Measurement Techniques on Distance Using a Web Browser

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Abstract

The Internet provides a convenient and effective medium by which real (as opposed to simulated) experiments can be made available to students in distance learning courses. Here a laboratory exercise in measuring techniques is described. The measurements are performed on a DC-motor with a propeller. The voltage to the motor is controlled. Input power, propeller speed and force are measured. The students use an ordinary web browser to control and take readings from the instruments. Various relations are then studied 'off-line' using *Excel* or *Matlab* and vibration analyses are performed by making Fourier transforms of the force sensor signal.

Introduction

Access to the Internet has changed the traditional ways of 'Distance Education' in many ways. Online science tutorials, databases and simulations are nowadays frequently used but a crucial ingredient is often missing from online science: there is almost no opportunity for students to carry out real experiments - as opposed to interact with simulations. In many distance learning courses in science this is compensated by bringing the students to the University laboratories during say a weekend each month which often limits the geographic uptake region of the participants. The need for online experiments was also discussed recently by Hugh Cartwright in a previous issue of *CAL-laborate* (http://science.uniserve.edu.au/pubs/callab/vol5/cart.html).

At the Department of Physics, University of Uppsala we have several years of experience from a distance learning course: Computer based measuring techniques on distance (http://www.fysik.uu.se/kurser/fy660/course.htm). This course focuses on the computer interface and programming of instruments, in particular through GPIB (General Purpose Interface Bus - IEEE488), which is a standard interface for many instruments like DMM, oscilloscopes, etc. With Ethernet based GPIB-controllers the instruments may be programmed from any PC on a TCP/IP network.

However, this article describes an ordinary laboratory exercise in measuring techniques where the details of the computer interfacing is of less interest for the students. All controls and readings of the instruments are done using a web browser, which allows the use of any type of computer system: PC, Macintosh, Workstations, *Windows*, *Linux*, etc. No installation of any driver software is necessary on the user's computer. The technical concept is applicable not only to exercises in measuring techniques, but to most experiments where computer controlled instruments are possible to use.

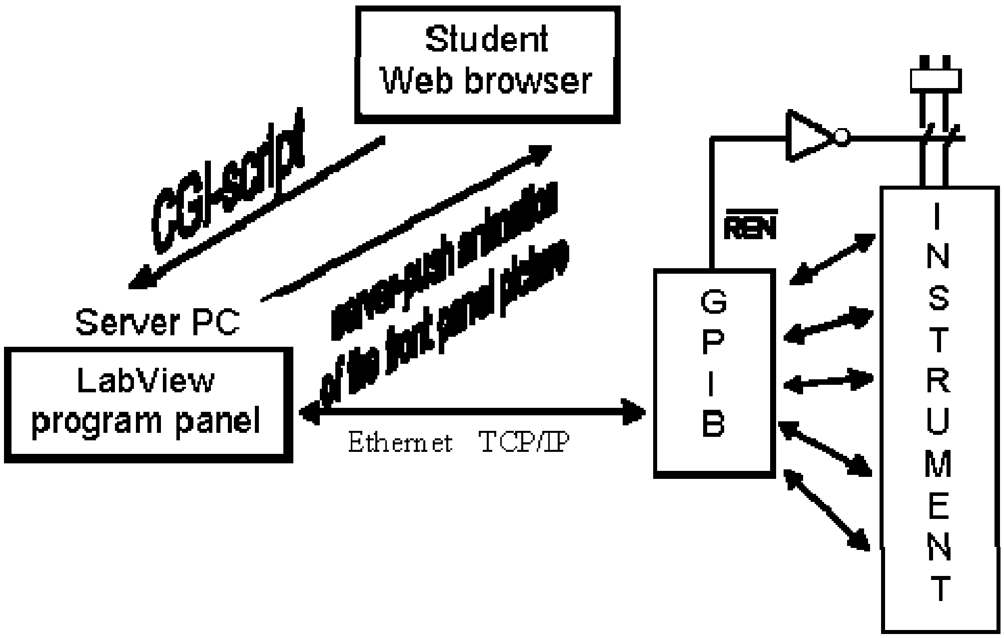

Figure 1. Interface details

Exercises

Measurements are performed on a small DC-motor with a propeller mounted at the low end of a flexible glass-fibre plate. The voltage of the power supply is set and the actual voltage and current is read. Hence the input power (P) can be calculated and later compared with the rotational speed and force. A digital multimeter (DMM) is used to read the speed as a frequency and the force as an output voltage from the strain gauge. The strain gauge voltage is also registrated on an oscilloscope.

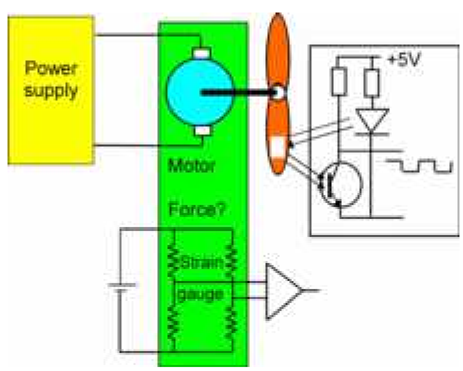

Figure 2. Exercise setup

The driving power of a propeller is proportional to the cube of the speed (f) which can be verified by plotting P versus f, f^2 and f^3. Since friction losses are important, in particular at low speeds, a least squares fit to a polynomial is also recommended. The relation between the pulling force and the speed should also be studied by plotting relevant diagrams. Here care must be taken to the pendulum movement of the motor induced at each change of the speed.

