IME-100

ECE

Lab 1

Electrical and Computer Engineering Department

Kettering University

IME-100, ECE Lab1
Circuit Design, Simulation, and Layout

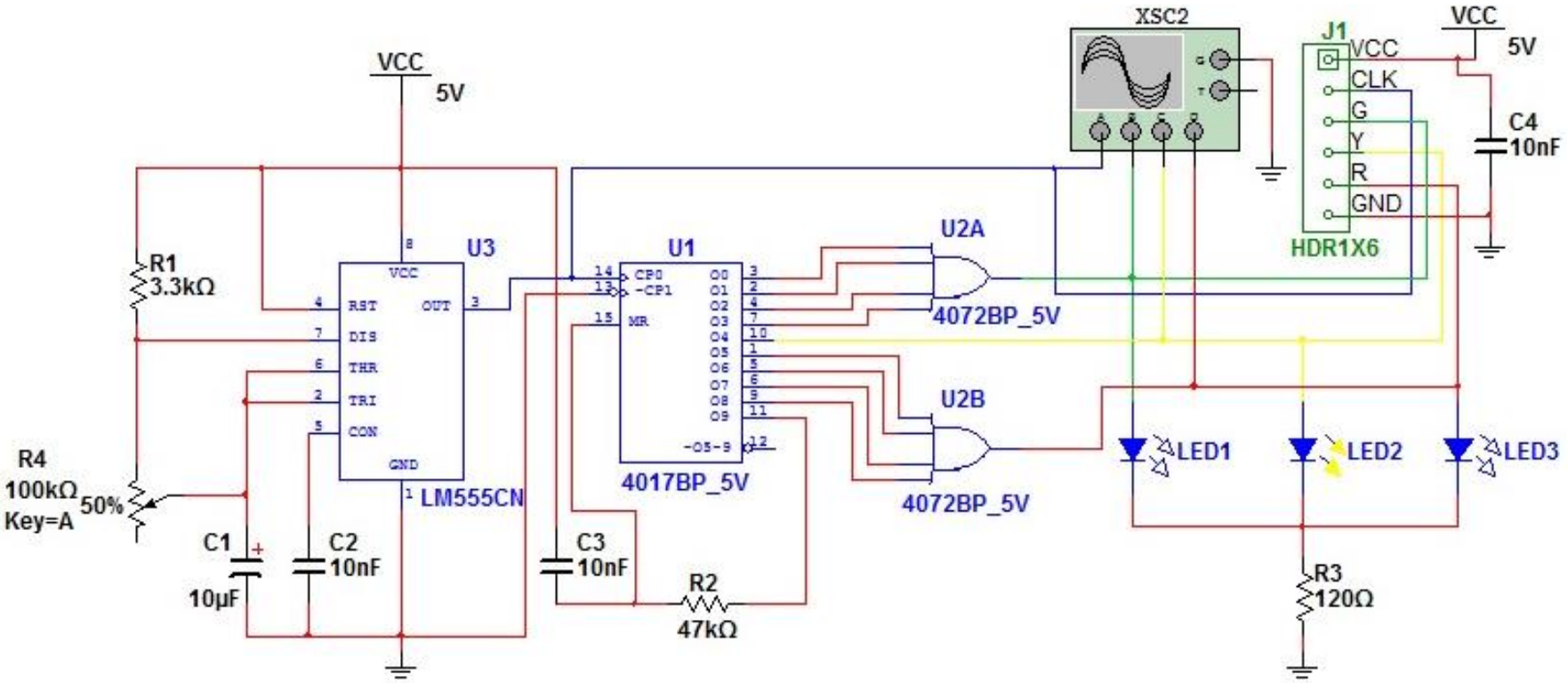
In this laboratory exercise, you will do the following:

- Use a Schematic Capture program, NI Circuit Design Suite; Multisim, to draw an LM555 based traffic light circuit.
- Use the simulation capabilities of the program, NI Circuit Design Suite; Multisim, to simulate the traffic light circuit operation.
- Observe how the timing of the traffic light circuit can be controlled using a variable resistor.
- Investigate circuit board layout using the program, NI Circuit Design Suite; Ultiboard.

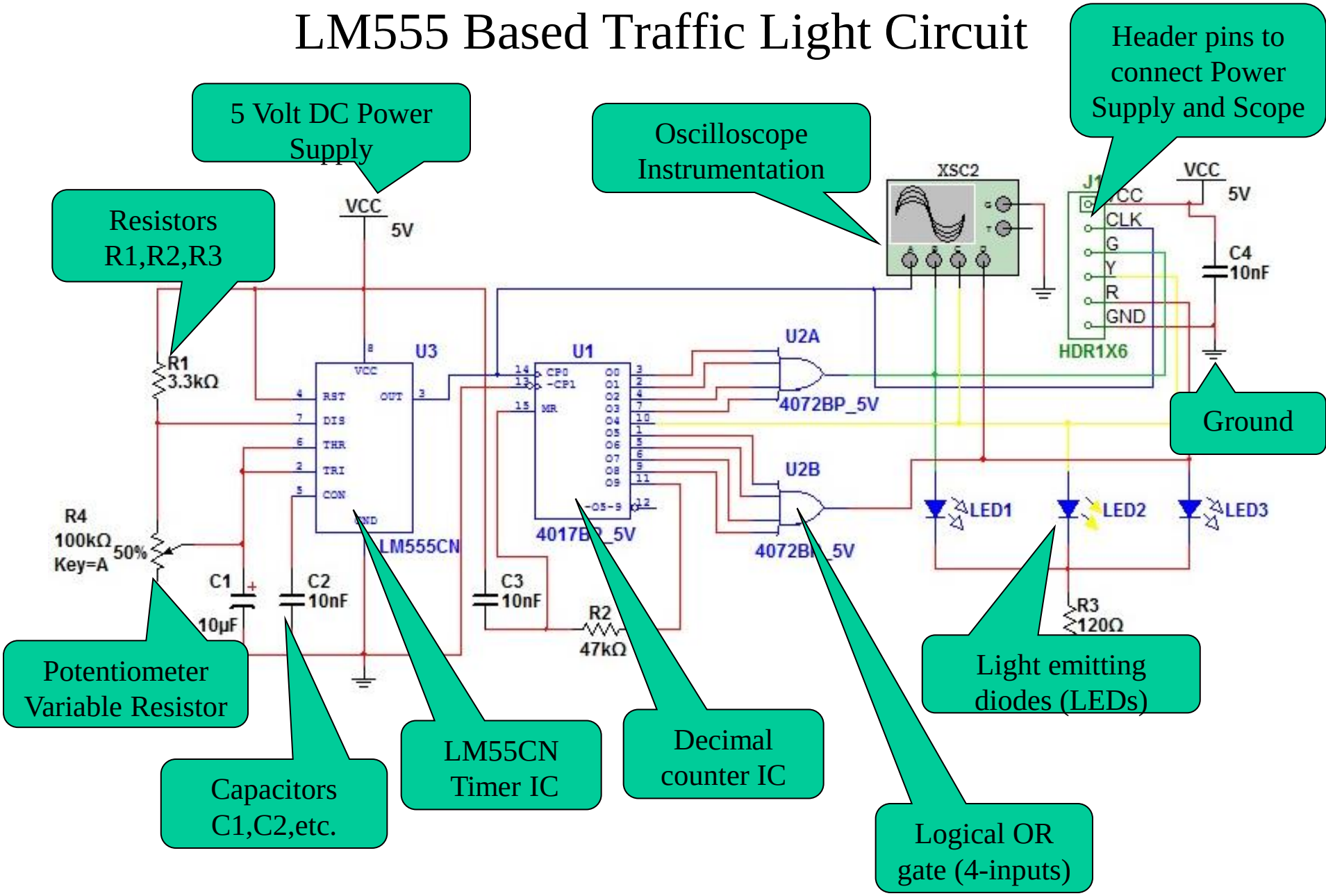
Getting Started

1. Laboratory Computers
    i. Log-in with User Name: Kettering Student (no password required)
    ii. IME-100 information (Lab presentation, files, etc.) in folder on desktop
    iii. NI programs (MultiSim, Ultiboard) under the Start menu
    iv. At the end of lab, Logout of computer; arrange keyboard and mouse
2. Laboratory Instrumentation
    i. Use instrumentation only when instructed

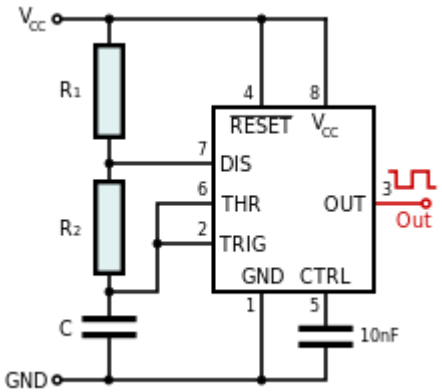
LM555 Based Traffic Light Circuit

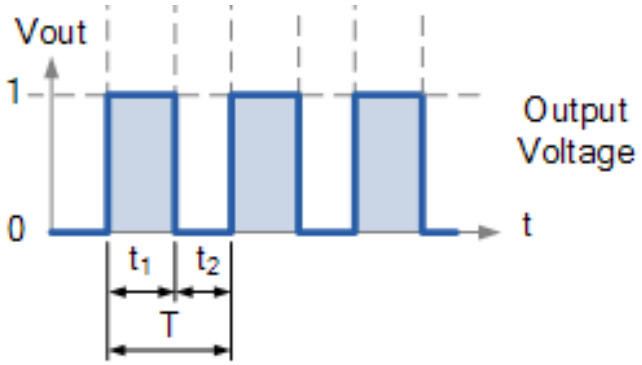


LM555 Based Traffic Light Circuit



The operation of the LM555





Formula for high time t1, low time t2, and period T :

