How to open a local electronics laboratory for remote access Part 3

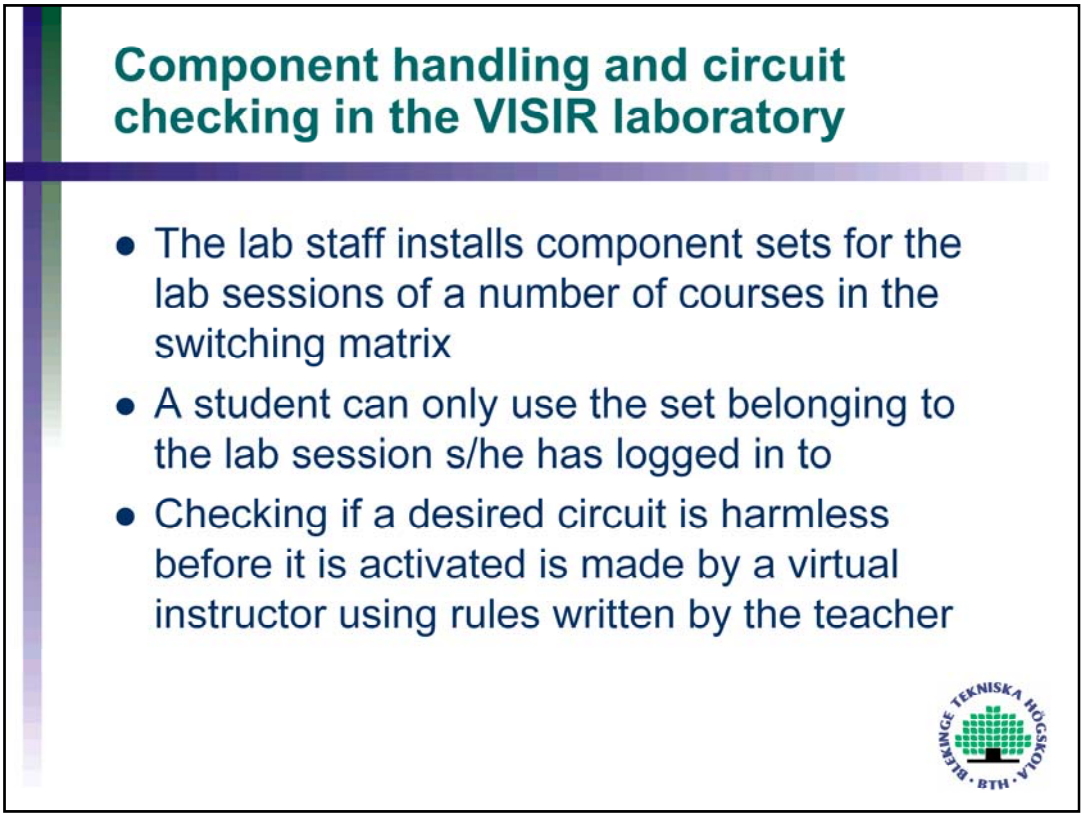
Providing components and avoiding destructive circuits

Outline

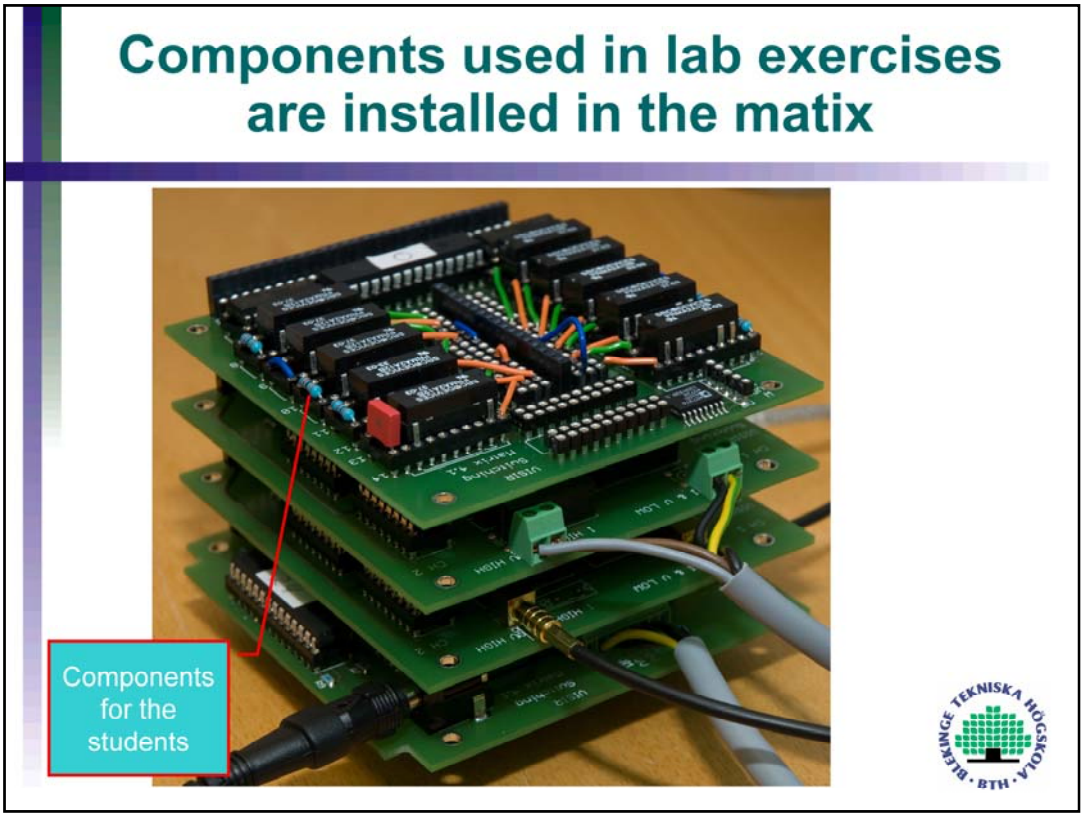
- Providing physical components for remote experimenters
- Assuring that it is only possible to activate harmless circuits
- Advanced experiments
- Summary

Component handling and circuit checking in a local laboratory

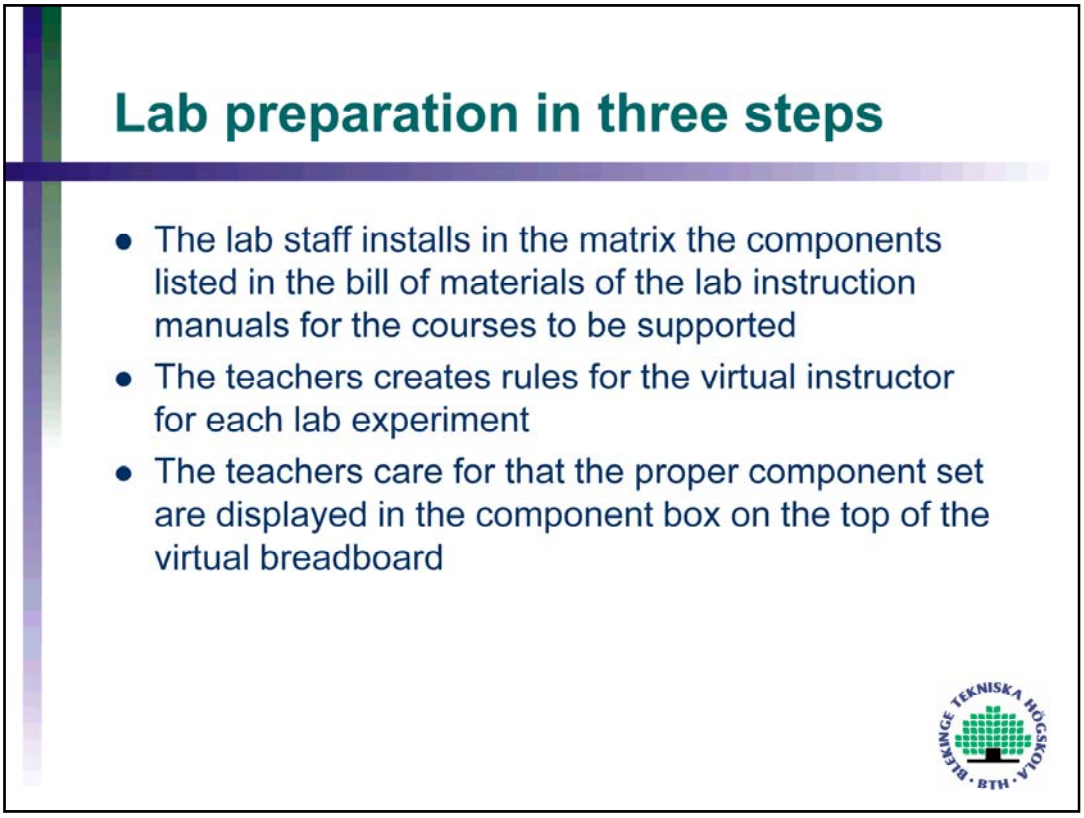
- The instructor puts a set of components to be used in the lab session on each workbench
- During the session the students are permitted to activate the sources in their circuits only when the instructor have checked that the circuits are harmless



The teacher can not depend on the lab instructor to check that the circuits are harmless because the instructor is not always present.

