

E-LEARNING TOOLS FOR EDUCATION AND TRAINING IN DIAGNOSTICS AND MACHINE CONDITION MONITORING

Ondrej Kreibich and Radislav Smid

*Faculty of Electrical Engineering, Department of Measurement
Czech Technical University in Prague, Technicka 2, Prague, Czech Republic*

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Abstract: This paper presents an integration of e-learning into an existing course of diagnostics, machine condition monitoring (MCM) and nondestructive testing (NDT), educated at our university. A diagnostics education belongs to field of study where e-learning is used less commonly than in other fields for its necessity to attending a laboratory. Laboratory education, forms an integral part of many university courses, mainly in natural and technical university education, are necessary to improve students' knowledge by experiments with laboratory samples and devices. There could arise a problem for foreign and distance students, who cannot physically attend these courses. Therefore the aim of this project is presentation of a possible solution on the example of laboratory electro-mechanical device fully accessible via Internet.

1 INTRODUCTION

Nowadays, e-learning as a modern educational method is used in many fields of study, mainly in humanities, natural science and computer science.

On the other hand, there are a few fields e.g. in Electrical or Mechanical Engineering, where students should attend laboratory courses in order to improve their knowledge by the experiments with laboratory samples and devices.

Within the frame of recently solved project concerning the development of vibrodiagnostic device in our NDT laboratory, there has arisen an idea to enable remote access to this vibrodiagnostic device via the Internet and to extend the device with IP camera. In addition to already existed online support to this course in the Moodle system. Such design helps to foreign and distance students almost feel they are working with a real laboratory device.

Furthermore remote access to laboratory equipment could not be used for education purposes only; for instance could be suitable for presentation of research projects.

2 PREVIOUS WORK

In the past, we developed for educational and research purposes an electro-mechanical device, cal-

led vibrodiagnostic simulator. The simulator is based on simple mechanical system, which is able to demonstrate individual damages of transmission system e.g. gear transmission, bearings and unbalance (Vachtsevanos, 2006). These damages can occur at common machines due to unsuitable procedures in manufacture, unsuitable construction and finally sudden changes in operating state.

Simulated damages are analyzed by means of usual vibrodiagnostic methods. Results of analysis of these phenomena can serve for project planning of maintenance of devices in industry and thus protect them against already mentioned damages during expected lifetime of the devices. Next important factors are minimalization of time for maintenance and reparation, optimalization of performance of the devices and provide safety of operation.

Methods of simulation of possible damages can be useful for searching and specification damages without necessity for complete dismounting of all machine.

The simulators are used in such cases where the laboratory experiments on real devices are not possible due to oversize of real machinery. Next important reasons for application of simulators are unavailability of real machinery testing samples, limitations in manufacture and limitations performance of real device.

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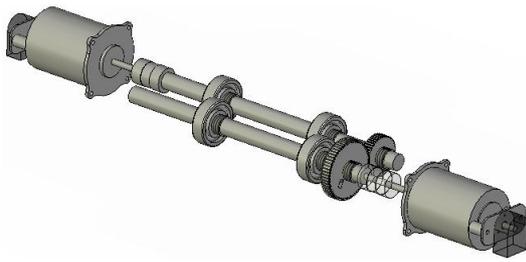


Figure 1: The fundamental design of training device.

2.1 Mechanical Design

Mechanical components of the training device were chosen from available commercial products, such as DC motors, ball bearings, jaw couplings. Commercially unavailable parts were made individually.

Technical documentation of all the components was made for manufacturing procedures of the device.



Figure 2: The training device prepared for an exercise in our laboratory.

Simulator is suitable for:

- demonstration of failures of gear transmission
- demonstration of failures of ball bearings
- demonstration of failures of unbalance
- measurement of revolution speed of device
- loading of device with electronically controlled brake
- orbit measurement of one of the shafts due to two sensors IN-081 (Brüel & Kjær).

2.2 Acquisition of Vibration Signals

Electronic control of the simulator was divided into two individual sections (Fig. 3):

- Control unit - controls revolution speed of device

- Data acquisition unit - serves for digitalization of signals received from accelerometers

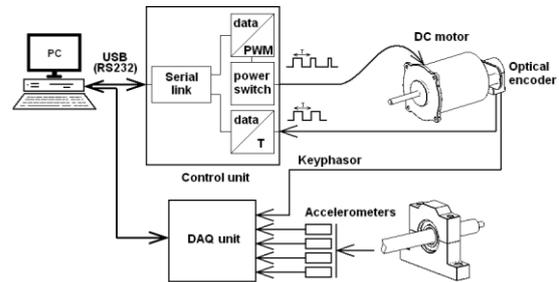


Figure 3: The block diagram of data acquisition unit and electronic control unit.

2.2.1 Electronic Control Unit

The control unit transforms data coming from PC onto signal which is important for control of the engine. For this purpose is most used PWM method – pulse width modulation. Such received signal controls power switch. By means of the alternating switching on/off is changed average value of current flow over DC motor and thus its speed of rotation is controlled.