$$t_1 = 0.693 * (R_1 + R_2) * C$$

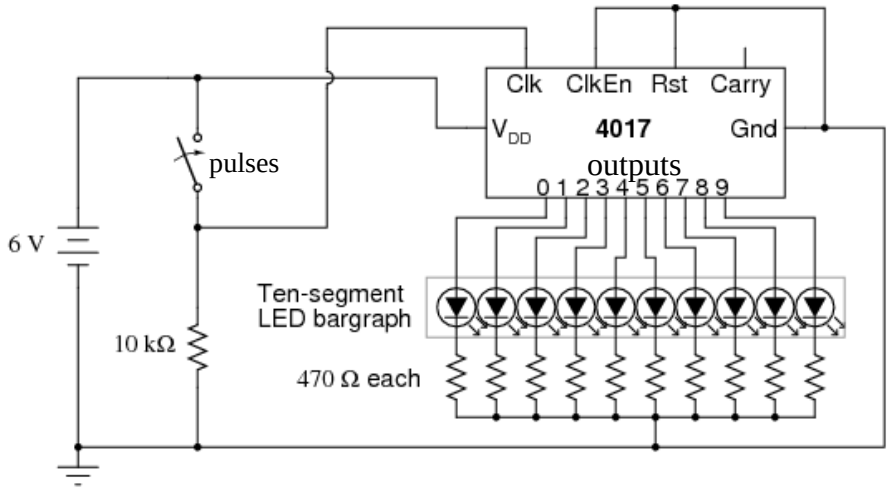
$$t_2 = 0.693 * R_2 * C$$

$$T = t_1 + t_2 = 0.693 * (R_1 + 2 * R_2) * C$$

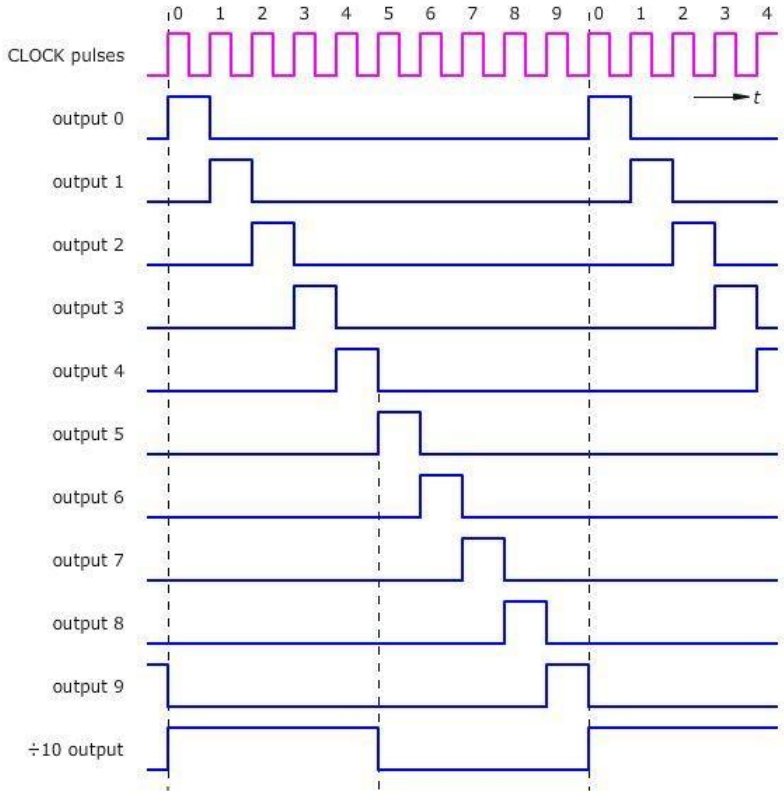
$$f = \frac{1}{T} = \frac{1.44}{(R_1 + 2 * R_2) * C}$$

Example: If R_1 = 4.7 KΩ, R_2 = 27 KΩ And C = 50 µF, calculate t_1, t_2, T, and f

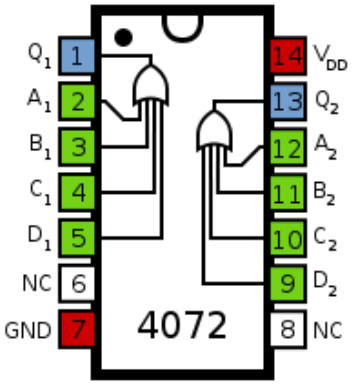
The operation of decimal counter 4017



The circuit uses LEDs to show count of the number of pulses applied by using the switch

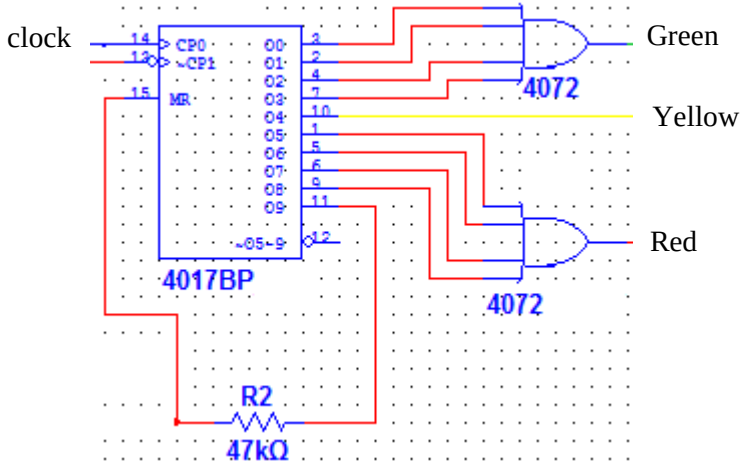


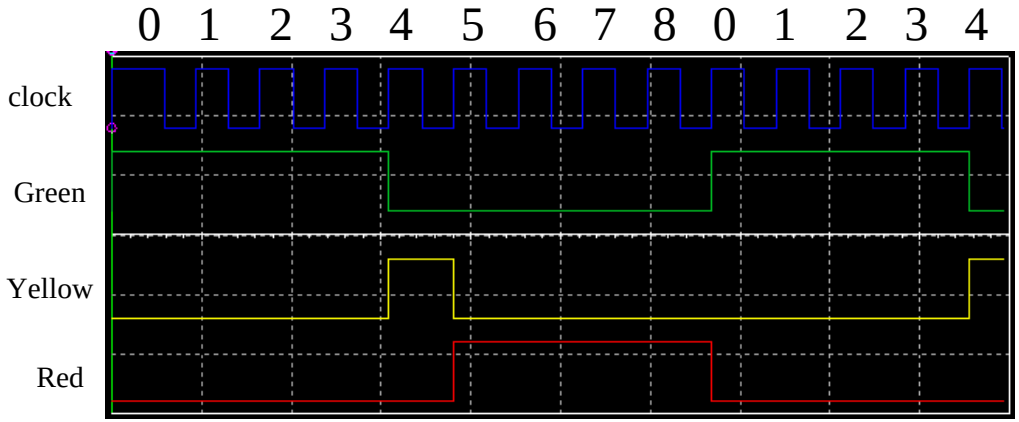
The operation of logical OR gate 4072



Truth Table for a Single Gate

A	B	C	D		Q
0	0	0	0		0
0	0	0	1		1
0	0	1	0		1
0	0	1	1		1
0	1	0	0		1
0	1	0	1		1
0	1	1	0		1
0	1	1	1		1
1	0	0	0		1
1	0	0	1		1
1	0	1	0		1
1	0	1	1		1
1	1	0	0		1
1	1	0	1		1
1	1	1	0		1
1	1	1	1		1



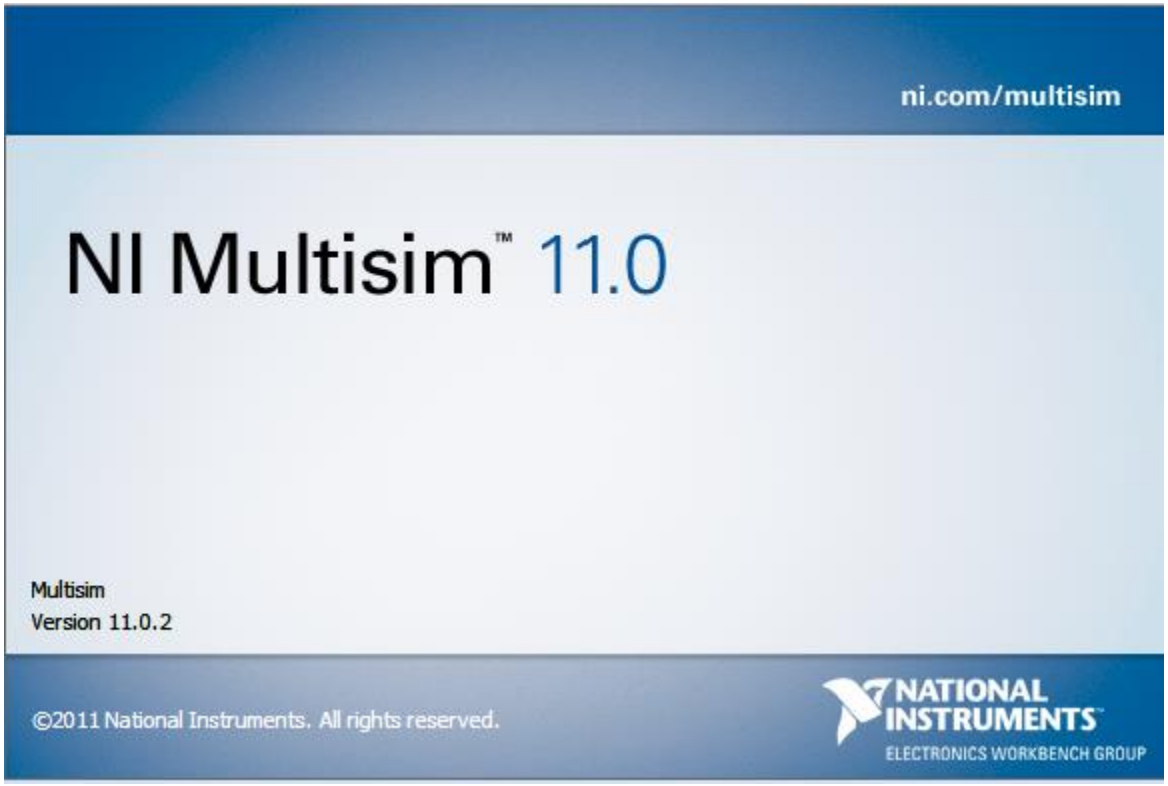


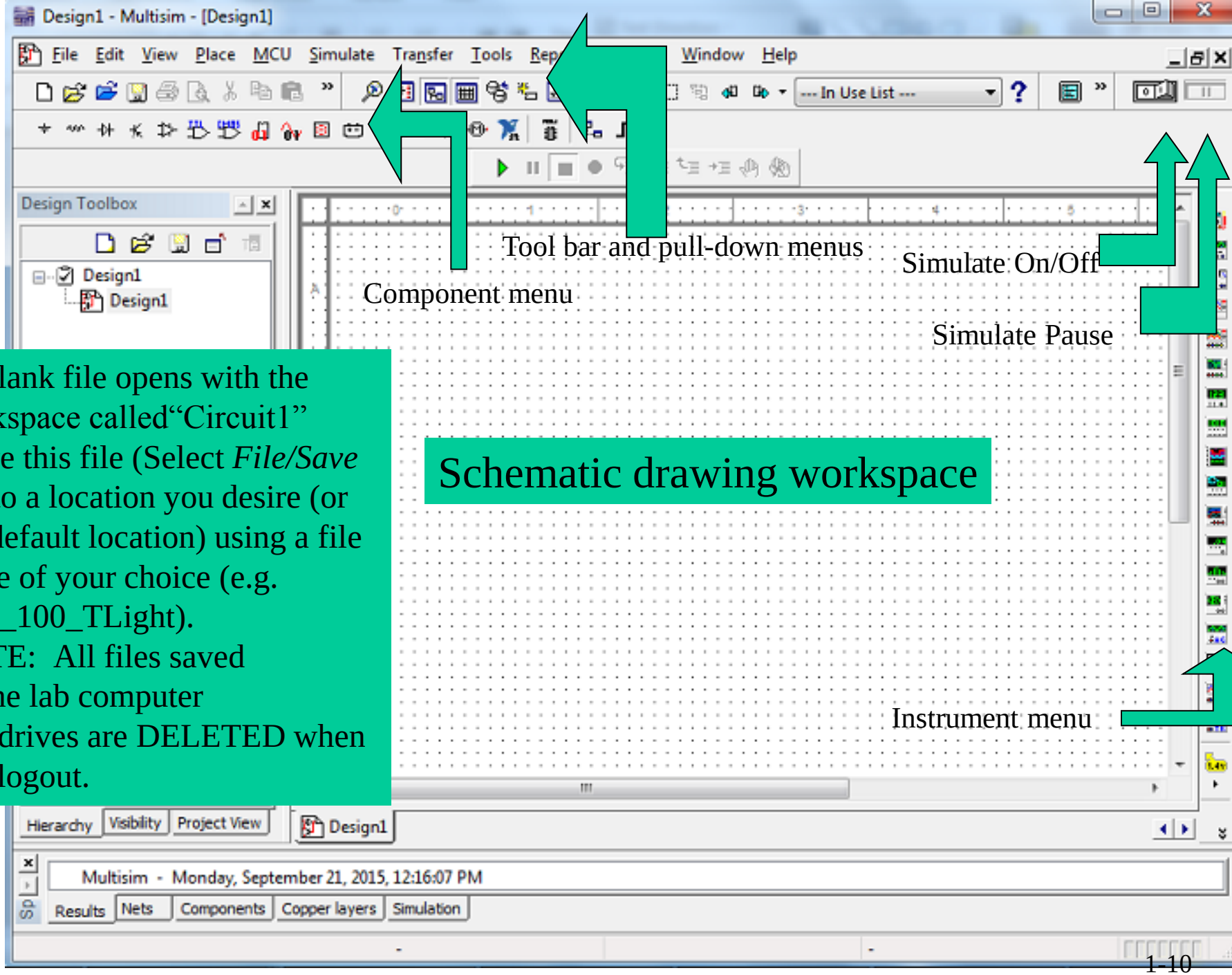
Part 1) Multisim Schematic Capture and Simulation

Start NI Circuit Design Suite: Multisim

- Find icon on desktop (shown here for Multisim 11.0)
- Multisim start-up screen takes a few moments to load, …Please Wait.

