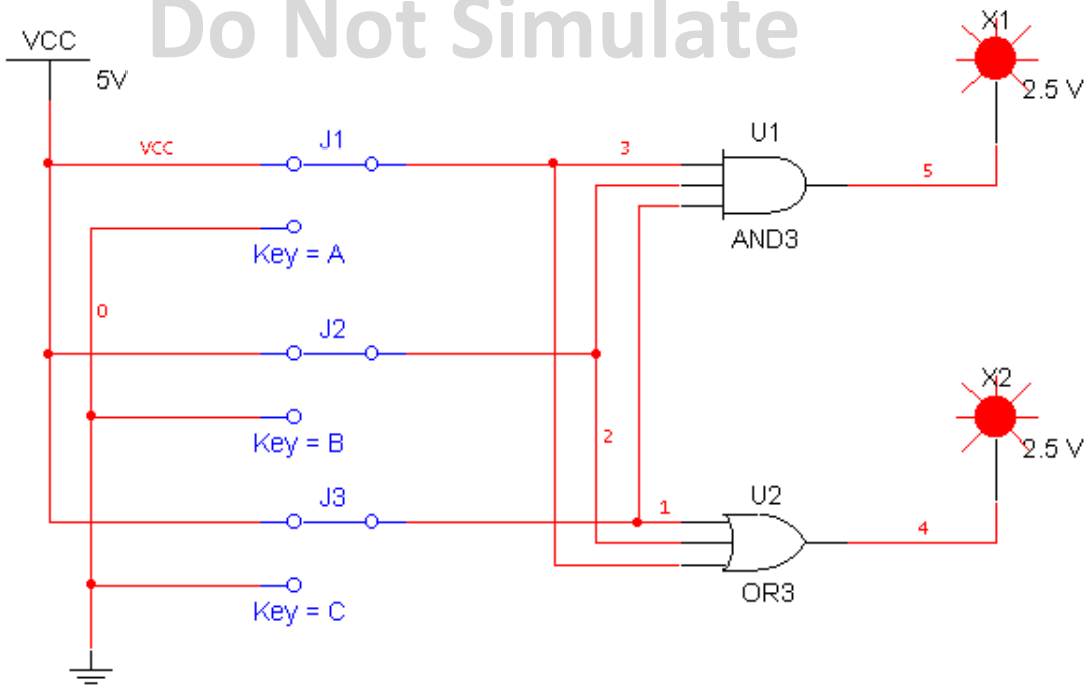


Symbol for AND function



Symbol for OR function

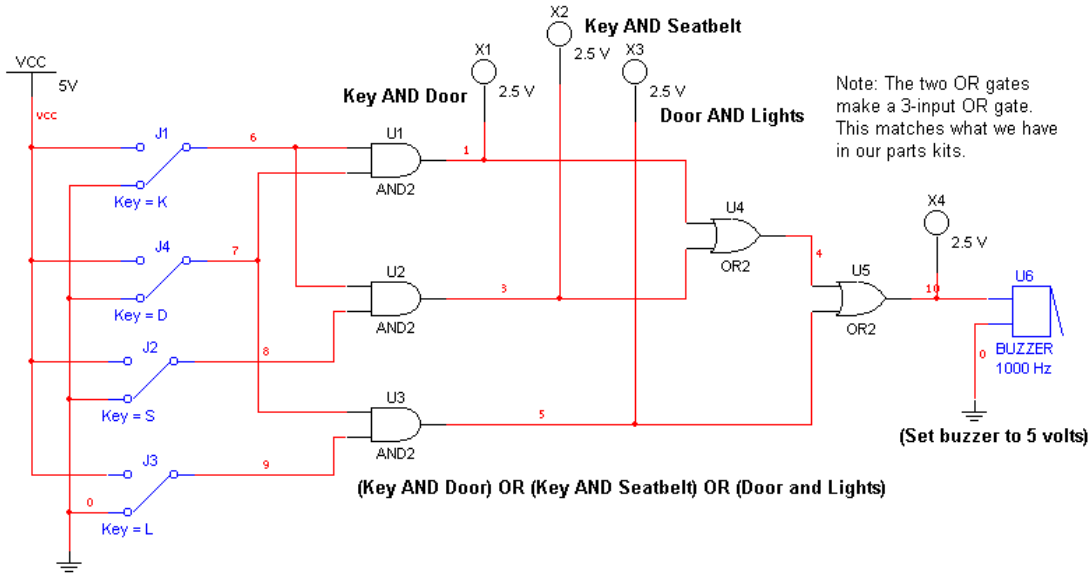
This circuit uses the integrated circuit symbols for the AND and OR logic gates.