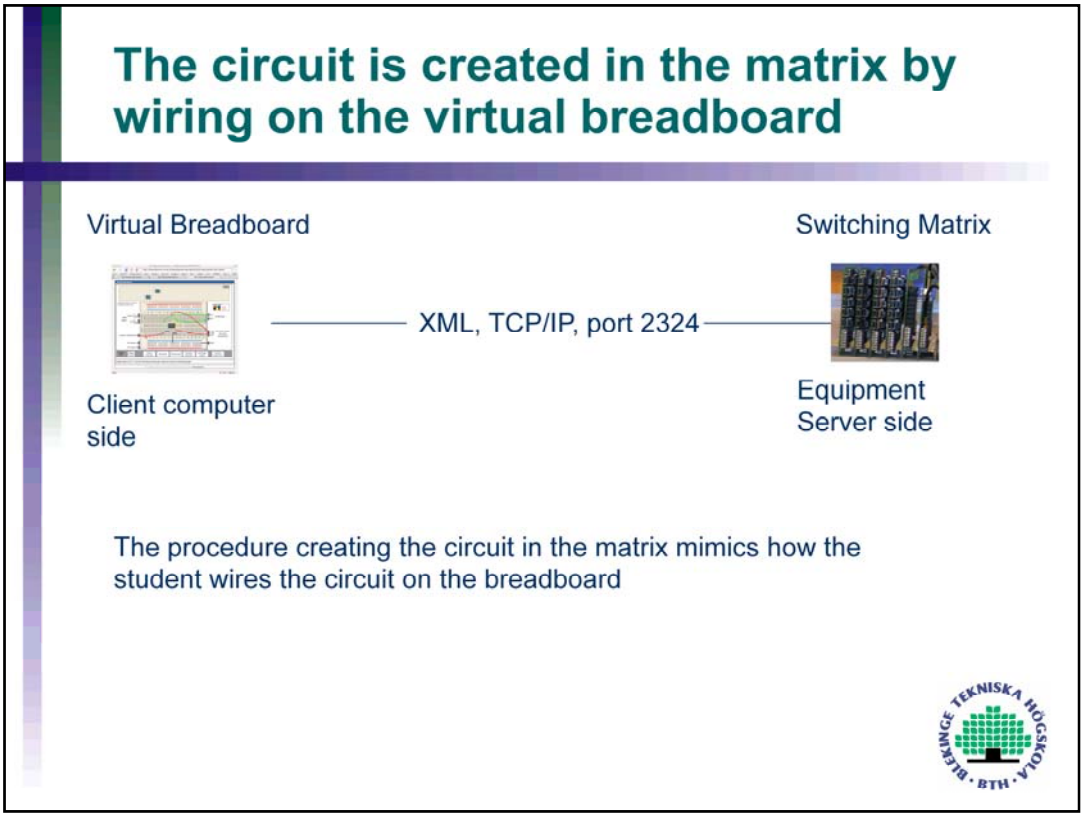


The switching matrix is a stack of boards. The relays are together with instrument connectors and component sockets arranged in a three dimensional matrix pattern. The teacher or lab staff installs the components to be used in lab assignments in the component sockets. The number of online components can be increased by adding more boards.

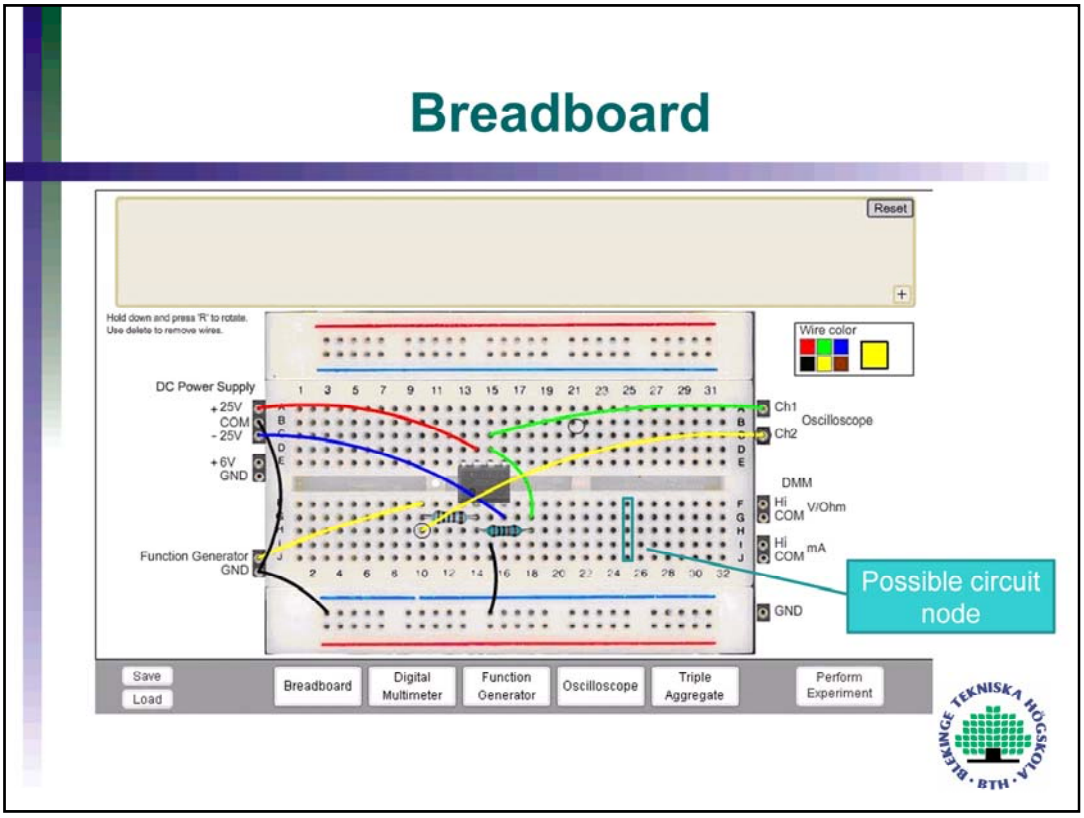


How to display the component sets have already been discussed in part two of this tutorial.

Before I start with the first step in the lab preparation I will shortly describe how the virtual breadboard and switching matrix combination works in the next four slides.

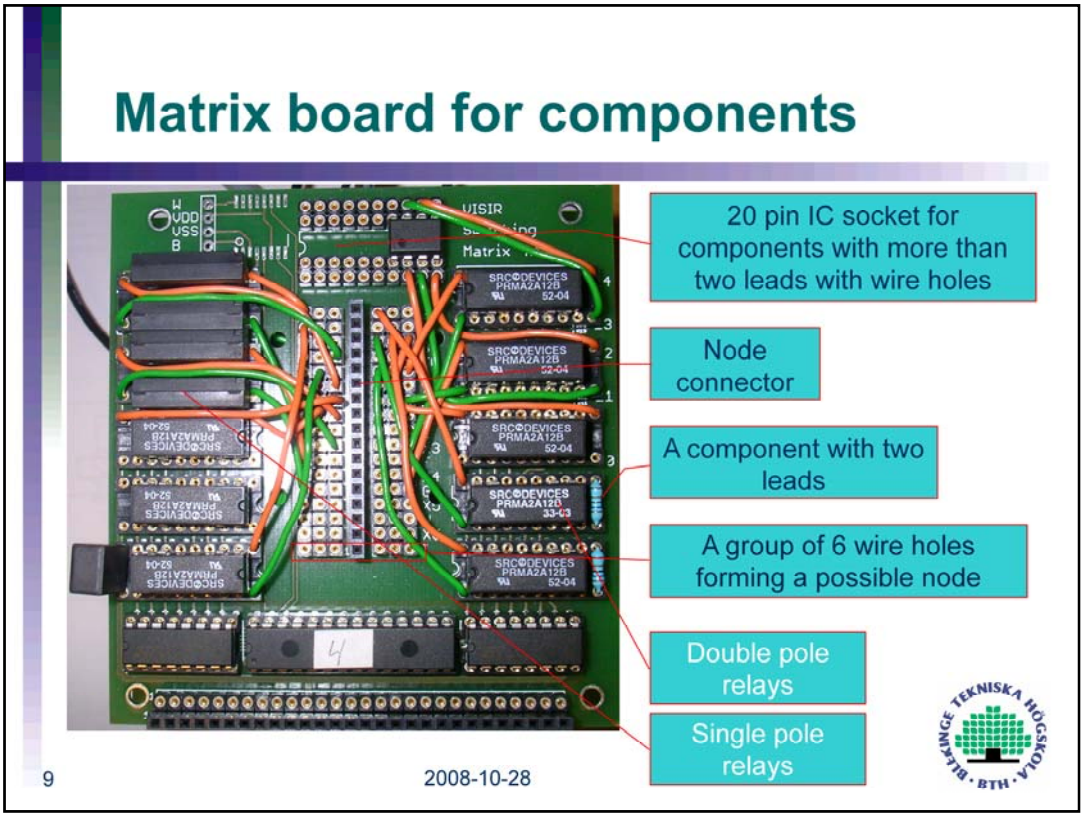


The student wires a experiment circuit on the virtual breadboard. Only when s/he presses the ”Perform Experiment” button a description of the circuit is sent to the server. A virtual instructor routine checks that the desired circuit is harmless. Then it is sent to the switching matrix where the circuit is created.