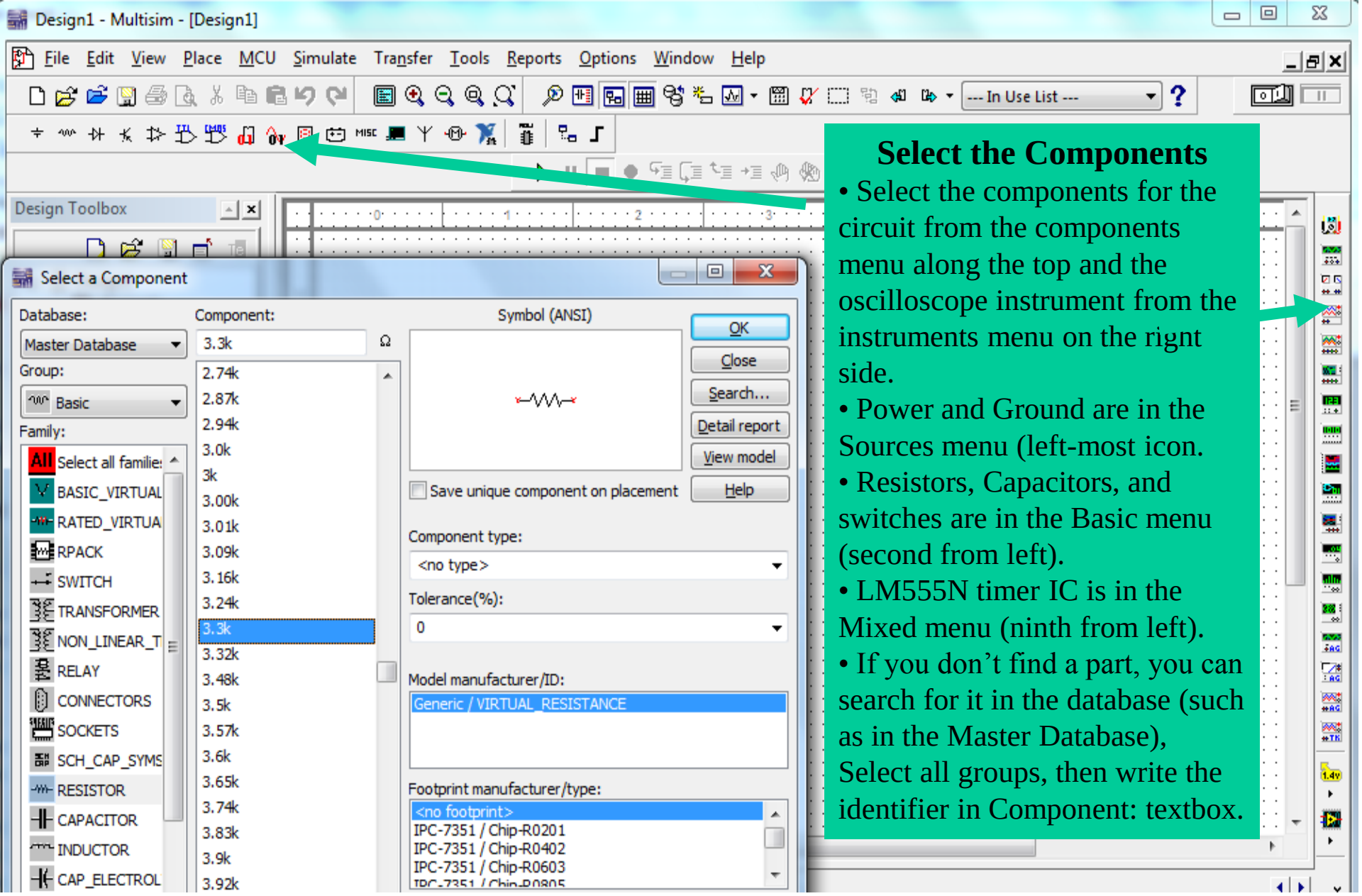
Multisim 11.0





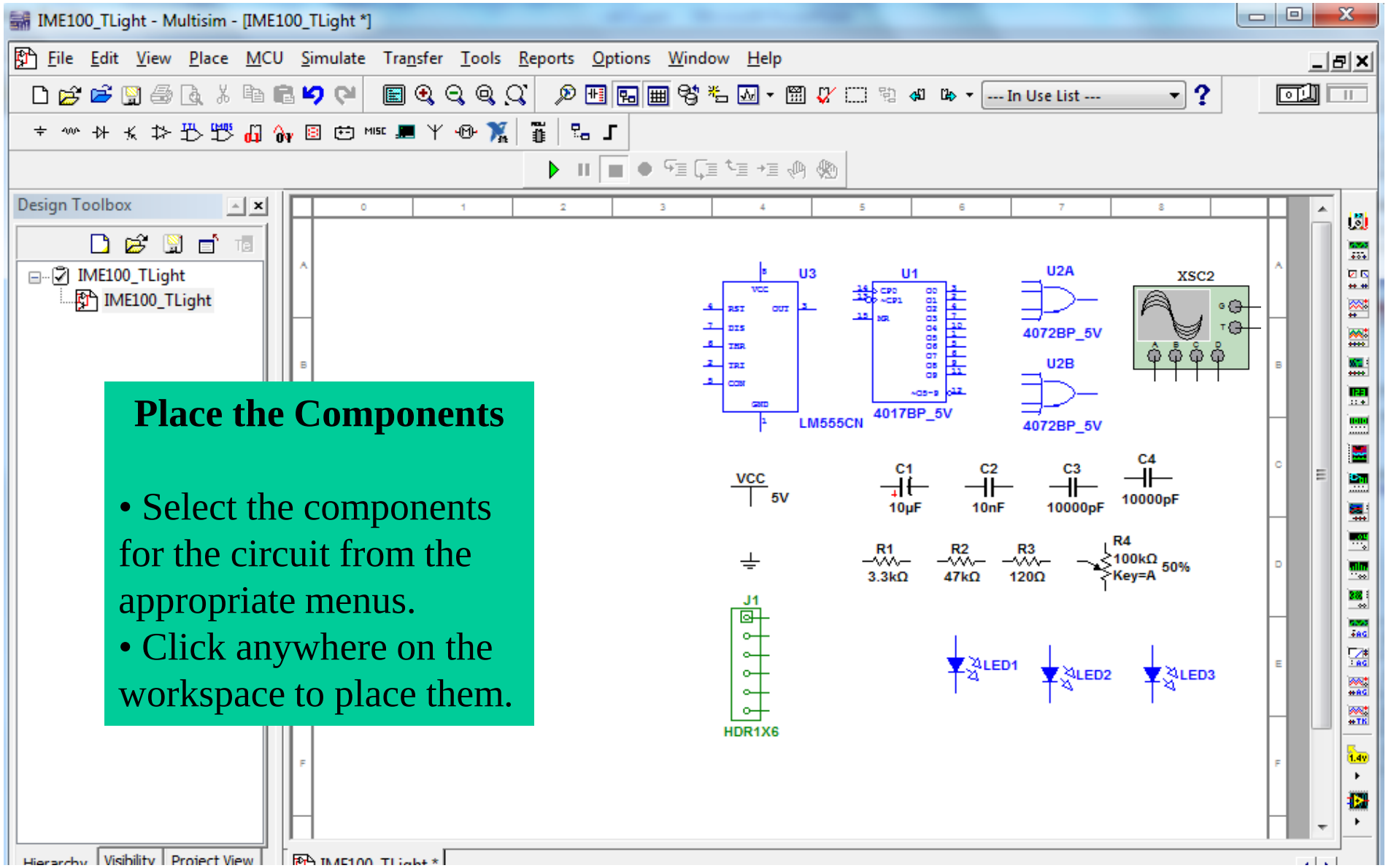
- A blank file opens with the workspace called"Circuit1"
- Save this file (Select *File/Save As*) to a location you desire (or the default location) using a file name of your choice (e.g. IME_100_TLight).

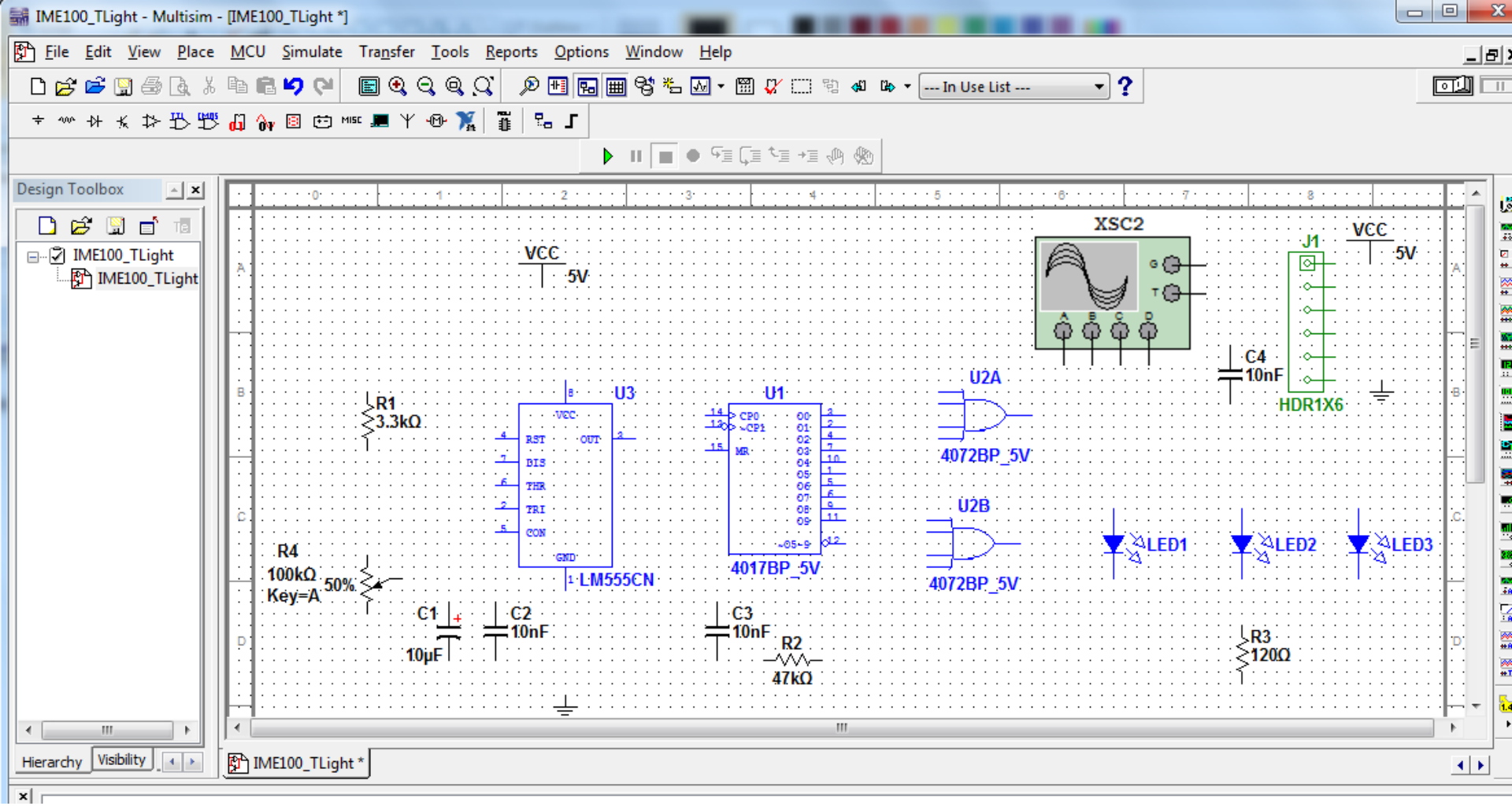
NOTE: All files saved on the lab computer harddrives are DELETED when you logout.