Circuit 4 – Integrated Circuit Logic Gates

Most integrated circuits use a 5 volt supply which is commonly referred to as Vcc. The symbol  represents the 5 volt battery. We also are using the LED symbol  instead of a regular light.

This is how the integrated circuit form of the automobile idiot buzzer system would look.



Circuit 5 – Integrated Circuit Form of Automobile Buzzer System

Description of Switches

Key

Open: Key not in ignition
Closed: Key in the ignition

Lights

Open: Lights off
Closed: Lights on

Seatbelts

Open: Seatbelts connected
Closed: Seatbelts not connected

Door

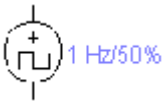
Open: Door closed
Closed: Door open

Decimal Numbers in Computers

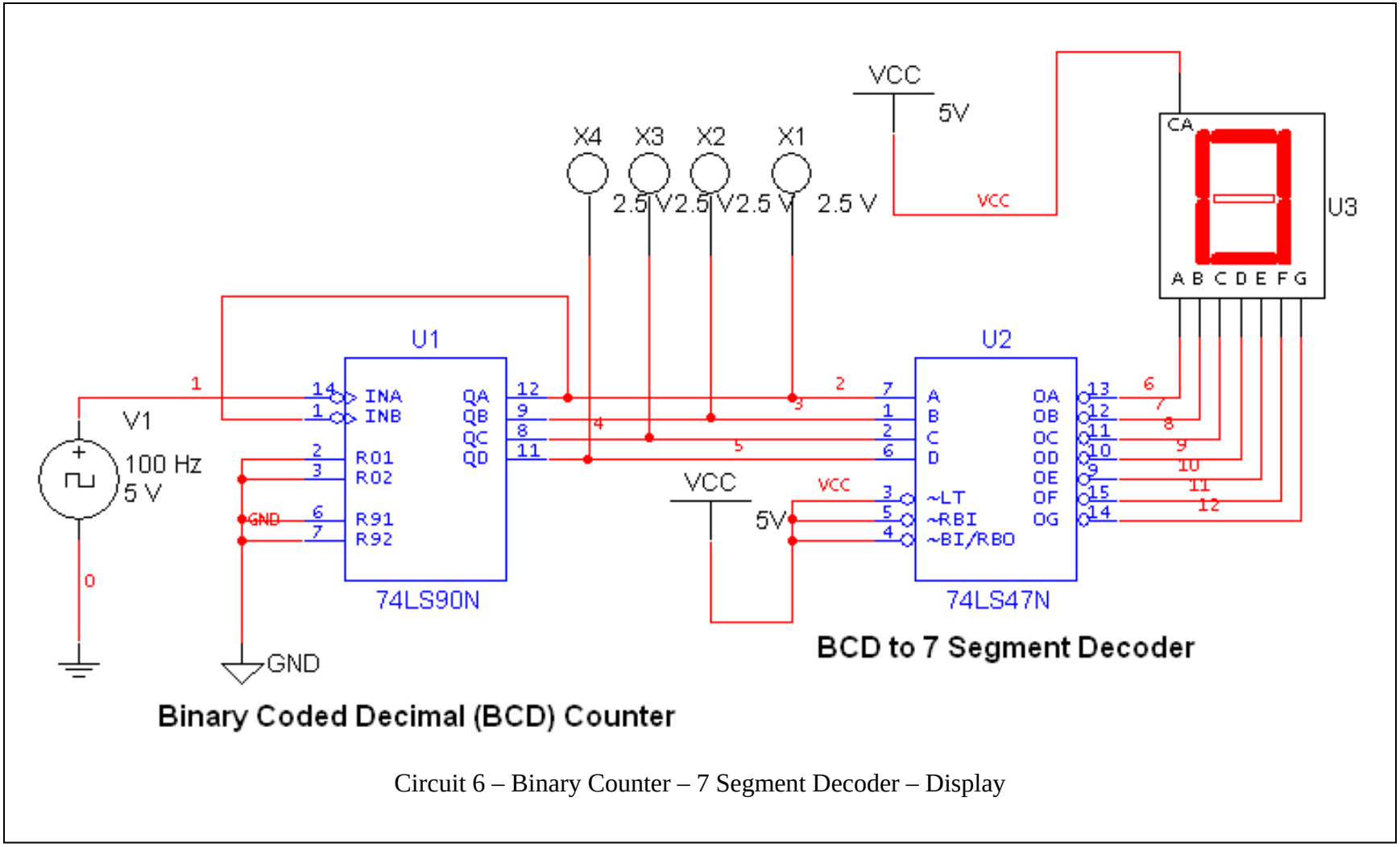
Many applications require the use of a counter. The next circuit will count from 0 to 9 in binary. The binary number system uses base 2. Characters in the right column (sometimes labeled a) have the value 2^0. In the next column to the left (labeled b) they have the value 2^1. The next column (labeled c) is 2^2. The next (d) is 2^3. They evaluate from left to right as 8 - 4 - 2 - 1. The binary numbers from zero through 9 are:

For ease of use, we are using a modified binary system which only has values of zero through nine. This is referred to as binary coded decimal (BCD).

Binary	Decimal
d c b a	
8 4 2 1	
0 0 0 0	0
0 0 0 1	1
0 0 1 0	2
0 0 1 1	3
0 1 0 0	4
0 1 0 1	5
0 1 1 0	6
0 1 1 1	7
1 0 0 0	8
1 0 0 1	9

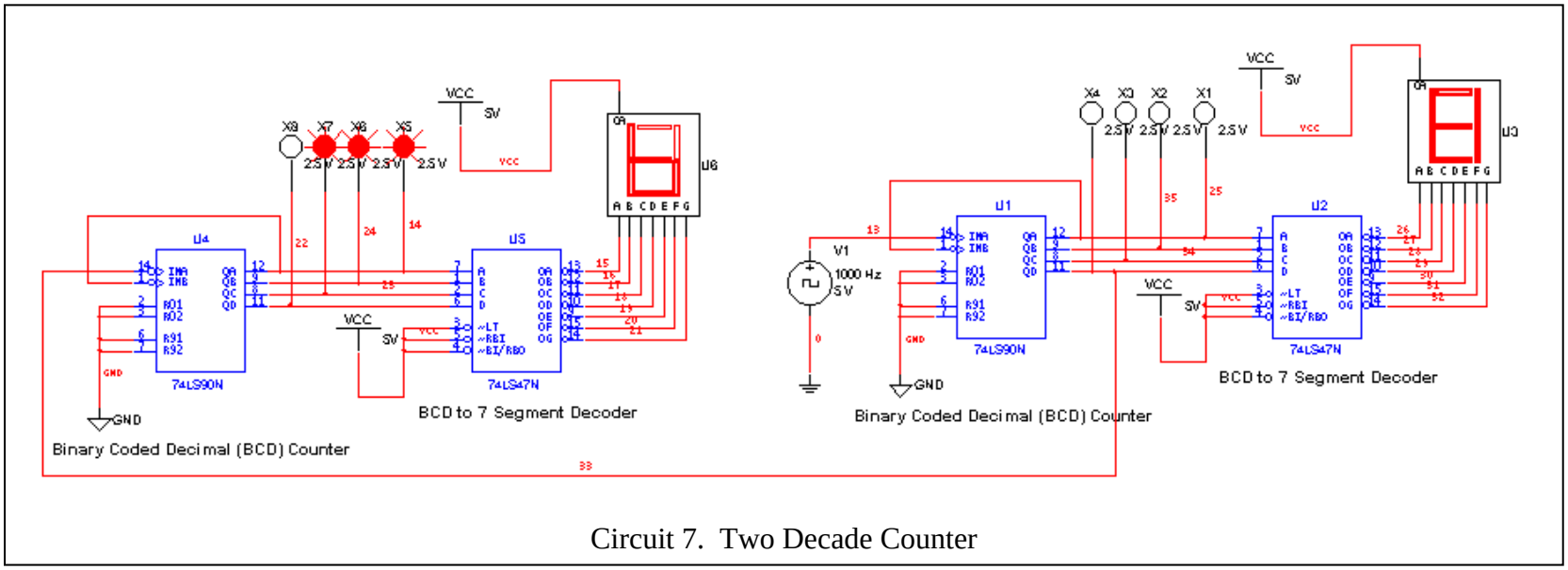
The next circuit consists of a signal generator 

