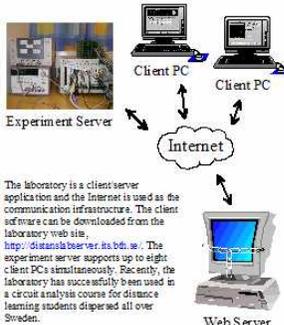
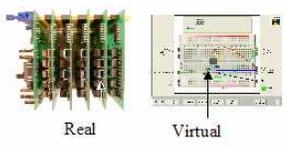
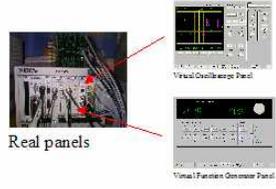
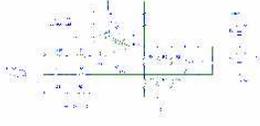


# A Remote Electronics Laboratory providing Student-formed Circuits in Teacher-defined Sessions

Ingvar Gustavsson, [igu@bth.se](mailto:igu@bth.se)

Henrik Åkesson, [hsy@bth.se](mailto:hsy@bth.se)

<p><b>Overview</b></p> <p>The Instrument Server, the Web Server and some PC Clients</p>  <p>The laboratory is a client server application and the Internet is used as the communication infrastructure. The client software can be downloaded from the laboratory web site: <a href="http://distanslabserver.bth.se/">http://distanslabserver.bth.se/</a>. The experiment server supports up to eight client PCs simultaneously. Recently, the laboratory has successfully been used in a circuit analysis course for distance learning students dispersed all over Sweden.</p>	<p><b>A Remote Electronics Laboratory providing Student-formed Circuits in Teacher-defined Sessions</b></p> <p><b>Invitation</b></p> <ul style="list-style-type: none"> <li>Emulating a local laboratory for undergraduate education the Remote Electronics Laboratory provides remotely controlled hardware experiments.</li> <li>Universities and other teaching organizations are invited to test the laboratory and make use of it for experiments or regular laboratory sessions, using their own components and learning material in a language of their choice.</li> </ul> <p>The Experiment Server is located in Rönneby at Blekinge Institute of Technology in the south of Sweden</p>  <p>Ingvar Gustavsson Henrik Åkesson Blekinge Institute of Technology School of Engineering Dept. of Applied Electronics BOX 220, S-360 72 Rönneby, SWEDEN</p>	<p><b>Virtual Breadboard</b></p> <p>Using a virtual breadboard the students control relays in a switching matrix in the experiment server</p>  <p>The teacher or the laboratory staff mounts the components to be used during the laboratory sessions into sockets in the switching matrix. The students will use the mouse pointer to connect at least some of the corresponding virtual components on the virtual breadboard to form desired circuits.</p> <p>The number of nodes on the virtual breadboard is limited due to the hardware complexity of the switching matrix but is adequate for experiments in undergraduate education. The number of sockets for components in the switching matrix can be increased by adding additional boards to the matrix.</p>
<p><b>Virtual Front Panels</b></p> <p>Computer-based instruments in the experiment server are fitted with virtual front panels shown on the client PC screen</p>  <p>The local laboratories at BTH use the 54600B desktop-type oscilloscopes from Agilent Technologies. The similarity between the oscilloscope panels is intentional. Students have no problem using the front panel with the hard buttons when they are used to the virtual panel. Later on, other oscilloscope panels will also be provided.</p>	<p><b>Laboratory Session Preparation</b></p> <ul style="list-style-type: none"> <li>The teacher sends the components to be used in his or her laboratory sessions to Rönneby by mail. If the desired components can be provided by the laboratory, the teacher only has to send the component list by email.</li> <li>To avoid dangerous mistakes such as component overloading, the teacher can set limits to the source voltage and DC currents the students can set and only permit loops with sufficient impedance level to be created. The teacher defines the so called "maximum circuit" to set these restrictions. Every maximum circuit and all its subsets must be safe. Such a circuit for experiments on operational amplifiers is shown below. A software module checks that every circuit created on the virtual breadboard is a maximum circuit or a subset of such a circuit.