The wire holes at the sides of the virtual breadboard connects to the instruments mimicking the box carrying the detachable breadboard in the local laboratory but the sockets and the instrument cables are omitted.

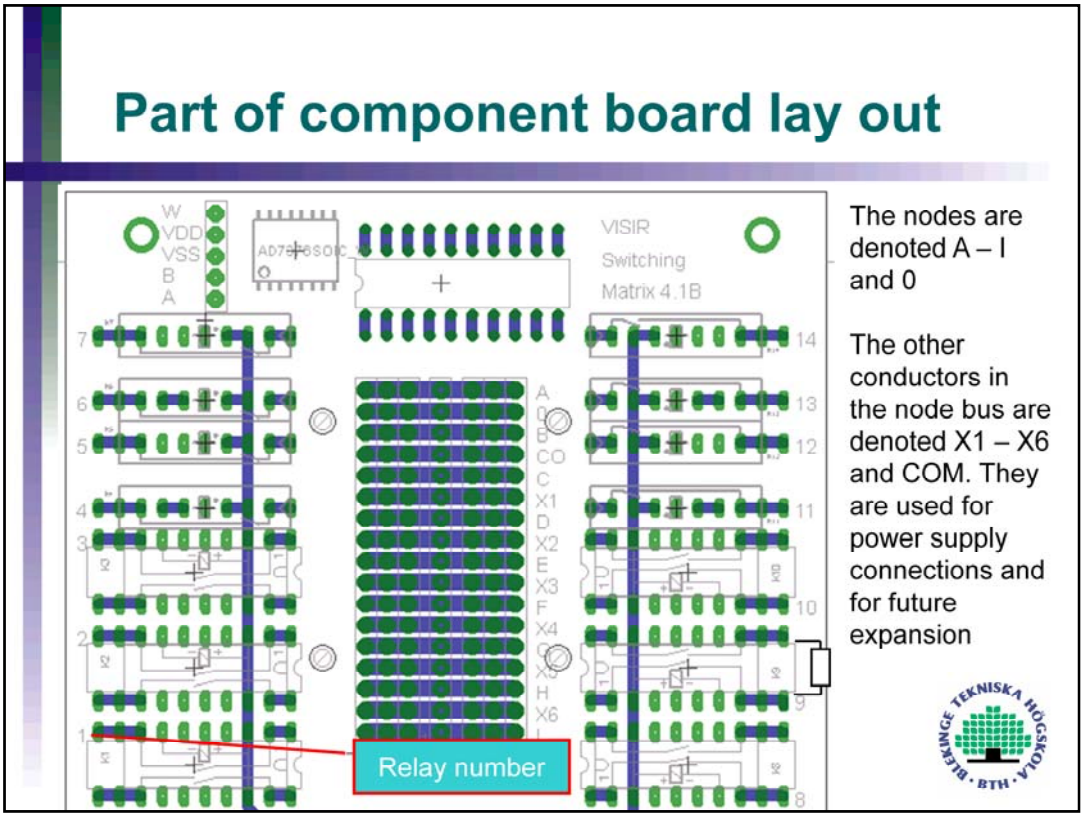
The wire holes of a breadboard are connected in groups of five holes. Each such group can be a circuit node terminating up to five wires or leads. If more than five wire holes are required for a node a jumper lead to an adjacent group of five creates a possible circuit node for up to eight wires or leads etc.



The component board is the top board of the stack shown earlier. This board type emulates the breadboard. There are 17 groups of six connected wire holes forming 17 possible nodes corresponding to the groups on the breadboard. The center connector, ”the node connector” propagates the possible nodes from board to board creating a node bus. The notation “node” refers to the fact that every conductor created by these stacked connectors could be a node in a desired circuit. However, only 10 of the possible nodes are used as nodes of desired circuits in the current version of the software. The other seven are used for power supply connections or are reserved for future expansion.

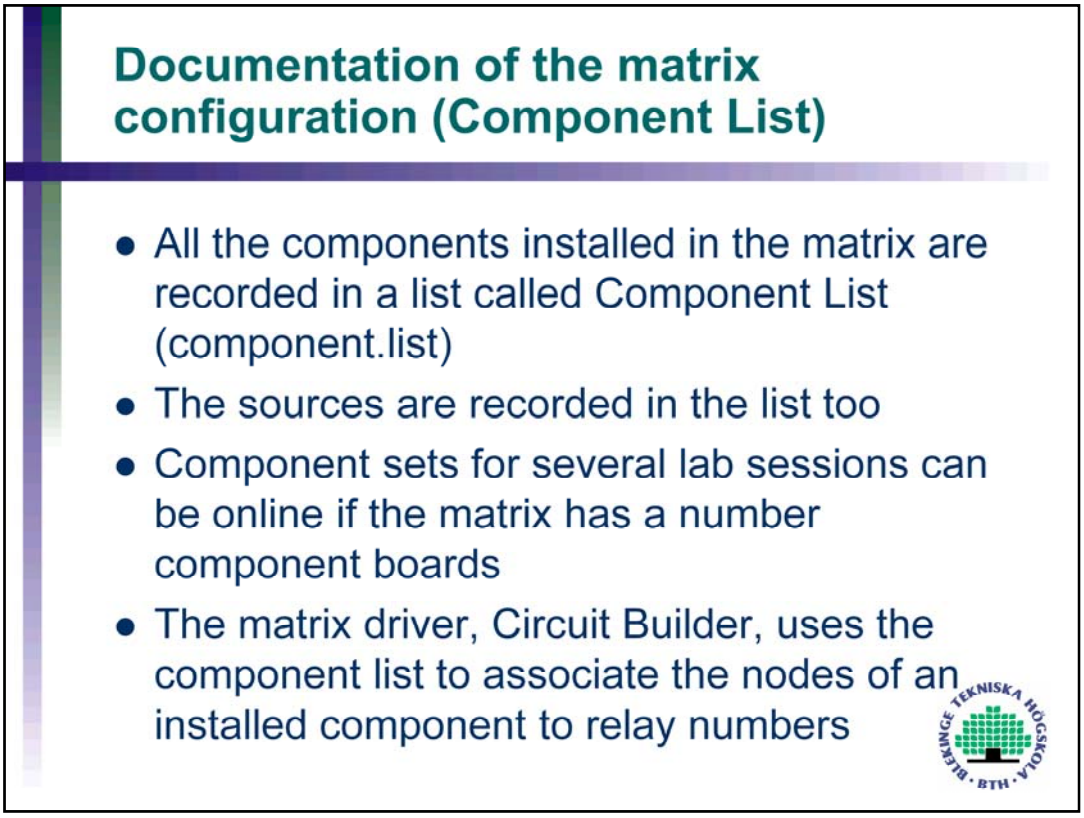
The teacher or the lab staff wires two-lead components installed in the wire holes close to the relays to the nodes via two relay switches. Components with more than two leads or pins installed in the IC socket are wired to the nodes via an adequate number of relay switches. Thus the components are connected to the nodes only when the relay switches are closed. In this way the components will be available for the students creating circuits. If more sockets are required additional component boards can be put on the stack.

The relays are identified a number printed on the board to the left or the right of the relay. Each board are also indentified by a number stored in the firmware of the board.