set to give one transition per second. The counter integrated circuit, 7490, counts the transitions in binary and the value is shown on the four LED displays. The binary signals need to be converted to drive a 7 segment display. The binary to 7 segment decoder performs this task.



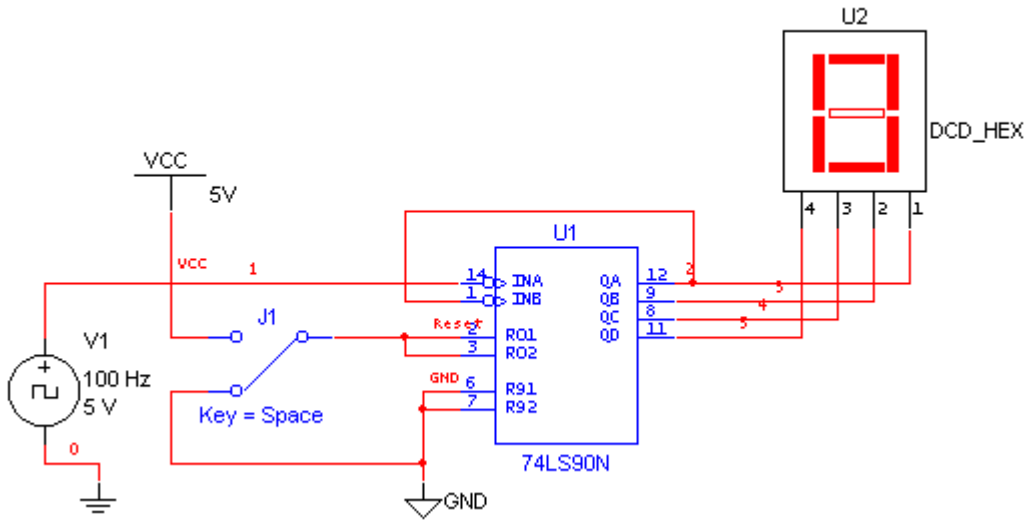
Circuit 6 – Binary Counter – 7 Segment Decoder – Display

Next we will make a two decade counter which will count from 00 to 99. Change the size of the drawing sheet to size B. Move the circuit to the right side of the page by doing Edit | Select All (control A) and dragging the components to the desired position. Make a copy of the circuit by Select All and Paste (control V). Delete the signal generator on the left counter. The QD signal of the least significant digit will be used to clock the next stage. Place a wire from INA to QD.