Select the Components

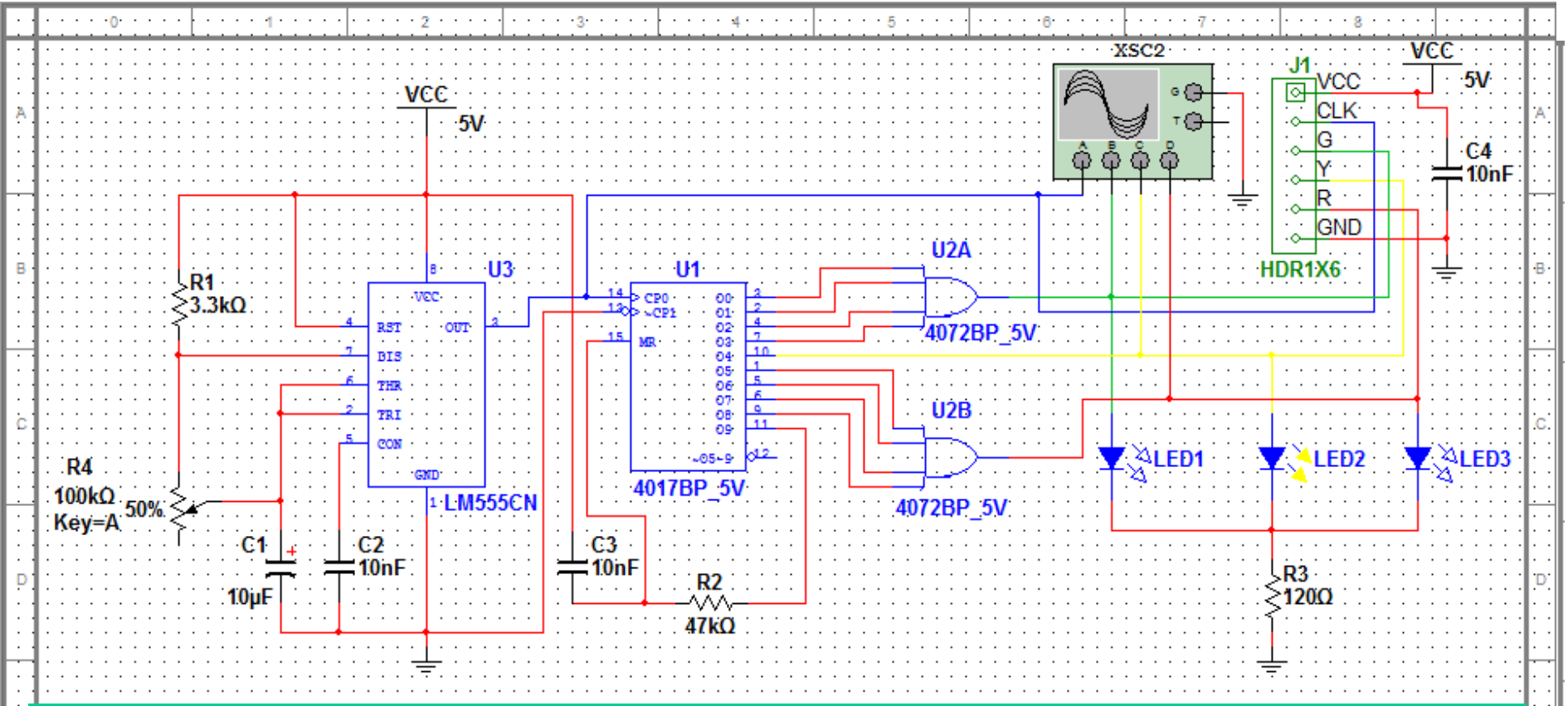
- Select the components for the circuit from the components menu along the top and the oscilloscope instrument from the instruments menu on the rignt side.
- Power and Ground are in the Sources menu (left-most icon.
- Resistors, Capacitors, and switches are in the Basic menu (second from left).
- LM555N timer IC is in the Mixed menu (ninth from left).
- If you don't find a part, you can search for it in the database (such as in the Master Database), Select all groups, then write the identifier in Component: textbox.


IME100_TLight - Multisim - [IME100_TLight *]
File Edit View Place MCU Simulate Transfer Tools Reports Options Window Help
--- In Use List ---
Design Toolbox
IME100_TLight
IME100_TLight
Place the Components
• Select the components for the circuit from the appropriate menus.
• Click anywhere on the workspace to place them.
U3
LM555CN
U1
4017BP_5V
U2A
4072BP_5V
U2B
4072BP_5V
XSC2
VCC
5V
C1
10µF
C2
10nF
C3
10000pF
C4
10000pF
R1
3.3kΩ
R2
47kΩ
R3
120Ω
R4
100kΩ
Key=A
50%
J1
HDR1X6
LED1
LED2
LED3
Hierarchy
Visibility
Project View



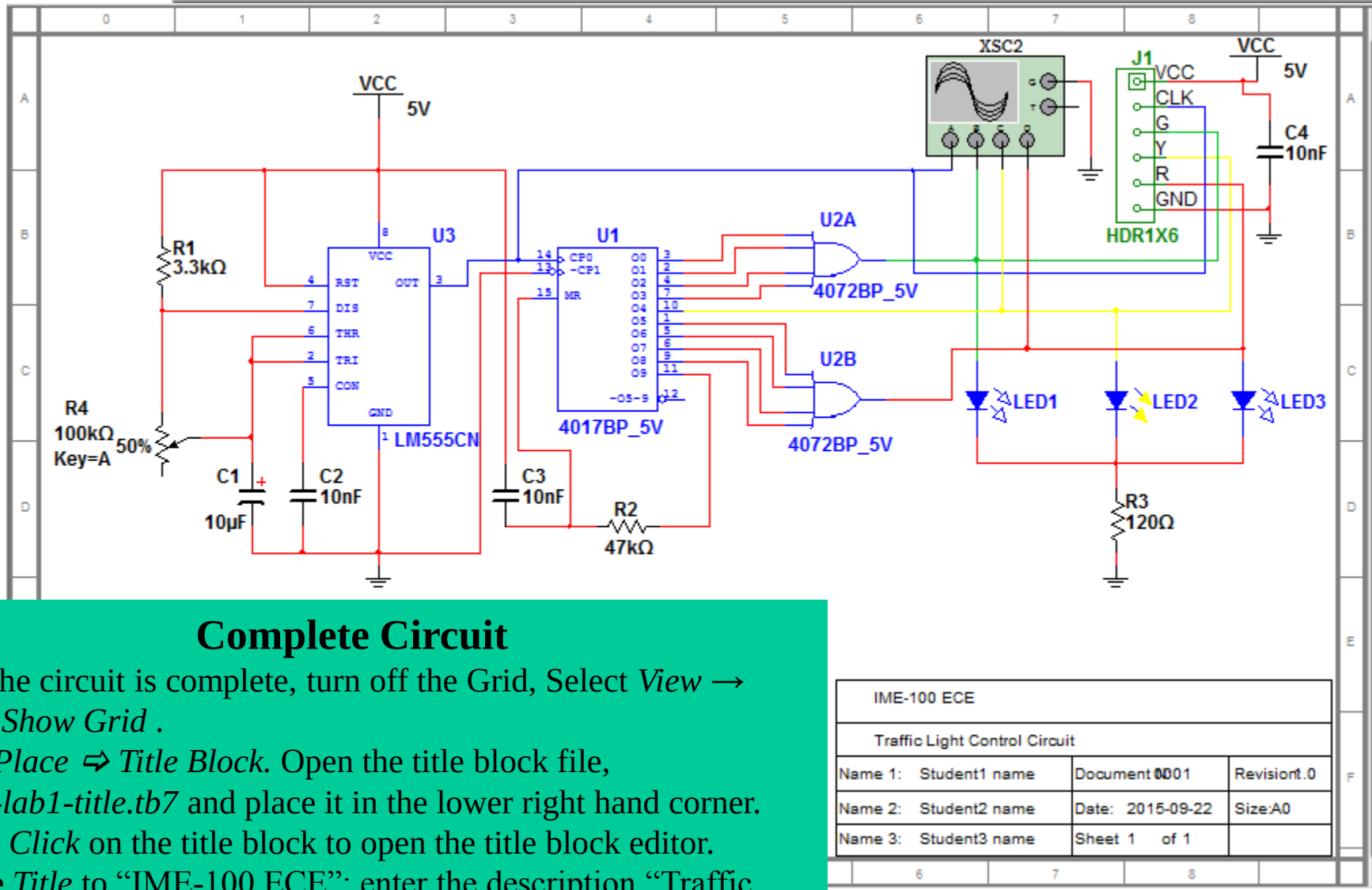
Arrange the Components

- After they are placed, arrange the components (*Click and Drag*) as you want them to appear in the final schematic.
- Rotate components with *Ctrl R*