The electric equation describing the DC-motor: $U = k \cdot f + R \cdot I + U_C$ may also be studied. By a least squares fit to a function with two independent variables, f (speed) and I (current), the three constants are determined: the proportionality factor k in the 'Lenz law' term, the coil resistance R and the contact voltage U_C. Then the 'ohmic' relation between U and I can be demonstrated by plotting $(U-k \cdot f)$ versus I.

Figure 3 shows the user panel (in Swedish) with the oscilloscope reading of the force signal and its Fourier transform. The fast frequency is due to rotational related vibrations and the slow modulation is due to the above mentioned pendulum movement. Oscilloscope data is stored in a downloadable text file so the students can make their own Fourier transforms using e.g. *Matlab*, *Excel* or any other standard software. By comparing vibration spectra recorded at different driving voltages, speed related peaks and their harmonics can be identified and separated from noise peaks.

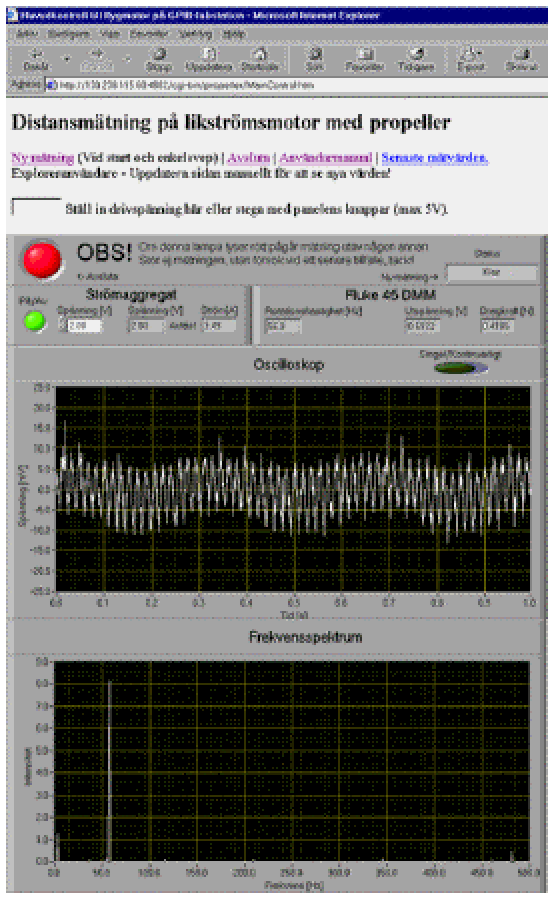

Figure 3.

Experimental setup and software

The experimental equipment is part of a permanently accessible GPIB-controlled 'measuring station' (for details see http://www.fysik.uu.se/kurser/fy660/DL_gpib/). The programming of the instrument controls and the web-interface is performed in *LabView* including *Internet Toolkit*

from National Instruments. The actual web page is coded in standard HTML. The virtual instrument panel, with any fancy output format, is sent to the web browser as a picture, identical to the panel displayed on the server PC monitor:
<IMG SRC="/.monitor?Maldemo.vi&refresh=2&type=png&full=on" ALIGN="BOTTOM" BORDER="1" USEMAP="#panel" ISMAP>
where 'Maldemo.vi' is the name of the actual *LabView* control program. In *Netscape Navigator* the picture will be automatically refreshed but the method 'monitor' is not yet supported by *Internet Explorer*. However, the full page may be refreshed using:
<META HTTP-EQUIV="REFRESH" CONTENT=5>
or by a manual refresh.

The user input is transferred through cgi-calls either by mouse clicking selected areas on the panel picture or by 'HTML-Forms'. An example of the latter method is the input area above the panel, used to set an arbitrary voltage but the voltage may also be stepped up or down by clicking on the buttons under 'Spänning'. Similarly, the power is switched on or off by clicking on the 'På/Av'-button. There are also switches to control the measuring cycles.

More details are found in a number of examples that come with the *LabView Internet Toolkit* or by a short demonstration from the author (so far only in Swedish) at:
http://material.fysik.uu.se/dl_gpib/Mal/webstyrning.htm

The instrument station is dedicated for distant learning students, as opposed to classes in distributed teaching, and can only be used by one student at a time. The red 'lamp' on the front panel indicates that the equipment is in use but at the moment there is no protection against other users interfering with instrument settings. However, the web site is password protected and the number of students participating in a course is limited. No scheduling has been required so far.

The main power to all instruments is controlled by the GPIB Remote Enable (REN) signal and a hardware timer. In this way a master reset of all the equipment is obtained after each user, even if the Internet connection should hang up.

Final comments

Web-based measurements can probably never replace the real contact with scientific instruments. Students using this laboratory exercise are assumed to have had a previous hands-on experience of the corresponding instruments in the real laboratory to fully understand what is going on. However, with exercises like this one, the number of scheduled meetings at the University campus and travelling costs may be reduced. Moreover, many measurements performed in hazardous enviroments, also require remote control of the instruments which also motivates the introduction of such experiments in teaching.

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