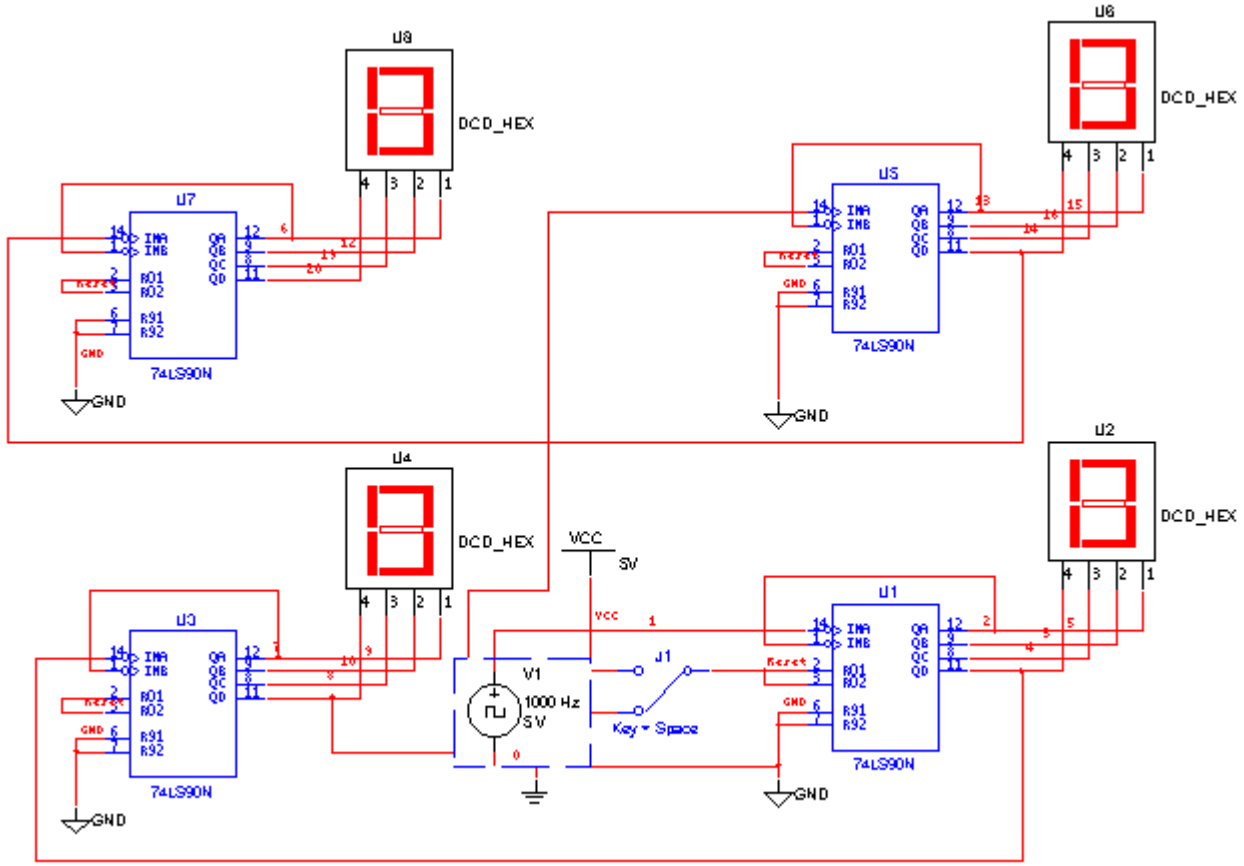
Circuit 7. Two Decade Counter

Create the following circuit. Use the DGND for the GND component. Use the DCD_HEX component which combines the decoding and display in one component. This will speed simulation so the circuit will count faster. The switch will cause the counter to reset when connected to Vcc and to count normally when connected to ground. Double click on the wire connected to R01 and name the net Reset.



Circuit 8. Counter with Display

Copy the circuit three times to make a four digit counter. Double click the wire connected to R01 and name it Reset. You should get a warning that that name has been used. Click OK. This will make a connection between both wire named Reset without having to draw the line. Do the same to the other two counters. Connect the QD of a counter to the INA of the next counter. Set the clock frequency to 1000Hx. Remember to stop and then start the simulation after changing the clock speed.



Circuit 9

Hands-on Simulation:

In the time remaining before the break, you will construct and simulate some of the circuits discussed. You will do circuits in the following order. If you are running short of time, skip some of the first ones so you can finish circuits 3, 5, and 6. We will be building circuits 5 and 6 in the second portion of the module so it is helpful if you can finish and understand these two.

- **Circuit 1: Wiring Residential Switches**

Circuit 2: Switches as Logic Elements Do not simulate

- **Circuit 3: Automobile Buzzer System**

Circuit 4: Integrated Circuit Logic Gates Do not simulate

- **Circuit 5: Integrated Circuit Form of Automobile Buzzer System**
- **Circuit 6: Binary Counter – Seven Segment Decoder**

Circuit 7: Two Digit Binary Counter – Seven Segment Decoder

Circuit 8: Simplified Binary Counter – Seven Segment Display

Circuit 9: Four Digit Binary Counter – Seven Segment Decoder

References:

Simulation Software:

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

www.electronicsworkbench.com

Electronic Components:

Jameco Electronic Components
1355 Shoreway Road
Belmont, CA 94002

www.jameco.com

Breadboard:

PAD_234 Digital/Analog Trainer

Electronix Express
365 Blair Road
Avene l, New Jersey 07001

www.elexp.com/tst_234.htm