Speed of the engine rotation is detected by sensor of RPM (optical encoder). Microcontroller is able to find time period between of individual pulses and this information is sent to the PC. By means of simple calculation is determined the rotation speed.

2.2.2 Data Acquisition Unit

Data acquisition unit is PMD-1208FS provided by Measurement Computing was used in this device owing to relatively low price and direct support of data acquisition toolbox under the Matlab software.

3 GOAL

First of all, there should be suitable to mention a few words about knowledge and skills which students attending our NDT laboratory course should obtain.

Within the framework of education at faculty of electrical engineering there are students with good theoretical background, but have never tried to apply electrotechnical knowledge to other field before. In this case the NDT course offers a great opportunity to interconnection among electrical and mechanical engineering.

The content of this course consists in finding and diagnose damages in prepared material samples (in case of demonstration of ultrasound, eddy-current

and acoustic emission diagnostic methods) or on laboratory devices (vibrodiagnostic method), the same as mentioned simulator is.

Students gain experience in various NDT methods, signal analysis, data acquisition and principles of sensors operation. These experiments bring to students significant improvement engineering skills and imagination in addition to theoretical education.

3.1 Integration of the Vibrodiagnostic Simulator Device into e-Learning Scheme

A meaningful extension of a classic laboratory education by e-learning depends on providing the similar perceptions to remote users like students physically attending a laboratory have. Main these perceptions are:

- visual sensation, students could easily figure out how does device work and what to do for successful manage the laboratory task.
- control and monitoring a device via PC
- data acquisition from sensors
- manipulation with a device.

If e-learning laboratory is useful, these mentioned points will be respected. In case of vibrodiagnostic simulator device, these points were solved by the following way.

3.1.1 Visual Sensation

The visual sensation is assured by a video transmission from IP camera which overlooking motion and state of device to remote user. There is used compact 1.3 megapixel network camera with digital pan-tilt-zoom that enhances viewing and monitoring. It uses 179 degrees wide angle lens to view horizontal and 99 vertical degrees of the actual vision. This cam lets move view around using a smaller viewing window.

There is even possibility to define a preset path, and the camera will cruise along the path you defined. When there is something that catches user attention, this cam allows zoom-in to see the details. It also allows recording at the same time.

3.1.2 Control and Monitoring

The vibrodiagnostic simulator device was made as fully electronically controlled from PC. There arise a solution in the remote desktop which solve remote access to device, thus any changes in design of

existent control unit were not required.

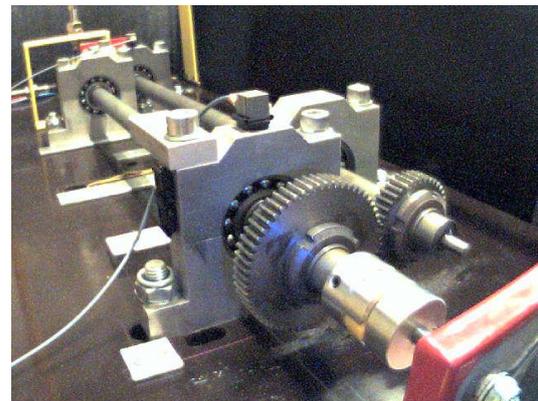


Figure 4: A snapshot from IP camera.

3.1.3 Control and Monitoring

The vibrodiagnostic simulator device was made as fully electronically controlled from PC. There arise a solution in the remote desktop which solve remote access to device, thus any changes in design of existent control unit were not required.

The remote desktop allows a user to log in to a remote system and access the desktop, applications and data on the system as well as control it remotely. However, this is only available in certain Windows editions, but for instance Windows XP and Windows Vista have this system pre-installed. A efficient firewall and regular system are recommended to block unauthorized access.

3.1.4 Data Acquisition

Data acquisition is provided by unit, connected with PC via USB interface, as described in 2.2.2. There is one software environment for control and data acquisition, equipped by GUI (graphical user interface), programmed under Matlab software. A remote user gets access to this application via mentioned remote desktop.

3.1.5 Manipulation with the Device

Generally, according to principle e-learner has not a free hand in manipulation with laboratory devices and must rely on mechanical and software possibilities which are allowed to them.

In the simulator case, manipulation is not allowed even to attending students during laboratory lesson for its complexity. Maintenance and changes in the structure a supervisor does on its own. Therefore the remote user has the same access to the device as an attending student.