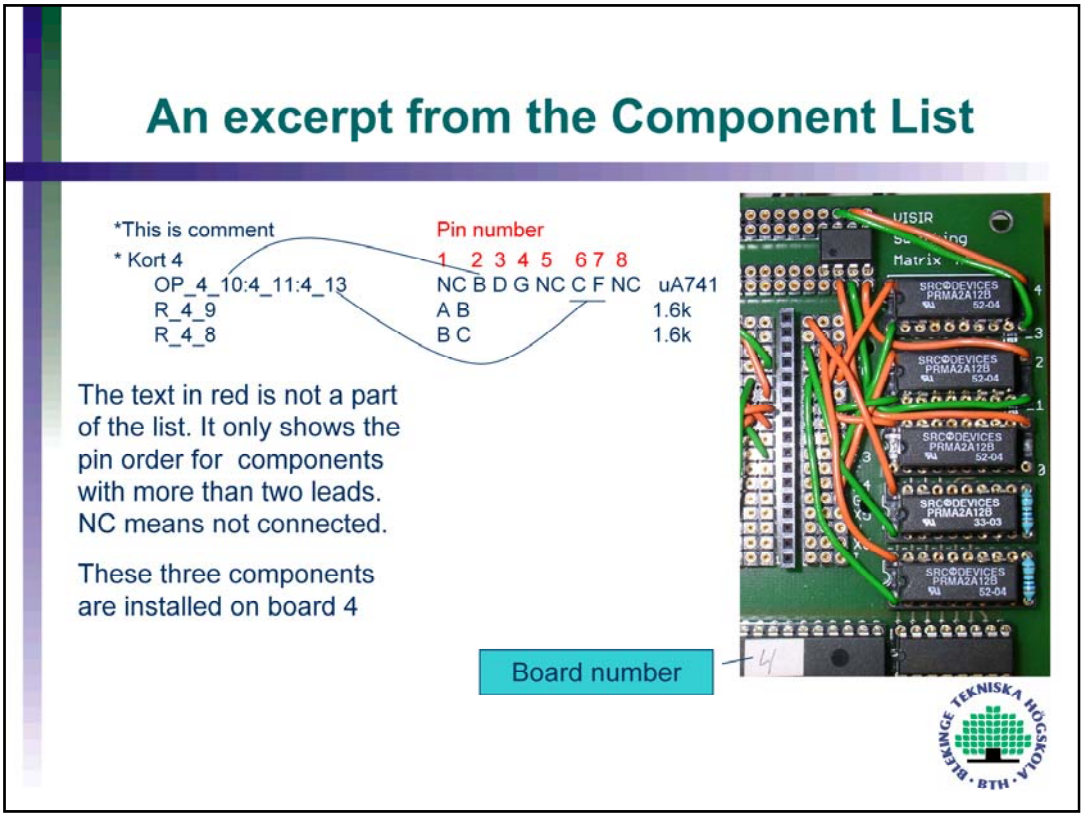


Here it is easy to see the node names, the relay switches and the relay numbers. On the boards they are concealed by sockets and wires. The relay numbers are used to identify the components the relays connect.

The two upper sockets for relays on both sides of the node bus can be populated with either dual pole DIL relays or with single pole SIL one. If DIL relays are used then the relay numbers are 5,7 and 11,13.



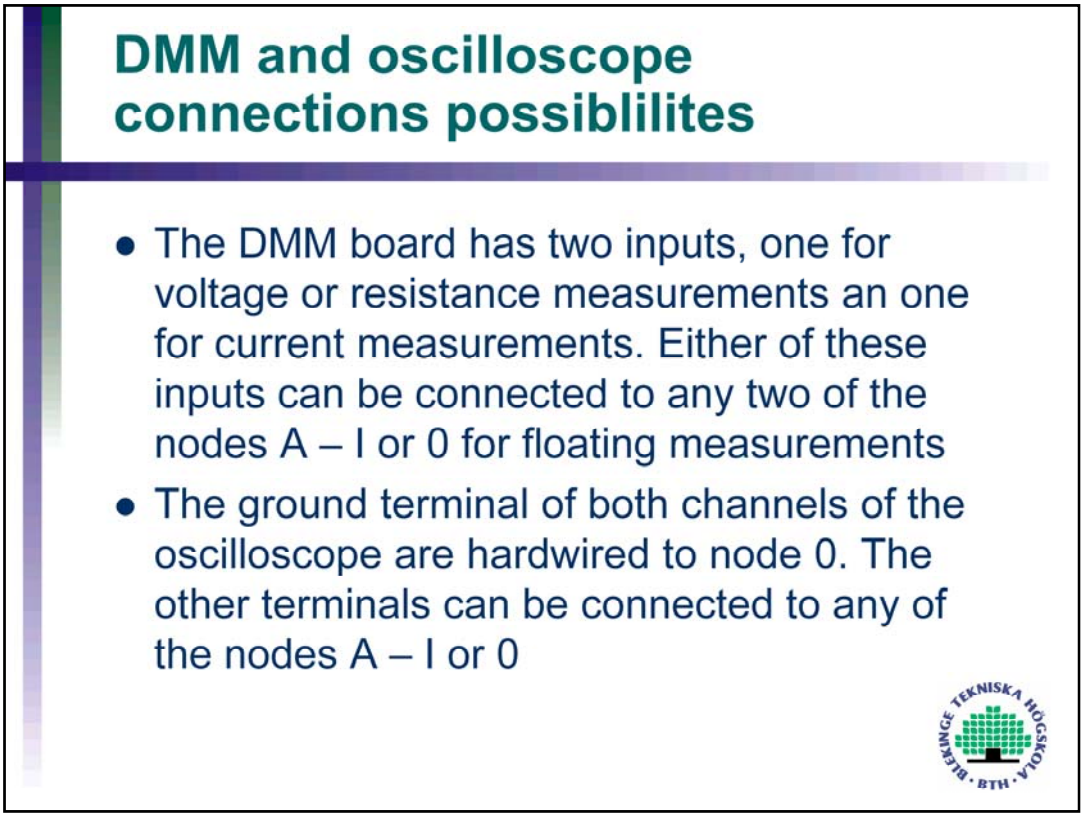
The Component List makes the installed components known to the software. There is only one component list per switching matrix.



This excerpt lists the components and the wires installed on board number 4. Each line represents one component. Separators on a line is white space but colon is separating the relays. In the slide the list is separated in three columns. The left column shows the numbers of the relays used. The middle column shows to which nodes the pin are connected.

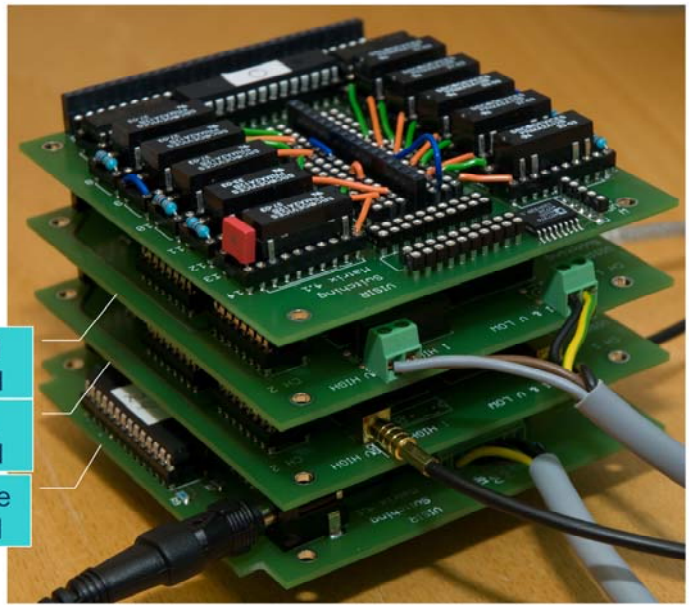
OP_4_10:4_11:4_13 means <component type>_<board number>_<relay number>:<board number>_<relay number>:<board number>_<relay number> i.e. three relays are used to connect the operational amplifier. NC means not connected.

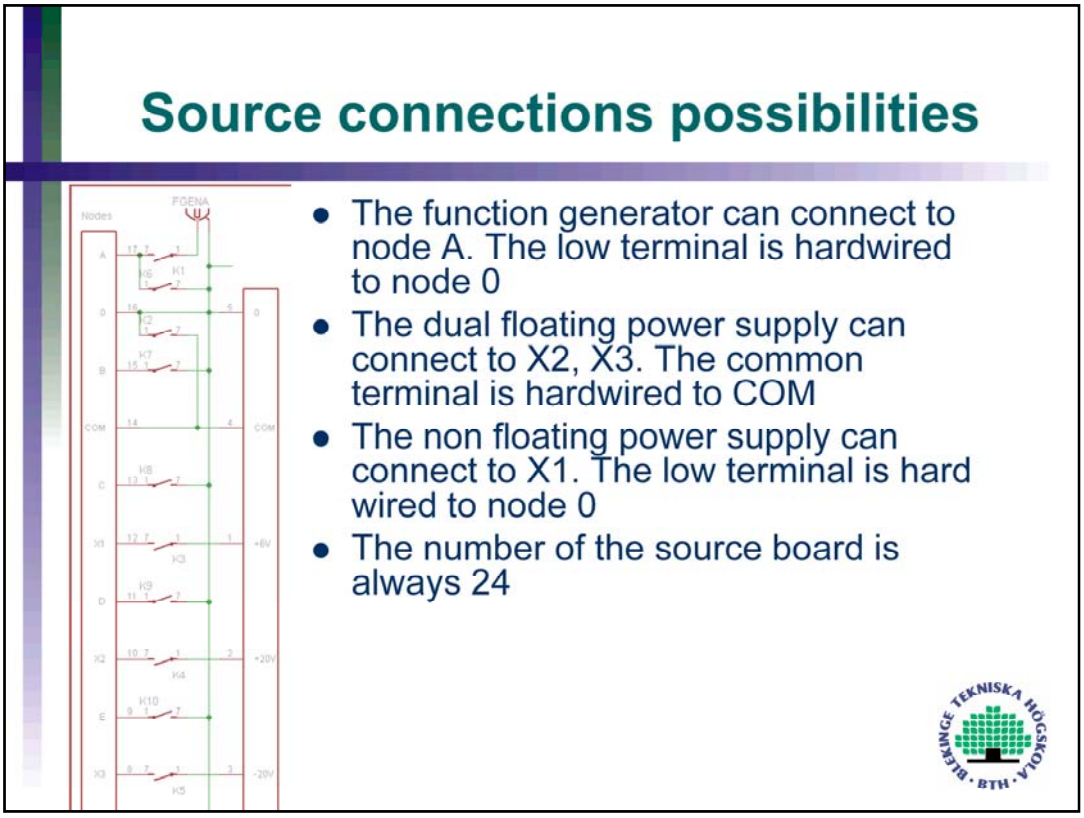
For example, pin 2 connects to node B via the upper switch of relay 10 and the pins 6 and 7 connects to the nodes C and respectively using relay 13.