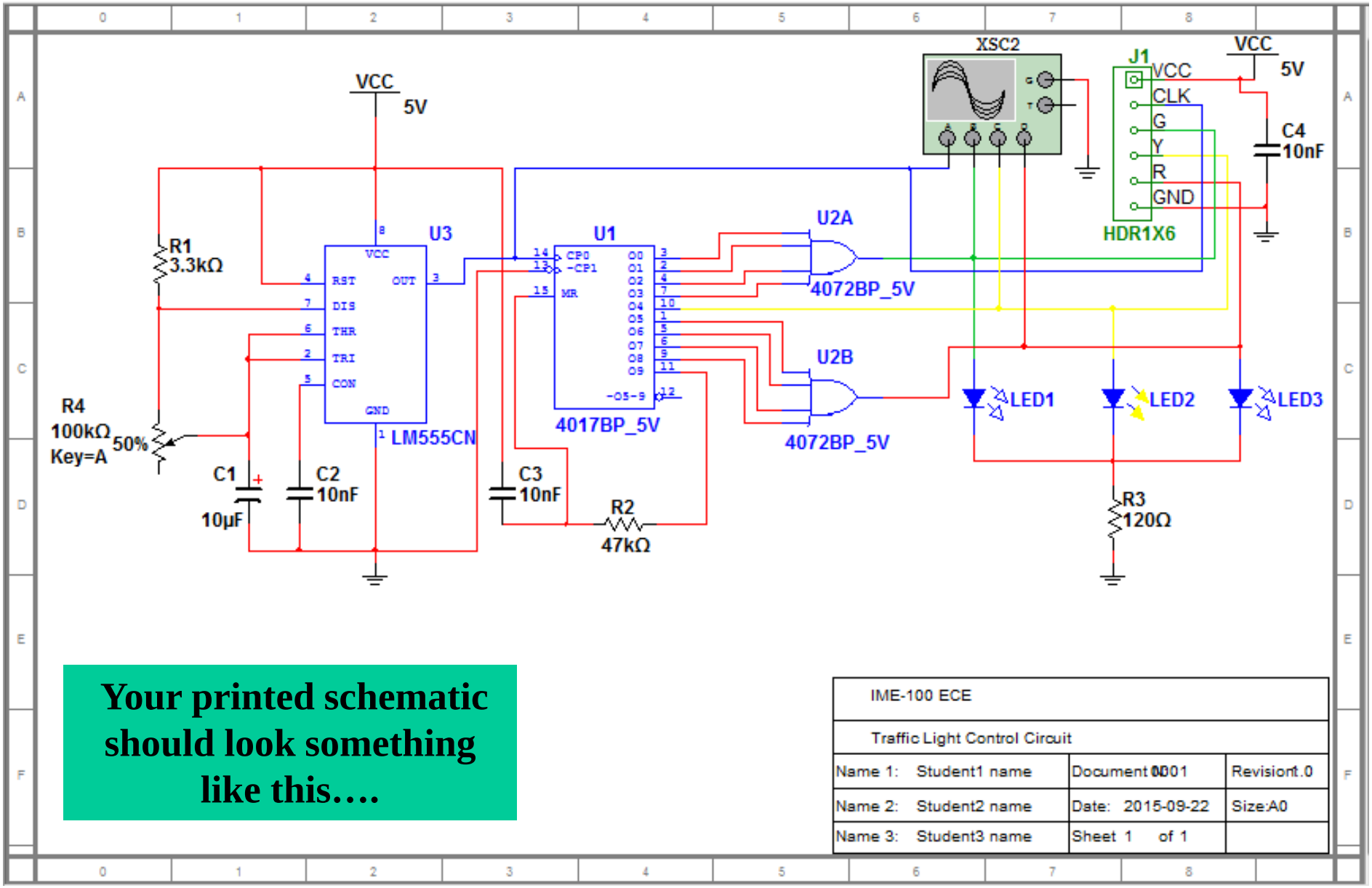
Wire the components together

- Point to where the wire is to begin (a cross-hair dot will appear), then *Click* to place a junction.
- Move the cross-hair dot to where the wire is to end, then *Click* to place another junction.



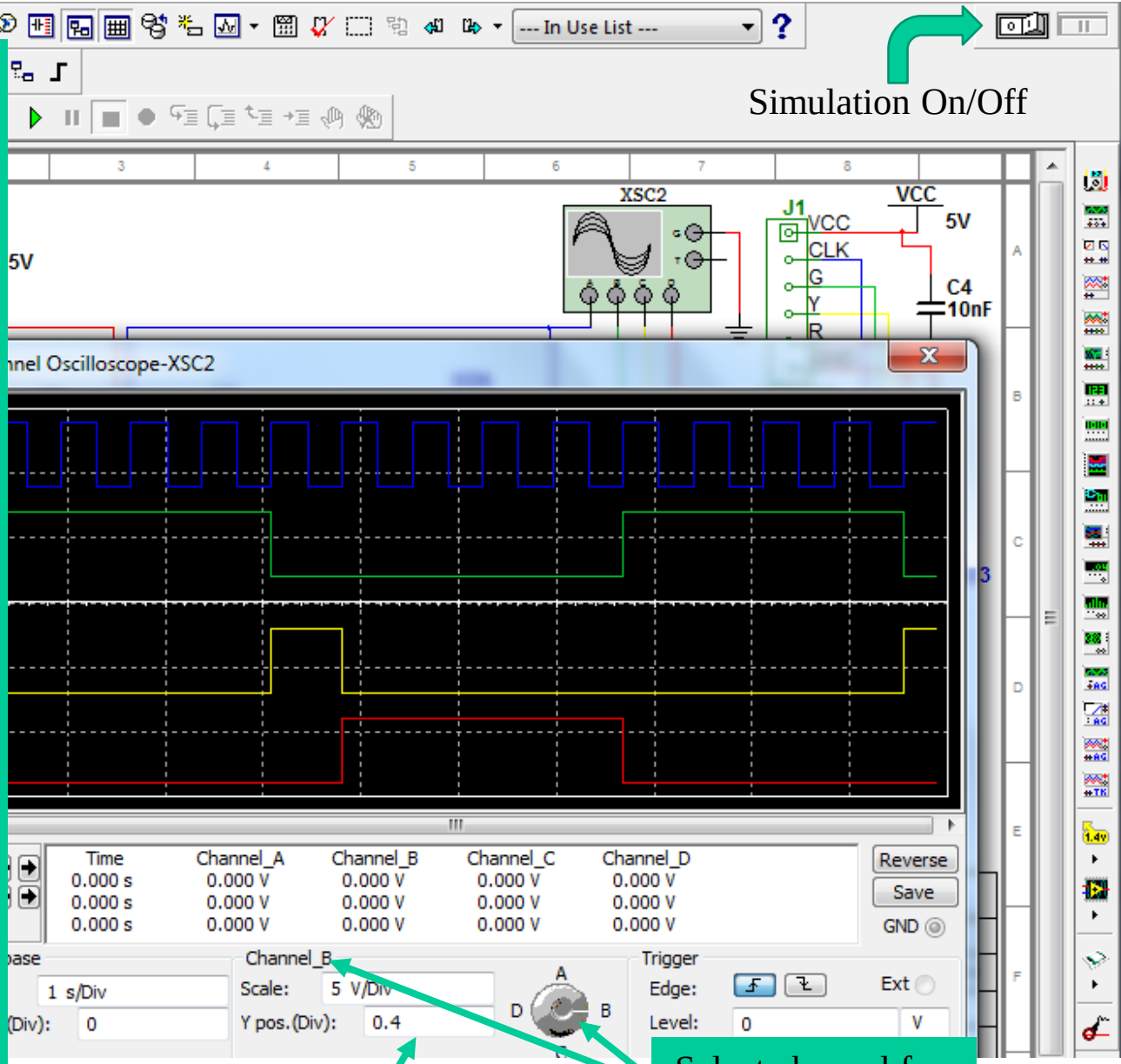
Complete Circuit

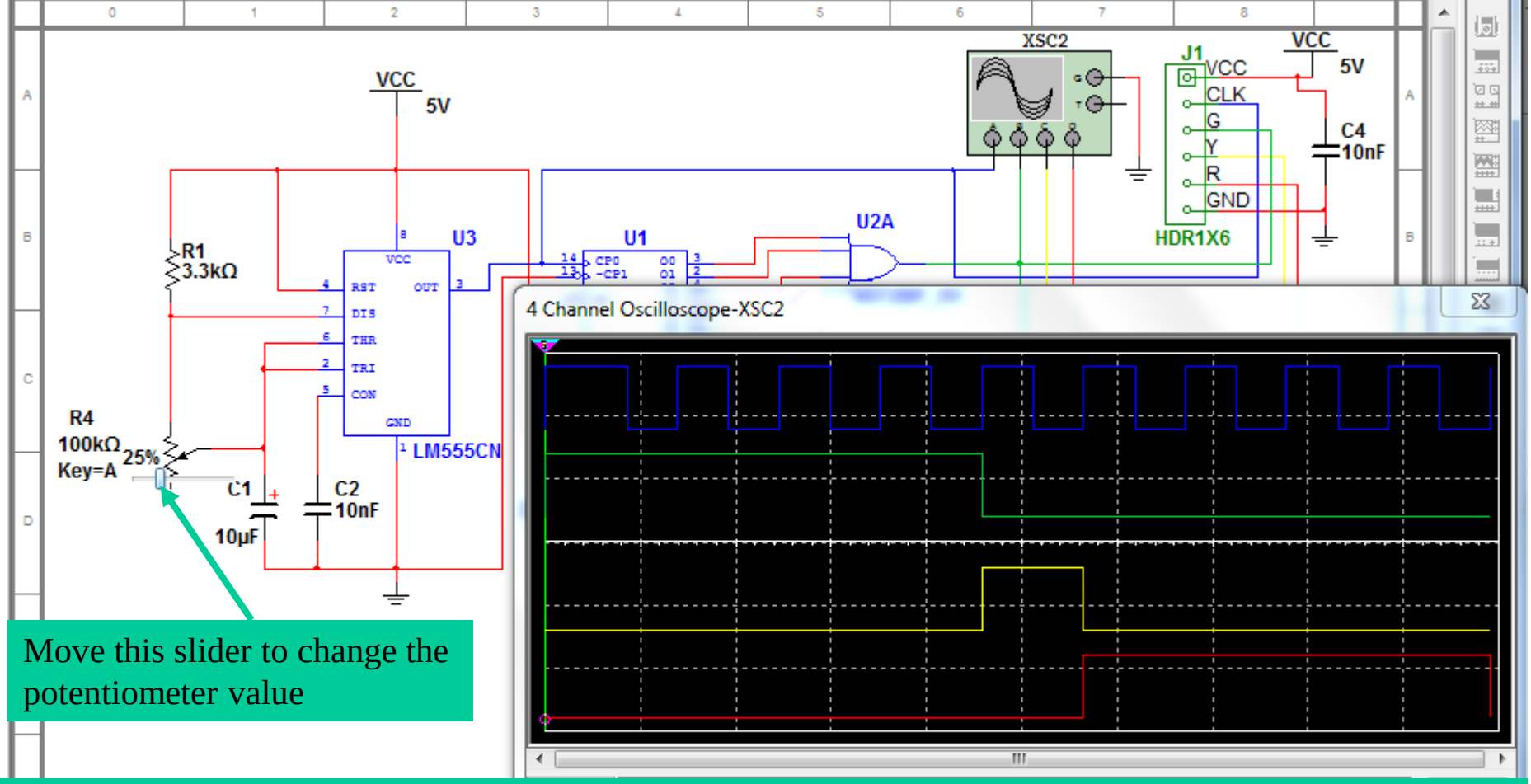
- When the circuit is complete, turn off the Grid, Select *View* → uncheck *Show Grid* .
- Select *Place* ⇨ *Title Block*. Open the title block file, *IME100-lab1-title.tb7* and place it in the lower right hand corner.
- *Double Click* on the title block to open the title block editor.
- Change *Title* to "IME-100 ECE"; enter the description "Traffic Light Control Circuit"; *Designed by:*,*Checked by:*, and *Approved by:*, to members of your group.
- Print a hardcopy of the circuit schematic. *Click* the *Print Circuit* icon.


XSC2
J1
VCC
CLK
G
Y
R
GND
HDR1X6
VCC
5V
C4
10nF
VCC
5V
R1
3.3kΩ
U3
VCC
RST
OUT
DIS
THR
TRI
CON
GND
LM555CN
U1
CP0
-CP1
MR
O0
O1
O2
O3
O4
O5
O6
O7
O8
O9
-O5-9
4017BP_5V
U2A
4072BP_5V
U2B
4072BP_5V
LED1
LED2
LED3
R4
100kΩ
50%
Key=A
C1
10µF
C2
10nF
C3
10nF
R2
47kΩ
R3
120Ω
Your printed schematic should look something like this….
IME-100 ECE
Traffic Light Control Circuit
Name 1: Student1 name
Document 0001
Revision 1.0
Name 2: Student2 name
Date: 2015-09-22
Size:A0
Name 3: Student3 name
Sheet 1 of 1

Circuit Simulation

- Double Click on the oscilloscope to open the oscilloscope window.
- Change Channel A, B, C, and D, Y positions to 1.8, 0.4, -1.4, and -2.8, respectively.
- Go to Simulate->Interactive Simulation Settings, change the set maximum time step (TMAX) to 1e-003 or 0.001
- Start the simulation using the Simulation On/Off button.
- You can pause the simulation using the pause button next to the On/Off button.
- From the oscilloscope traces, measure frequency of the clock, and the time duration of each of the traffic signals.