</li> <li>The voltages shown in the diagram are the maximum voltages permitted for each source. For the DC supply it is also possible to set current limits for each output.</li> <li>In the maximum circuit jumper leads are required for connection flexibility but they can be hazardous. If, for example, it is not allowed to short-circuit the source in the diagram, the jumper lead permitting the student to wire pin 3 of the amplifier to ground could be removed. On the other hand, the student will be prevented from forming inverting op amp circuits. In this case two maximum circuits must be designed: one for inverting circuits and one for non-inverting ones.</li> <li>All instruments represent a high impedance load except the DMM in current mode. Voltage measurements are not dangerous. To measure current using the DMM the student are only allowed to replace a jumper lead with the instrument. In the diagram there is a jumper lead permitting the amplifier output to be short-circuited to ground. Thus it is possible to measure the amplifier short-circuit current.</li> <li>The maximum circuit is designed to impose as few restrictions as possible on the experimentation. The students should have some freedom to modify the circuits in the instruction manuals and do harmless mistakes.</li> </ul> 	<p><b>Performance</b></p> <ul style="list-style-type: none"> <li>Apart from the fact that each student or student team at a client PC is working in a virtual environment without face-to-face contact with the instructor or other students in the laboratory, the only difference compared to a traditional laboratory session in a local laboratory is that it is not possible to manipulate the components and the wires with the fingers.</li> <li>The equipment provided are:             <ul style="list-style-type: none"> <li>Two channel oscilloscope. The hardware plug-in board is NI5112 and its virtual front panel mimics Agilent 54600B.</li> <li>DMM. The hardware plug-in board is NI4060. Currently only a preliminary virtual front panel of 1/2 digit DMM is available. Fulling two terminal measurements are supported.</li> <li>DC power supply. It is Agilent 3116A.</li> <li>Function generator. The hardware plug-in board is NI 5401 and or NI 5411 and the front panel mimics Agilent 33110A. Only standard waveforms are currently supported.</li> <li>Digital I/O. It is a 24 bit card. Used for reading and writing data to mixed signal components such as AD and DA converters. The software needed remains to be written.</li> <li>Breadboard. It is a 16 nodes 3 rows of one can be used as test points for the oscilloscope and the DMM. A component board in the switching matrix comprises 10 sockets for components with two leads jumper leads, two 20 pin IC sockets for components with more than two leads, and 10 two-hole single-throw relays.</li> </ul> </li> <li>The time sharing scheme used to allow simultaneous access to one server for up to 8 client PCs imposes restrictions on the time period allowed for each experiment, but in courses in electronics the teacher can without any inconvenience select the time constants involved within a proper range. The time period allowed for one measurement is 0.1 s.</li> <li>The laboratory is always open and can be used by registered students outside regular laboratory sessions. Some experiments are also provided for guest users. Only a 56 kbit/s modem and MS Internet Explorer are required. No video transmission is needed.</li> </ul>