The DMM and oscilloscope connection possibilities are fixed and are not recorded in the Component List but the connection possibilities for the sources are as shown I the next two slides.

DMM, oscilloscope and sources connections





The low terminals of the oscilloscope and the function generators are connected to protective earth and thus the node 0 is connected to protective earth too. GND on the breadboard refers to node 0.

The source connections are listed in the Component List

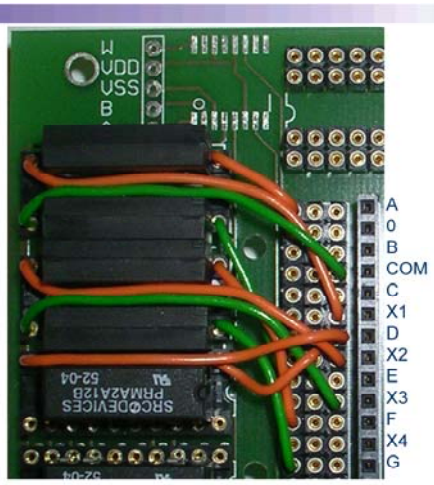
Excerpt from the Component List:

* Power supply
* Board 24 is the source board

VDC+25V_24_4:4_5	F
VDC+25V_24_4:4_3	D
VDC-25V_24_5:4_4	G
VDC+6V_24_3:4_7	A
VDCCOM_24_2	0

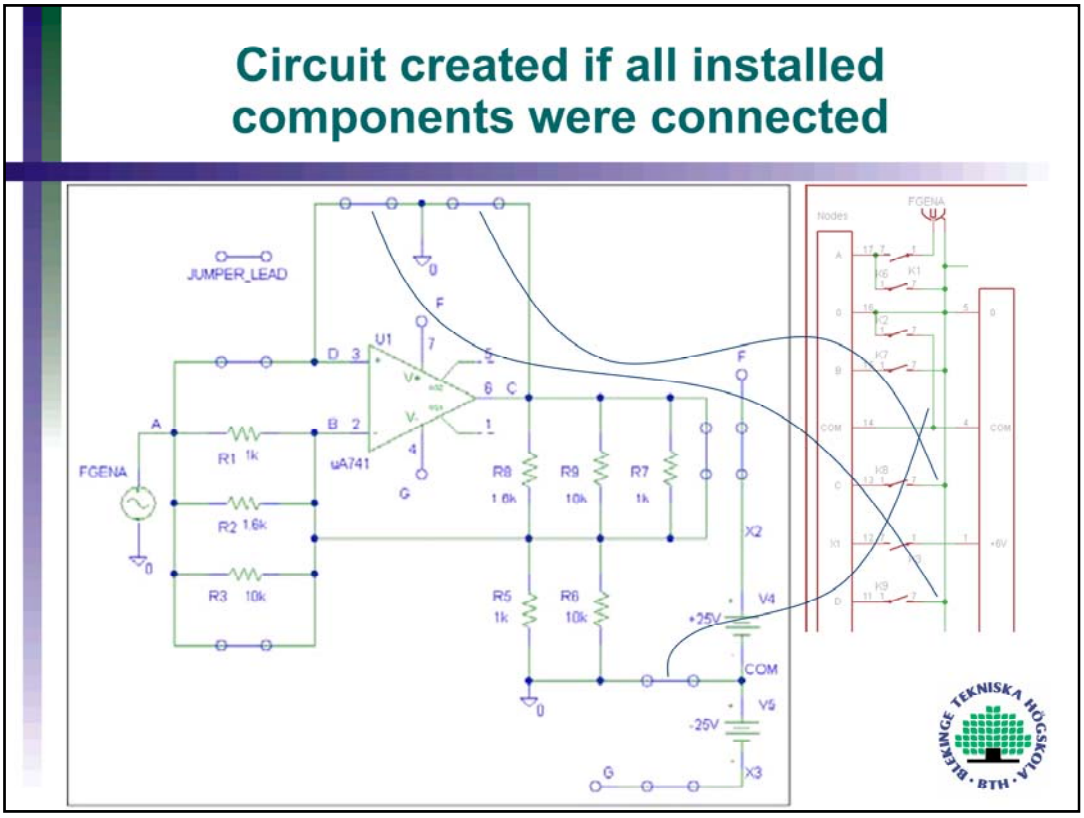
* Function generator

VFGENA_24_1	A



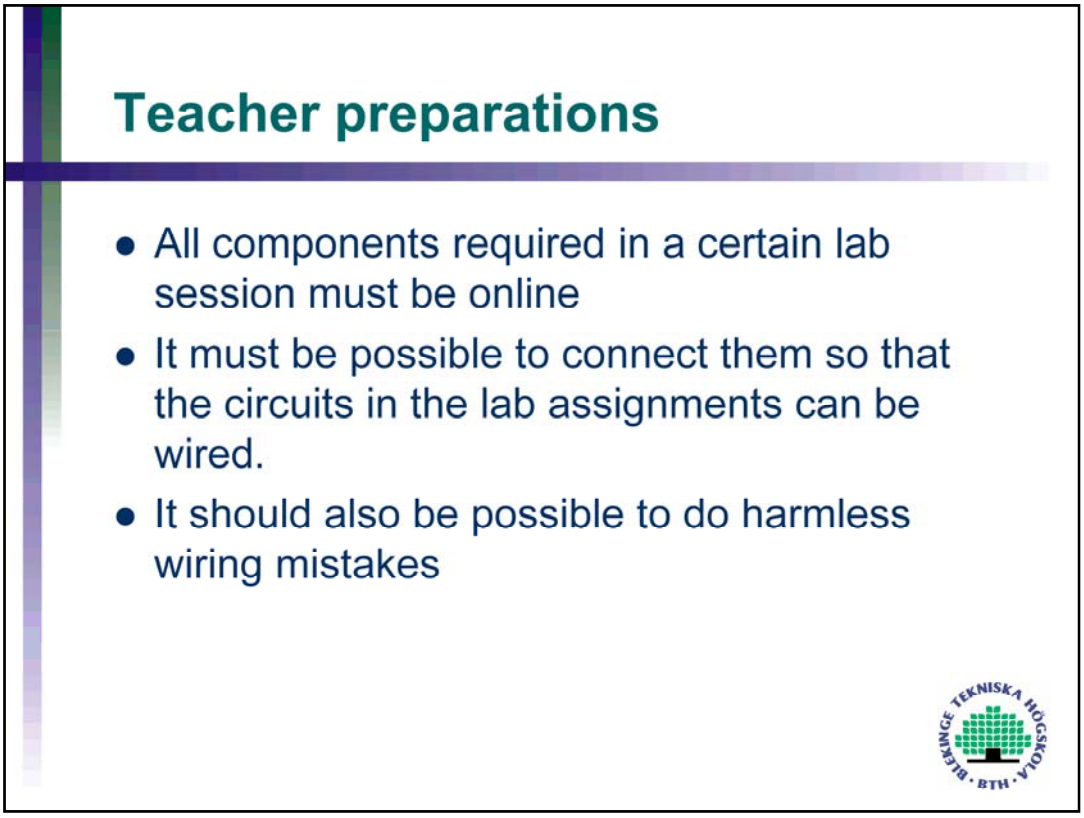
The X and COM connectors of the node bus are not supported in the current version of the software and must not be used in the Component List. Thus the power supplies must be connect to a node via two relay switches in series.