Circuit Simulation

- Change the value of the potentiometer (variable resistor) to 25% value.
- Observation what happens to the clock frequency and the time duration of the traffic signals.
- Achieve a representative oscilloscope trace similar to the one shown above, then press the *Pause Simulation* button.
- Print the oscilloscope display window for each of the 50% and 25% settings of potentiometer.

Under the *File* menu, select *Print Options* → *Print Instruments*, then select *Oscilloscope – XSC2* and *Print*.

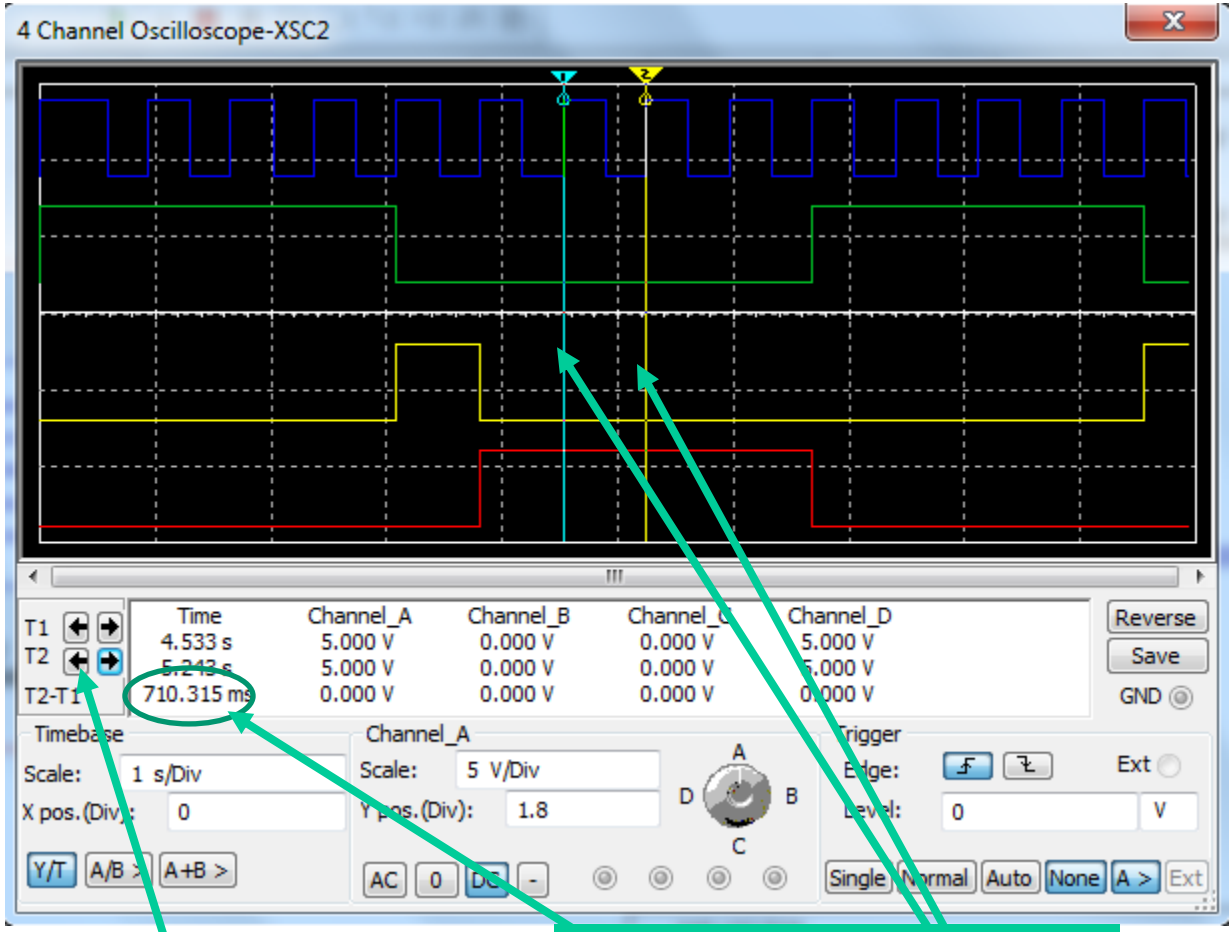
Your printed instrument screen should look something like this….

From your simulation, calculate :

1) Clock frequency
2) Green signal time duration
3) Yellow signal time duration
4) Red signal time duration

Answer the above questions for each of the following two settings on the potentiometer:

a) 50%
b) 25%



Use the time markers for measuring time between two edges in the waveform

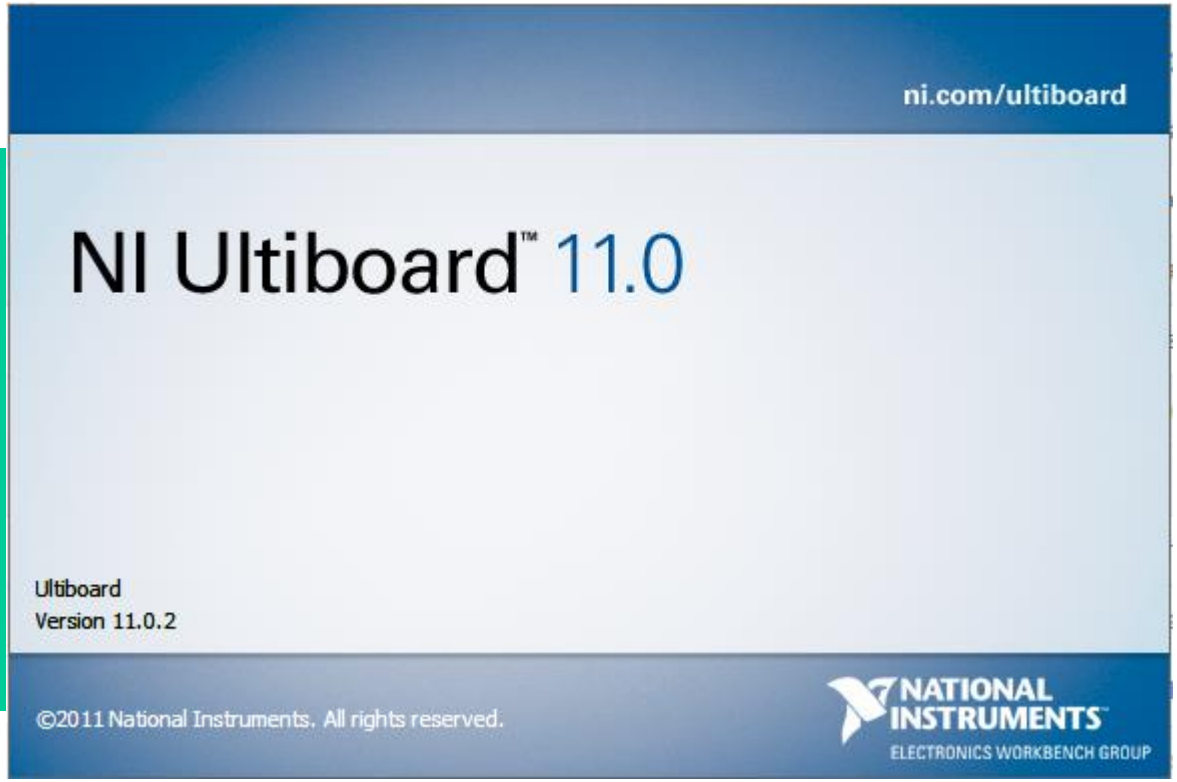
You can click and move the time markers 1 and 2, or use the left and right arrows next to T1 and T2 to move them step by step. Also, you can select a time marker with a left mouse click, and use the menu commands from right mouse click.

Part 2) Ultiboard PCB Layout

Ultiboard 11.0

Start NI Circuit Design Suite: Ultiboard

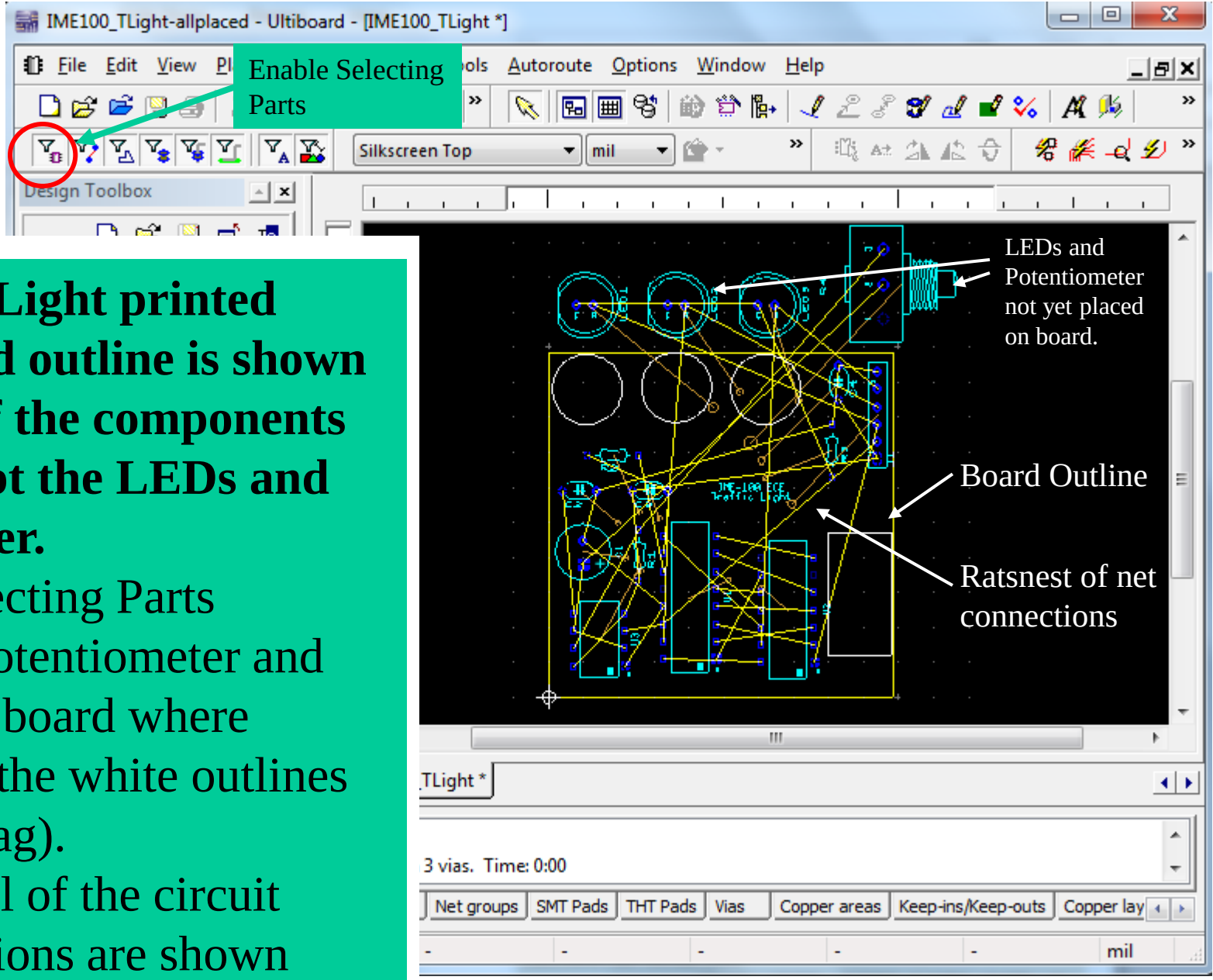
•Ultiboard start-up screen. (takes a few moments to load) …Please Wait…



- Open the PCB Layout file named IME100_Tlight.ewprj

The Traffic Light printed circuit board outline is shown with most of the components placed except the LEDs and potentiometer.