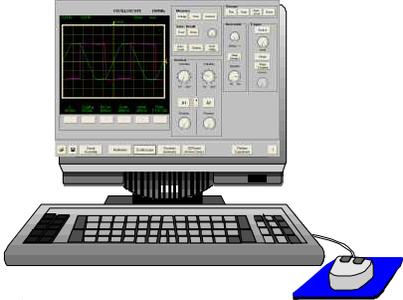
# Invitation

- Emulating a local laboratory for undergraduate education the Remote Electronics Laboratory provides remotely controlled hardware experiments.
- Universities and other teaching organizations are invited to test the laboratory and make use of it for experiments or regular laboratory sessions, using their own components and learning material in a language of their choice.

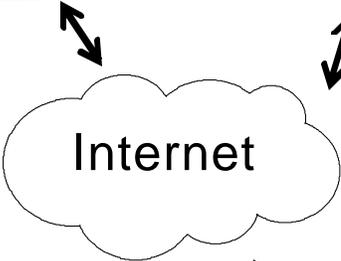
# The Instrument Server and a Client PC



Client PC



Experiment Server

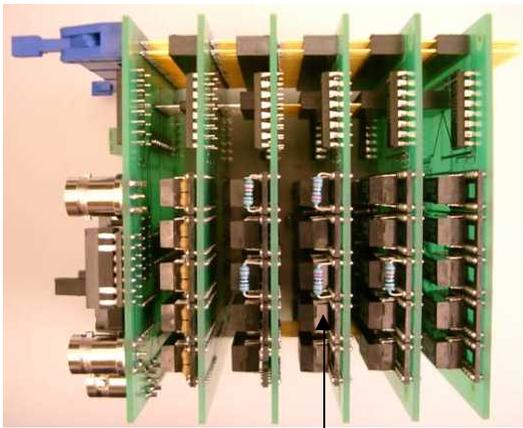


Web Server

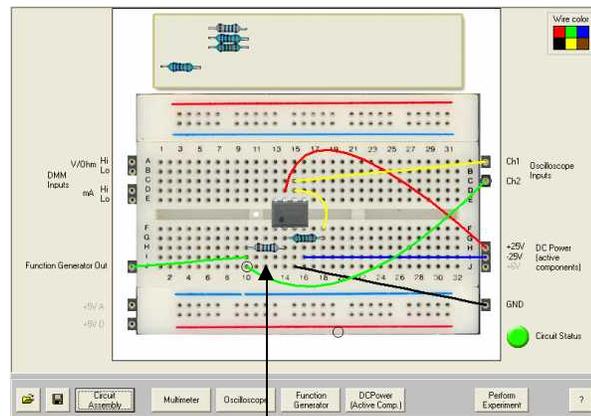


The laboratory is a client/server application and the Internet is used as the communication infrastructure. The client software can be downloaded from the laboratory web site, <http://distanslabserver.its.bth.se/>. The experiment server supports up to eight client PCs simultaneously. Recently, the laboratory has successfully been used in a circuit analysis course for distance learning students dispersed all over Sweden.

# Using a virtual breadboard the students control relays in a switching matrix in the experiment server



Real



Virtual

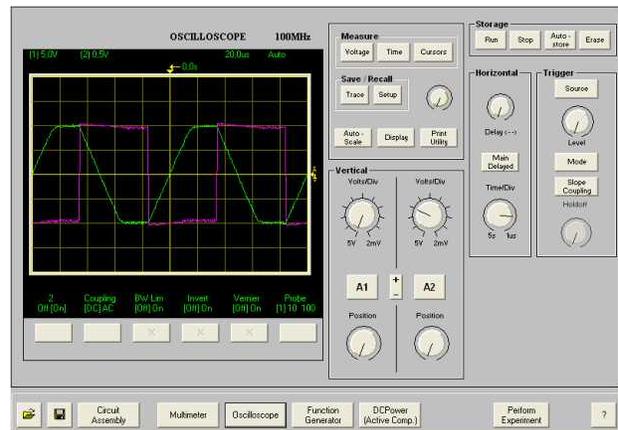
The teacher or the laboratory staff mounts the components to be used during the laboratory sessions into sockets in the switching matrix. The students will use the mouse pointer to connect at least some of the corresponding virtual components on the virtual breadboard to form desired circuits.

The number of nodes on the virtual breadboard is limited due to the hardware complexity of the switching matrix but is adequate for experiments in undergraduate education. The number of sockets for components in the switching matrix can be increased by adding additional boards to the matrix.