Now all the components required for some basic experiments on operational amplifiers are installed. In the next slide the circuit that would be created if all relay switches were closed.



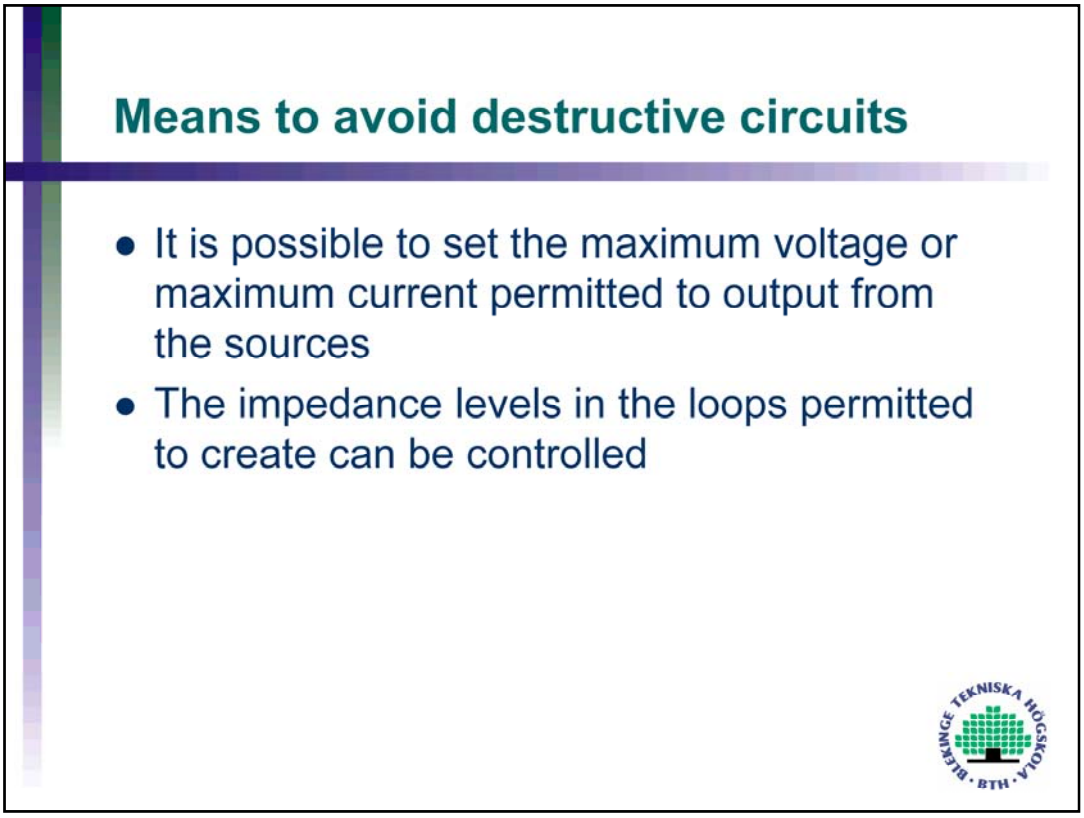
This configuration can support experiments on operational amplifiers both inverting and non-inverting. For example there are three different feedback resistors to choose from for inverting circuits.

Now the staff has configured the switching matrix. Let us go on with the teacher's preparations.



All component required are online and it is possible to wire circuits for experiments on operational amplifiers.

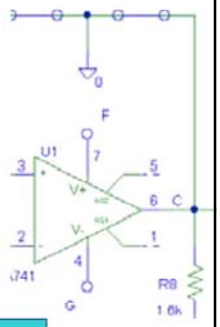
Is it sufficient if a switching matrix allows creation of the circuits in a number of instruction manuals? No, inexperienced students should be permitted to make, for example, wiring mistakes and get an opportunity to learn how to correct them. Apart from the circuits in the instruction manuals, a switching matrix should allow the student to create similar circuits that are safe as well.



The virtual instructor checks that every desired circuit is harmless before the voltage sources are activated. The virtual instructor rules are created by the teacher.

The teacher describes the rules in Max Lists listing all connections permitted

VFGENA_1	A 0	max:5
VDC+25V_1	F	vmax:15 imax:0.5
VDC-25V_2	G	vmax:-15 imax:0.5
VDCCOM_1	0	
OP_1	nc1 B D G nc5 C F nc8	uA741
R_R1	A B	1k
R_R2	A B	1.6k
R_R3	A B	10k
R_R4	B C	1k
R_R5	B C	1.6k
R_R6	B C	10k
R_R7	0 B	1k
R_R8	0 B	10k
JUMPERLEAD_S1	A B	
JUMPERLEAD_S2	A D	
JUMPERLEAD_S3	B C	
JUMPERLEAD_S4	0 D	
JUMPERLEAD_S5	0 C	



For example, omit the last line if the student would not be allowed to short circuit the op. amp. output.

The virtual instructor permits only activation of those circuits whose components and jumper leads are listed in at least one Max List. If no Max List is defined no circuit can be activated. The virtual instructor uses all Max Lists defined.

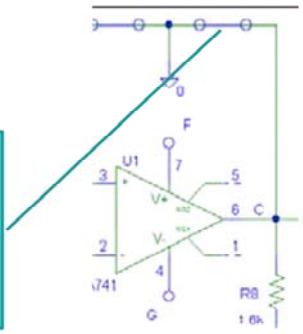
This was the end of the three preparation steps.

In more advanced courses the students experiment with larger circuits. These students want the circuits to be prefabricated and ready to test. The virtual breadboard and switching matrix combination is still useful. The ready-made circuit to be tested can be, for example, a printed circuit board or a circuit wired on a conventional breadboard. The ready-made circuit should be positioned adjacent to the switching matrix. In both cases the test points are wired to the switching matrix by the teacher. This circuit under test can, for example, be represented in the virtual component box as a 16 pin IC-chip where the pins are the test points or maybe source connections. The pin numbers should be found in the circuit drawing of the ready-made circuit. If the sources of the workbench are used to feed the ready-made circuit, the virtual instructor can supervise their voltages. Of course, combinations where additional parts of the circuit are wired on the virtual breadboard are also possible.

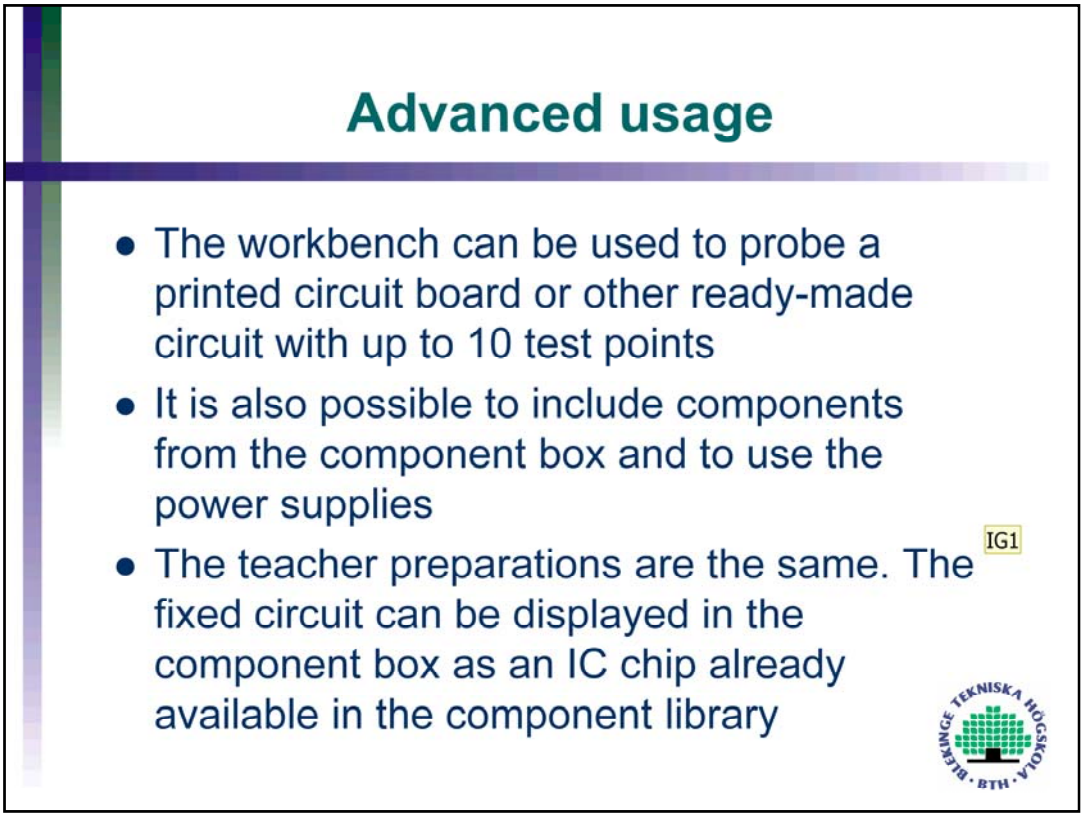
A special virtual instructor rule for current measurements using the DMM

- The DMM in current measurement mode are low impedance and must only replace a jumper lead

If you, for example, want to measure the short cicuit current of the op. amp. this jumper lead must be installed



This rule is always in force.



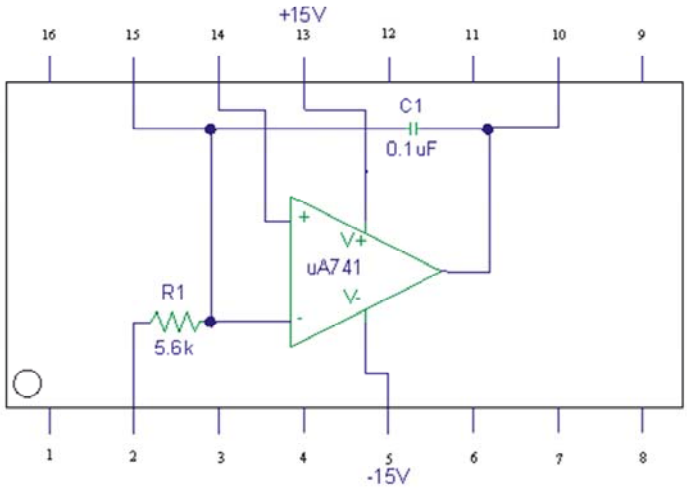
In more advanced courses the students experiment with larger circuits. These students want the circuits to be prefabricated and ready to test. The virtual breadboard and switching matrix combination is still useful. The ready-made circuit to be tested can be, for example, a circuit board or a circuit wired on a conventional breadboard. The ready-made circuit should be positioned adjacent to the switching matrix, as shown in a later slide. In both cases the test points are wired to the switching matrix by the teacher. This circuit under test can, for example, be represented in the virtual component box as a 16 pin IC-chip where the pins are the test points or maybe source connections. These pin numbers should be found in the circuit drawing of the ready-made circuit. If the sources of the workbench are used to feed the ready-made circuit, the virtual instructor can supervise their voltages. Of course, combinations of the cases are also possible

Slide 22

IG1 The last bulleted item is modified

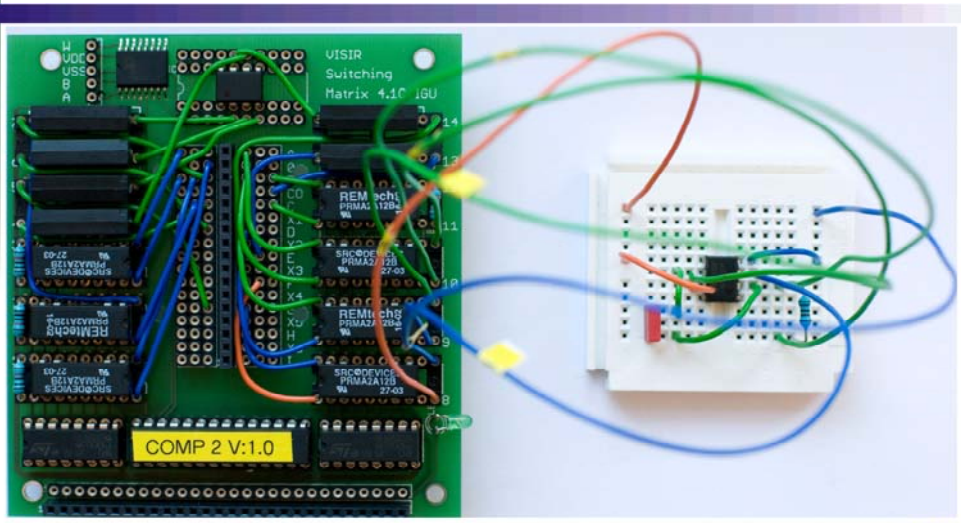
Ingvar Gustavsson; 2008-10-28

Example of simple a fixed circuit defined as a 16 pin IC

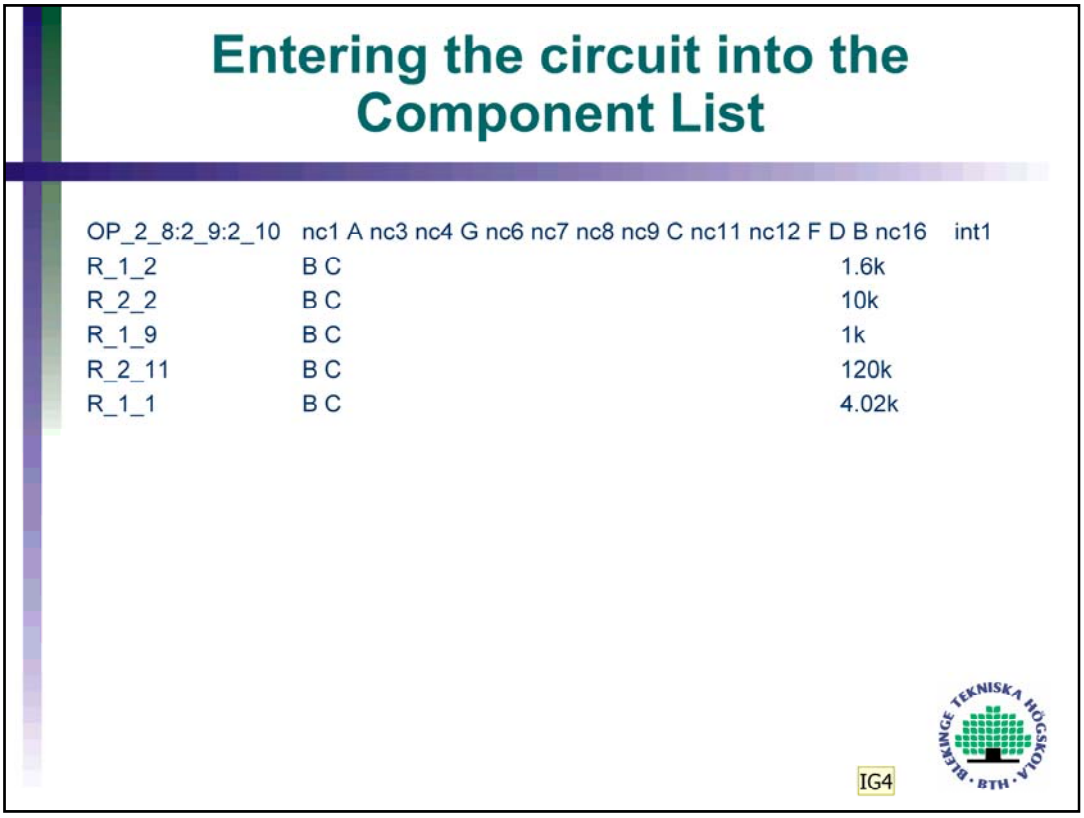


The fixed circuit in our example is here a simple integrator.

Connecting the fixed circuit on the breadboard to the matrix



Wire the circuit on a breadboard and connect it to the switching matrix in the same way as the op. Amp. Earlier. Short wires should be used.



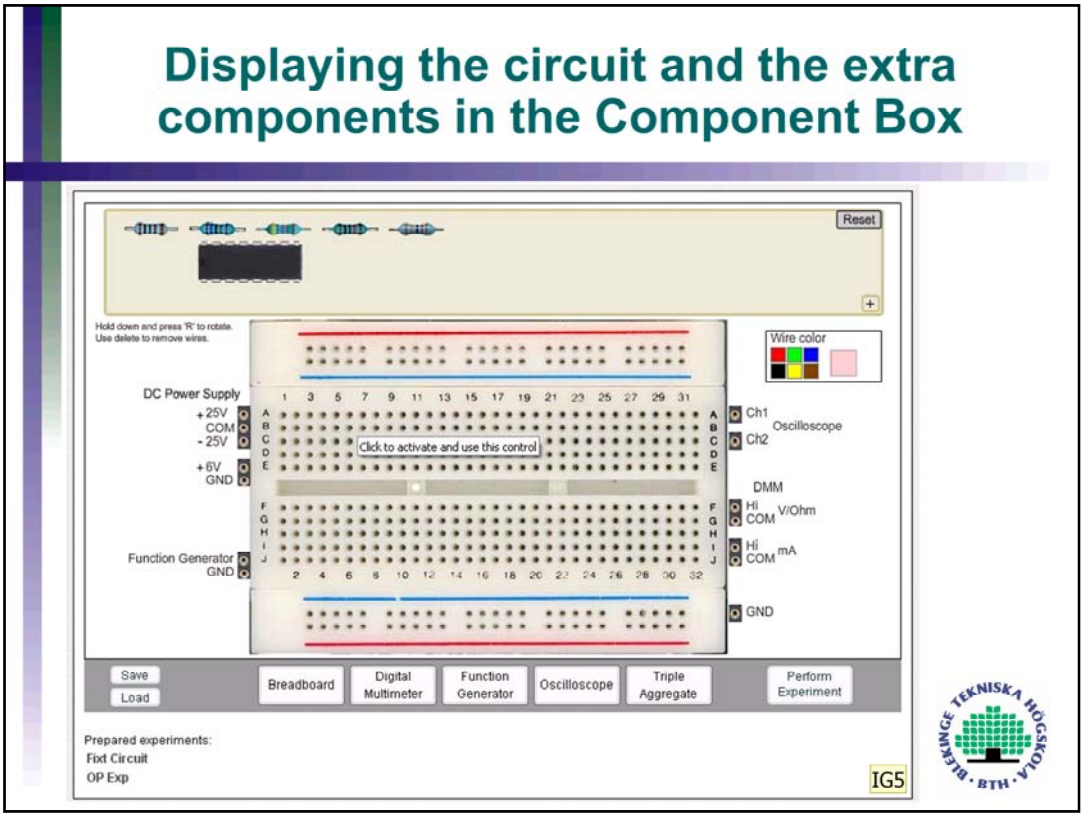
Add the fixed circuit and a few resistors to the Component List. Real integrators need a high impedance resistor in parallel with the capacitor.

Slide 25

IG4 The notes are modified.
Ingvar Gustavsson; 2008-10-28

Creating a Max List

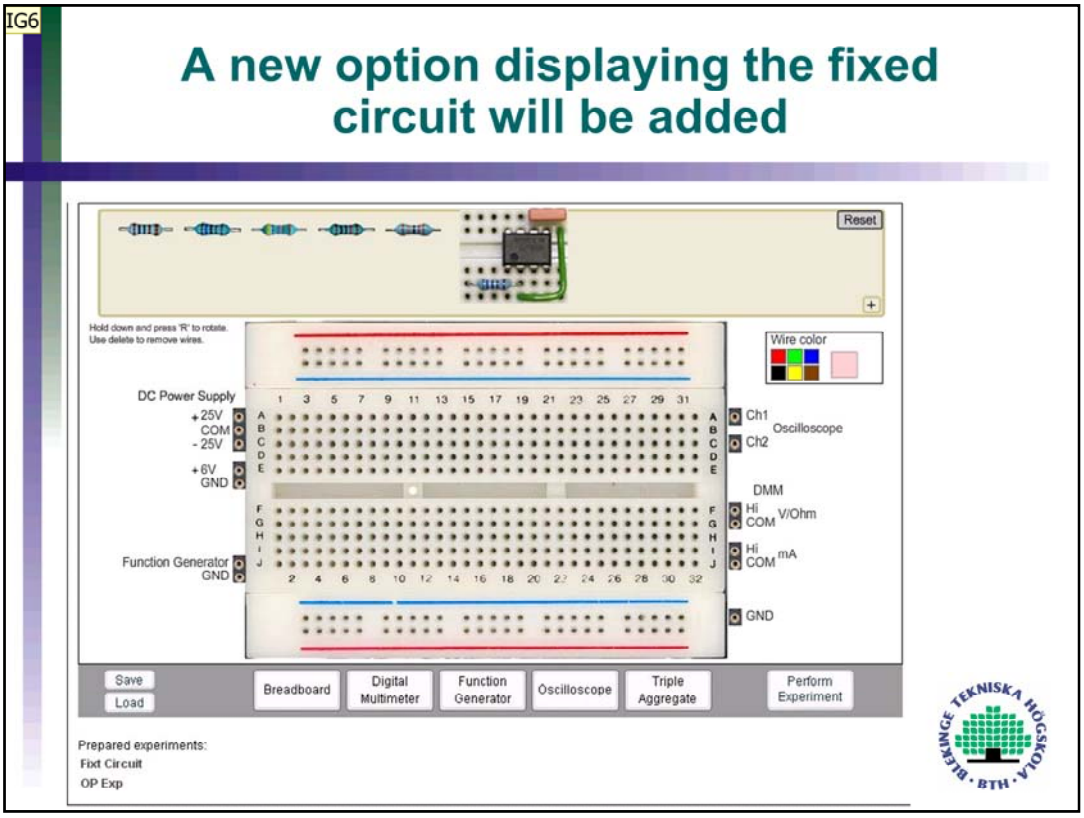
VFGENA_1	A	max:5
VDC+25V_1	F	vmax:15 imax:0.5
VDC-25V_2	G	vmax:-15 imax:0.5
VDCCOM_1	0	
OP_2_8:2_9:2_10	nc1 A nc3 nc4 G nc6 nc7 nc8 nc9 C nc11 nc12 F D B nc16 int1	
R_R1	B C	1.6k
R_R2	B C	10k
R_R3	B C	1k
R_R4	B C	120k
R_R5	B C	4.02k



How to create the component set for the fixed circuit experiment has been described in part 2.

Slide 27

IG5 The notes has been modified.
Ingvar Gustavsson; 2008-10-28

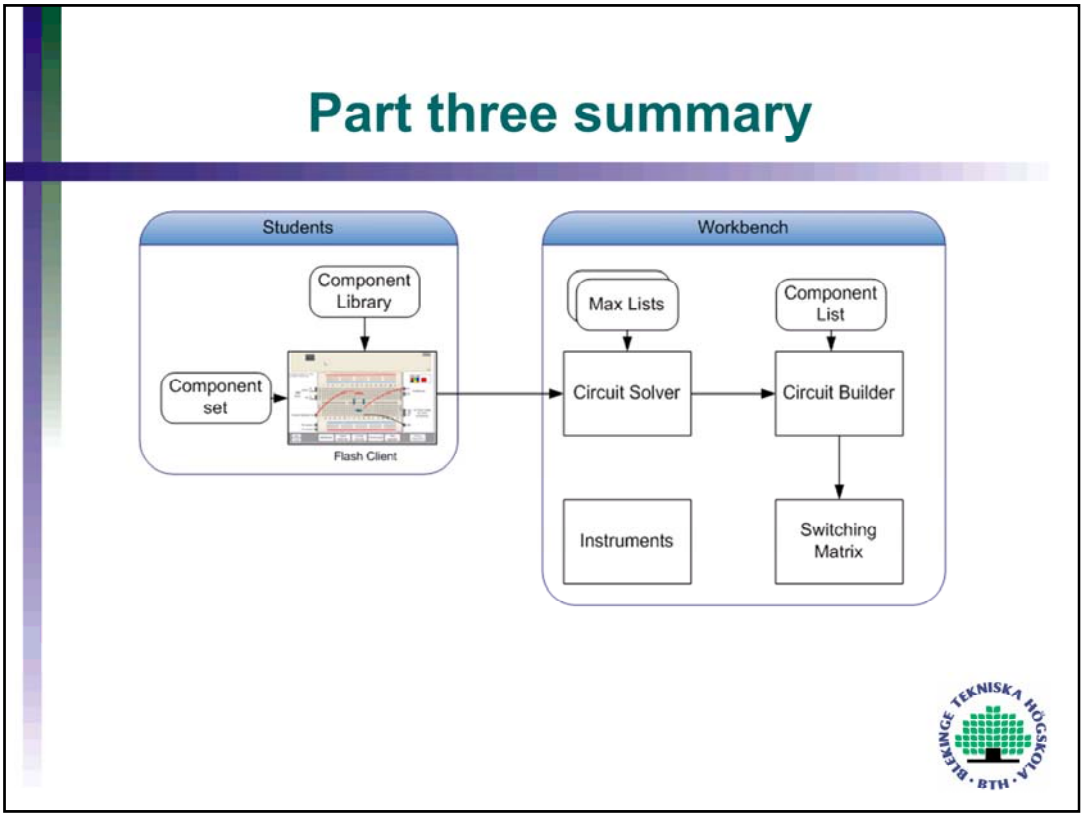


You must be familiar with how to introduce a new component in the component library to use this option.

Slide 28

IG6 New slide

Ingvar Gustavsson; 2008-10-28



The component set of the lab session the student selects is displayed in the component box when the student enters the laboratory. The photos of the components are read from the Component library. When the student presses the *Perfrom Experiment* button the circuit and the instrument settings are sent to the workbench. The Circuit Solver maps the desired circuit wired on the breadboard on to the wiring of the matrix to see if it is possible to create desired circuit and then compares the solved circuit with the Max Lists to see if it is harmless. If so a list of the components to be connected is sent to the Circuit Builder which uses the Component List to convert them to relay numbers to send to the matrix.

Summary part 1 - 3

- The VISIR laboratory is an enhancement of the local laboratory
- The software representing almost 20 man-years of work is published and you are invited to join the VISIR group and contribute to the further development
- The goal is producing engineers who have a solid and documented experience of laboratory work without increased cost per student for universities