- Enable Selecting Parts
- Place the Potentiometer and LEDs on the board where indicated by the white outlines (click and drag).
- Note that all of the circuit net connections are shown with yellow lines (called a Ratsnest).

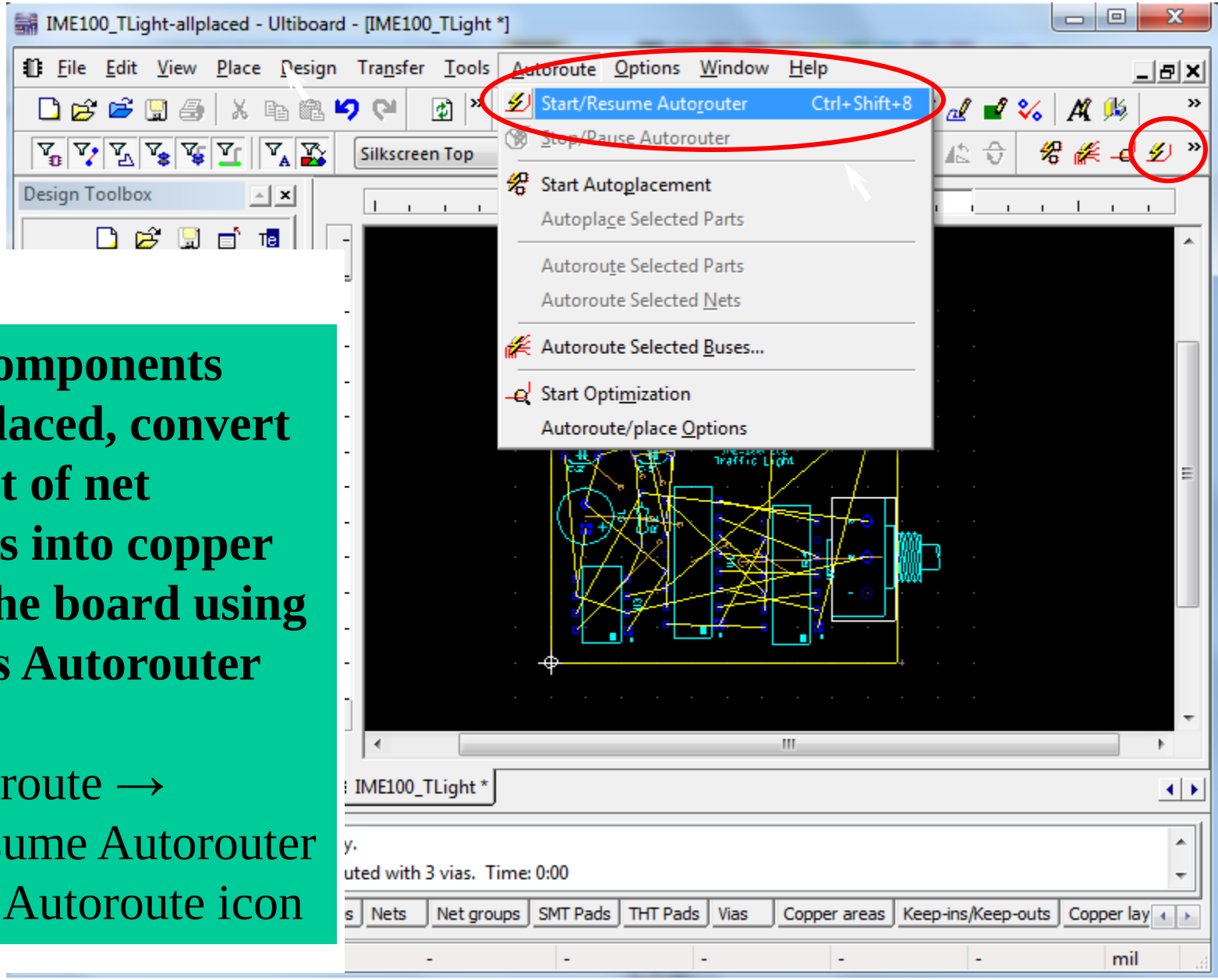


With the components properly placed, convert the ratsnest of net connections into copper traces on the board using Ultiboard's Autorouter feature.

Select Autoroute →

Start/Resume Autorouter

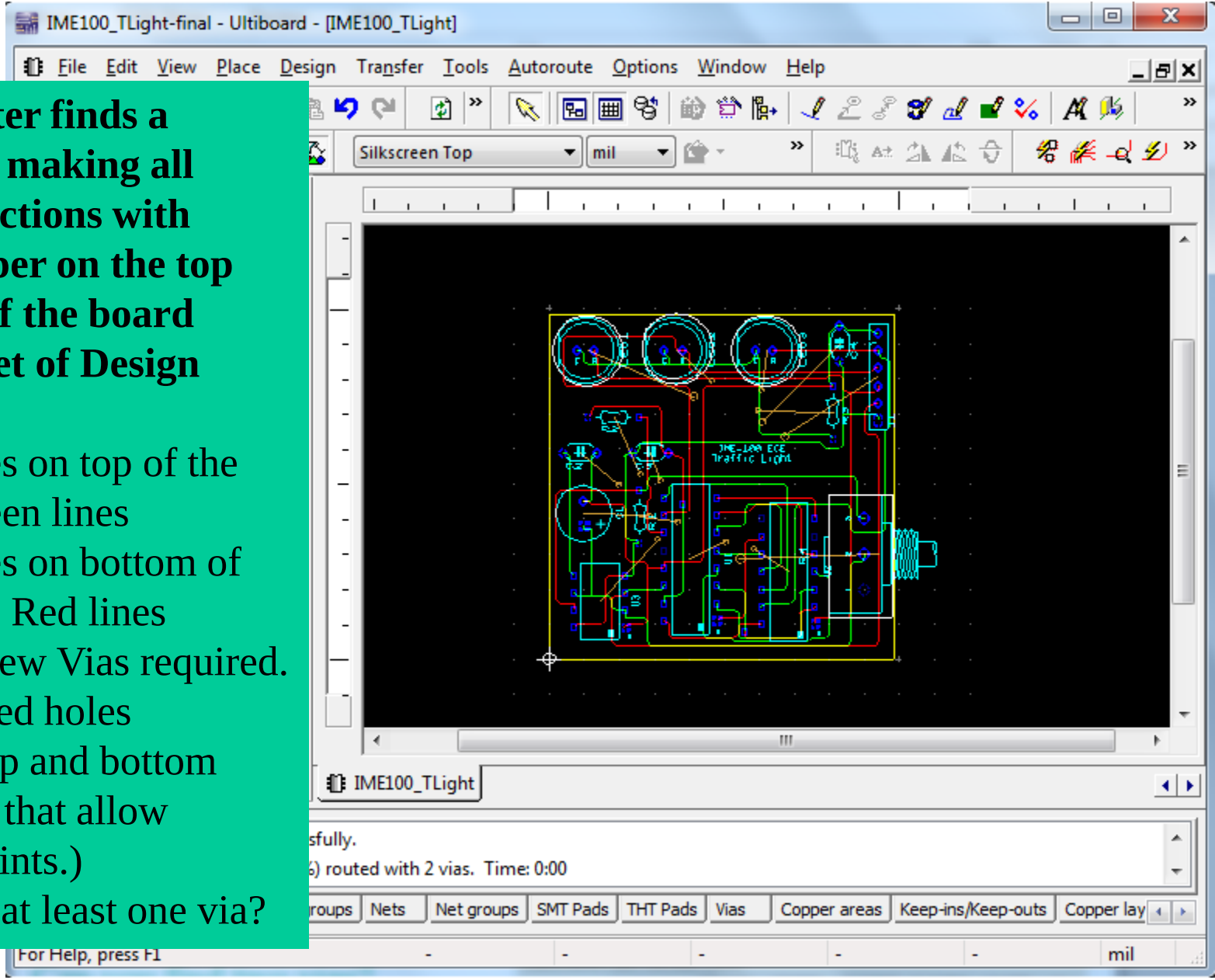
or click the Autoroute icon



The Autorouter finds a viable way of making all the net connections with traces of copper on the top and bottom of the board subject to a set of Design Rules.

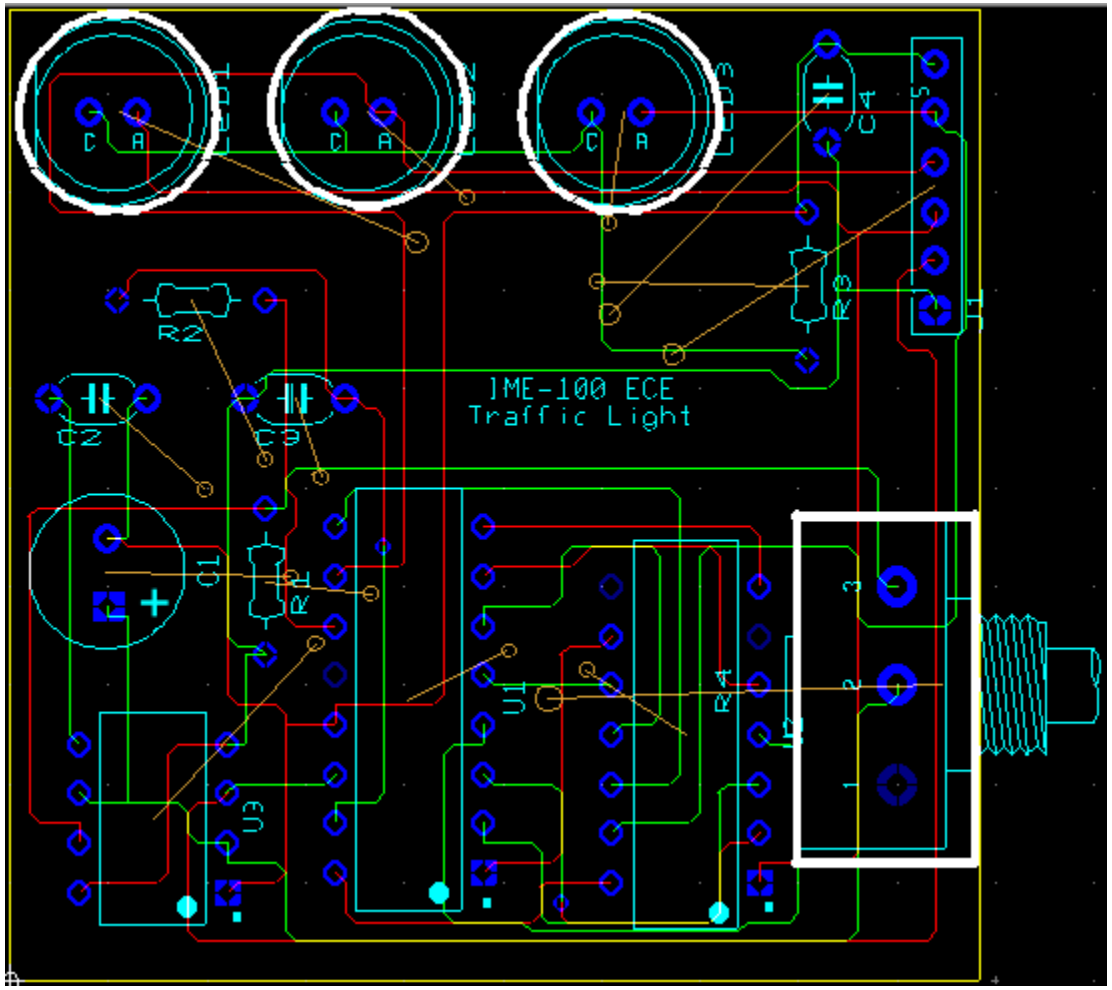
- Copper traces on top of the board are Green lines
- Copper traces on bottom of the board are Red lines
- There are a few Vias required. (Vias are plated holes connecting top and bottom copper traces that allow cross-over points.)