# Computer-based instruments in the experiment server are fitted with virtual front panels shown on the client PC screen



Real panel

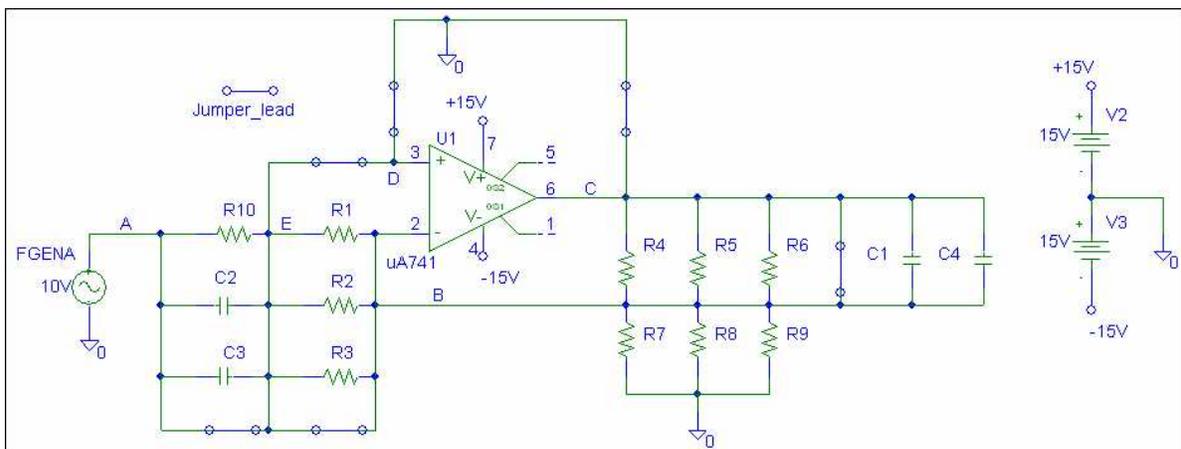


Virtual front panel of the oscilloscope

The local laboratories at BTH use 54600B desktop-type oscilloscopes from Agilent Technologies. The similarity between the oscilloscope panels is intentional. Students have no problem using the front panel with the hard buttons when they are used to the virtual panel. Later on, other oscilloscope panels will also be provided.

# Laboratory session preparation

- The teacher sends the components to be used in his or her laboratory sessions to Ronneby by mail. If the desired components can be provided by the laboratory, the teacher only has to send the component list by email.
- To avoid dangerous mistakes such as component overloading, the teacher can set limits to the source voltages and DC currents the students can set and only permit loops with sufficient impedance level to be created. The teacher defines the so called “maximum circuits” to set these restrictions. Every maximum circuit and all its subsets must be safe. Such a circuit for experiments on operational amplifiers is shown below. A software module checks that every circuit created on the virtual breadboard is a maximum circuit or a subset of such a circuit.



- The voltages shown in the diagram are the maximum voltages permitted for each source. For the DC supply it is also possible to set current limits for each output.
- In the maximum circuits jumper leads are required for connection flexibility but they can be hazardous. If, for example, it is not allowed to shortcut the source in the diagram, the jumper lead permitting the student to wire pin 3 of the amplifier to ground could be removed. On the other hand, the students will be prevented from forming inverting op amp circuits. In this case two maximum circuits must be designed: one for inverting circuits and one for non-inverting ones.
- All instruments represent a high impedance load except the DMM in current mode. Voltage measurements are not dangerous. To measure current using the DMM the student are only allowed to replace a jumper lead with the instrument. In the diagram there is a jumper lead permitting the amplifier output to be shortcut to ground. Thus it is possible to measure the amplifier shortcut current.
- The maximum circuit is designed to impose as few restrictions as possible on the experimentation. The students should have some freedom to modify the circuits in the instruction manuals and do harmless mistakes.

# Performance

- Apart from the fact that each student or student team at a client PC is working in a virtual environment without face to face contact with the instructor or other students in the laboratory, the only difference compared to a traditional laboratory session in a local laboratory is that it is not possible to manipulate the components and the wires with the fingers.
- The equipment provided are:
  - Dual channel oscilloscope. The hardware plug-in board is NI 5112 and its virtual front panel mimics Agilent 54600B.
  - DMM. The hardware plug-in board is NI 4060. Currently only a preliminary virtual front panel of a 5½ digit DMM is available. Floating two terminal measurements are supported.
  - DC power supply. It is Agilent 3136A.
  - Function generator. The hardware plug-in board is NI 5401 and/or NI 5411 and the front panel mimics Agilent 33120A. Only standard waveforms are currently supported.
  - Digital I/O, It is 24 bit card. It will be used for reading and writing data to mixed signal components such as AD and DA converters. The software needed remains to be written.
  - Breadboard. It has 16 nodes. Seven of these can be used as test points for the oscilloscope and the DMM. A component board in the switching matrix comprises 10 sockets for components with two leads/jumper leads, two 20 pin IC sockets for components with more than two leads, and 10 double-pole single-throw relays.
- The time sharing scheme used to allow simultaneous access to one server for up to 8 client PCs imposes restrictions on the time period allowed for each experiment, but in courses in electronics the teacher can without any inconvenience select the time constants involved within a proper range. The time period allowed for one measurement is 0.1 s.
- The laboratory is always open and can be used by registered students outside regular laboratory sessions. Some experiments are also provided for guest users. Only a 56 kbit/s modem and MS Internet Explorer are required. No video transmission is needed.