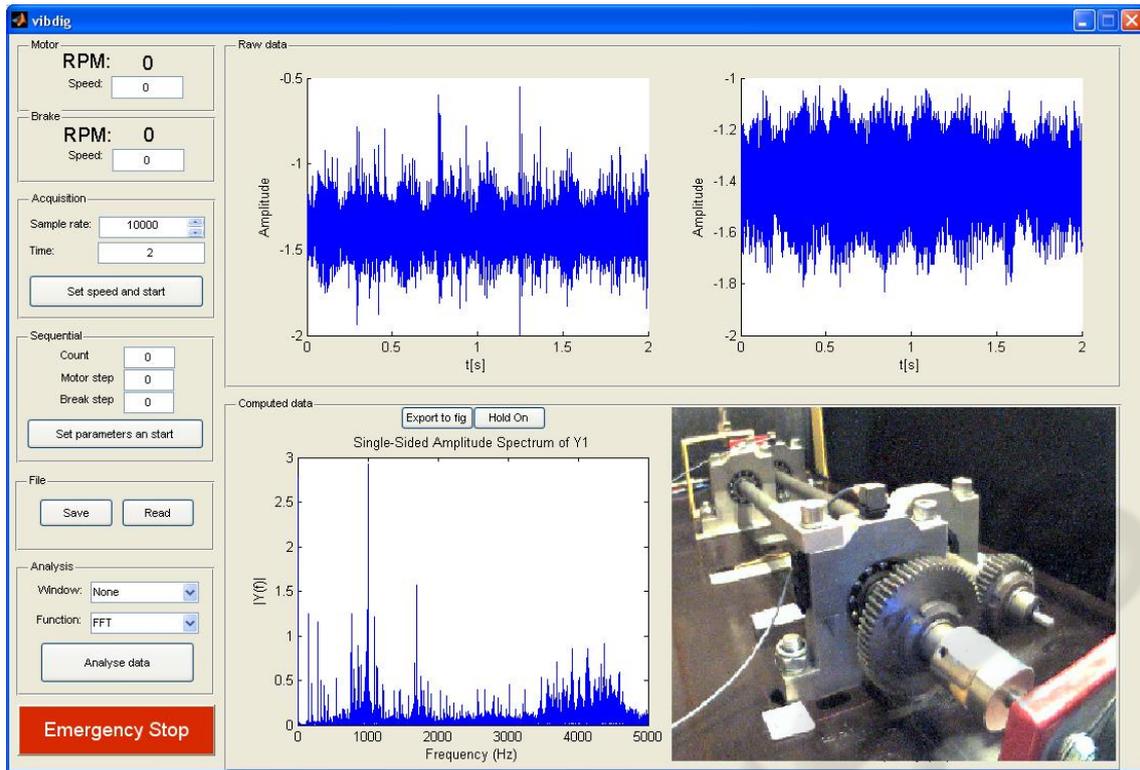


Figure 5: The application screen.

4 FUTURE WORK

The above mentioned approach is applicable for e-learning in this form; however there is still space for an improvement and extension.

Firstly, with the remote desktop only one user can work at the same time and other users have no chance to login to the device. Therefore the next step consists in programming web server application which enables multiuser access. In this scheme a user has access to the web application anytime and entered parameters stay in a line. If the device is free and prepared, it sends measured data back. Furthermore similar concept is used to connect to a device such as a PLC, which are used in machine condition monitoring very often. Both, distance and full-time students see how this technology works.

Secondly, a power-on function in the current version of the device, mainly electronic control unit, is not available, hence a staff must switch it on and check the device for proper function.

Finally, in our NDT laboratory, there is another current research project concerned Wireless Sensor Network systems.

Within this project, the simulator will be equipped with wireless sensor nodes which will

communicate over a gate connected with PC (Fig. 6). There will be nodes for measure:

- Temperature
- Vibration
- RPM

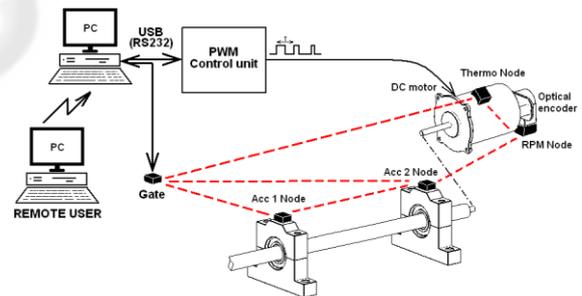


Figure 6: Block diagram of applied WSN on the training device.

This network structure makes possible teaching in next WSN fields in addition to signal analysis of vibrodiagnostic signals:

- New applications of WSN
- Network topology (ad-hoc, mesh)
- Coexistence of various WSN

- Disturbance in WSN
- Implementation of signal pre-processing into nodes

One of the aims of this project is to make the WSN system available to remote users and use it for e-learning in NDT course or create a new course concern WSN only.

5 CONCLUSIONS

In this paper we propose an enhancement of machine condition monitoring education by means of vibrodiagnostic simulator. This instrument adds a real experience with analysis of fault symptoms typical for rotating machinery. The integration of remote accessed simulator with traditional Moodle e-learning system and IP camera gives the teacher a complex tool for effective remote delivering of specialized knowledge in the area of machine condition monitoring.

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