Can you find at least one via?



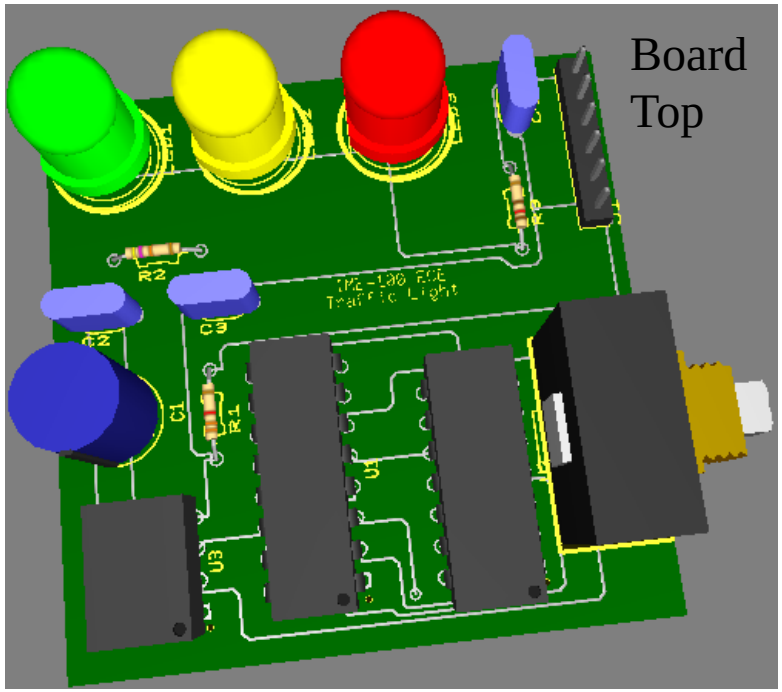
Make a printout of your Traffic Light PCB layout.

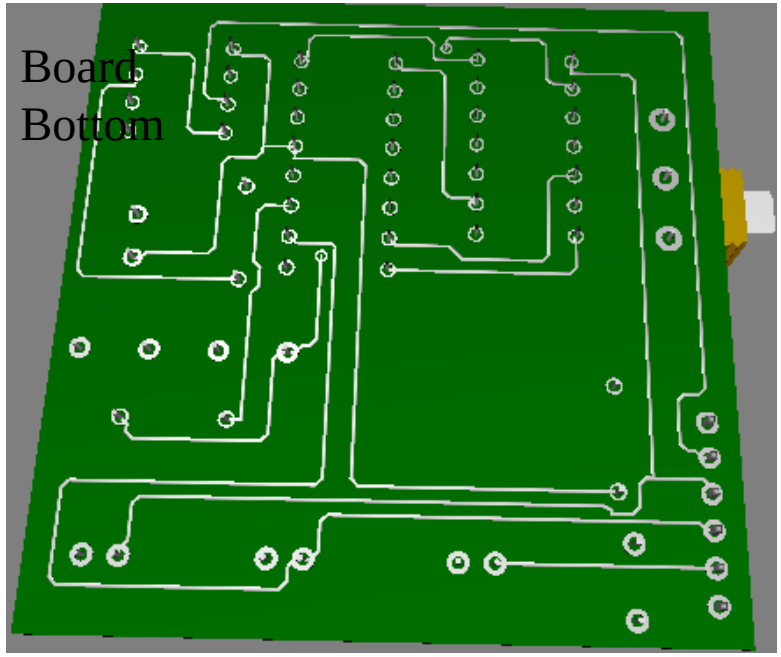
- Select File → Print
- Print only the Board Outline, Silkscreen Top, Copper Top, and Copper Bottom layers (all layers on the same sheet of paper).
- On your printout, highlight at least one via placed by the autorouter.



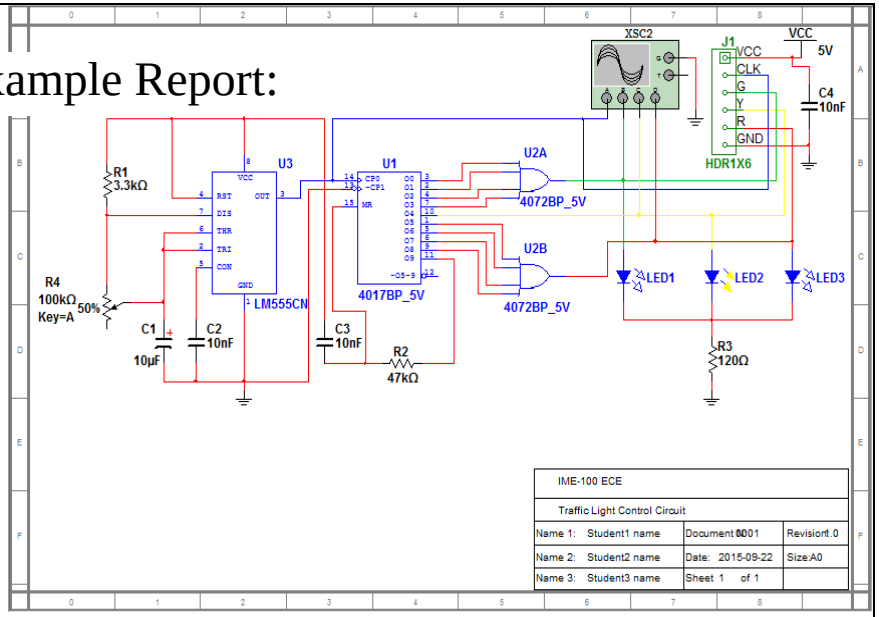
Investigate what your board might look like after fabrication using Ultiboard's 3D View feature.

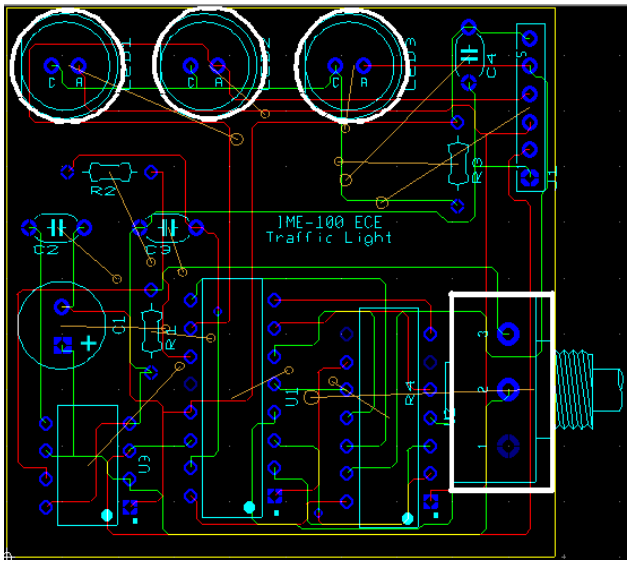
- Select Tools → View 3D
  or click on the Show 3D icon
- Use the mouse to move the board to view different perspectives. View both the Top and Bottom of the board.
- Make a printout of a representative 3D view of the top of your board.



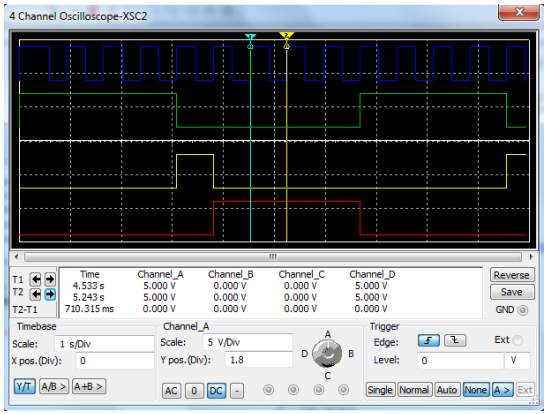


Example Report:





Highlight at least one via on your PCB layout.

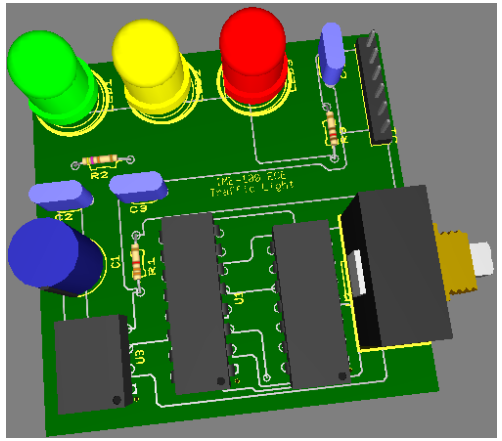


Your calculation of the clock frequency and duration of the Green, Yellow, and Red traffic signals as determined from the Oscilloscope trace for **50% Setting on the potentiometer**:

f_{clock} = _____(Hz)

Green on = _____ (sec)
Yellow on = _____ (sec)
Red on = _____ (sec)

Also give a second waveform and the same calculations for potentiometer setting of 25%



3D view of the Traffic Light PCB layout - Top of board.

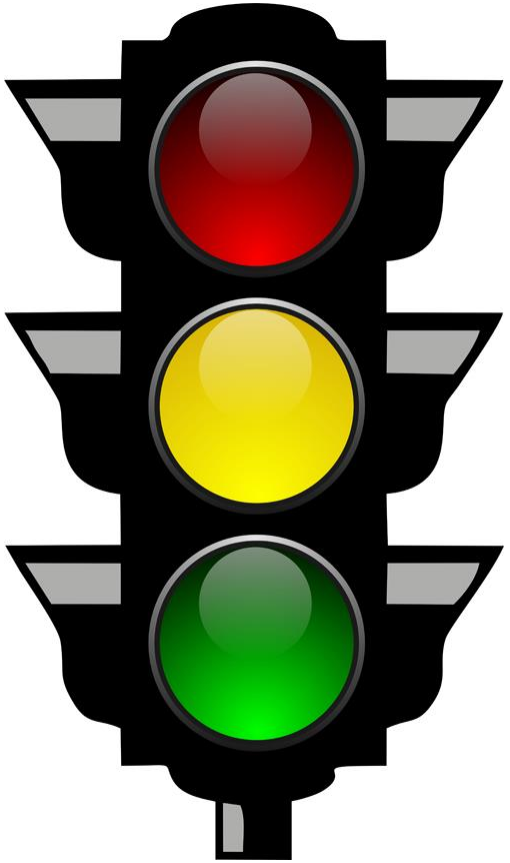
Homework: For the Curios You …

Due: Beginning of 2rd Week Lab

Think about other *useful and practical applications of a timer or clock*. Explore all possible scenarios such as in personal, household, industrial, and other applications.

Research and brainstorm your ideas with your lab partners to cover many possible applications, including potentially new ones.

Turn in a one page report for your answers.



Finishing Up

(and to get full-credit in the lab)

1. Clean-up bench – Leave it better than you found it!
    i. Pick-up any spare parts, wire-trimmings, etc
    ii. Detangle and coil wires
    iii. Logout of computer; arrange keyboard and mouse
    iv. Neatly arrange the chairs
2. Check-out with the instructor
    i. Submit your lab report
    ii. Leave the check-out sheet with your group names at your station

Lab 1 Check-Out Sheet

(to be left on the bench at the end of lab)

Group Members (please print name clearly):

_____

_____

_____

Instructor (check all that apply):

☐ Laboratory Report Submitted

☐ Computer Logout

☐ Bench clean-up

Wires, detangled and coiled,
Keyboard, Mouse, Instruments, etc.
Chairs arranged

Additional Comments: