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REAL-TIME REMOTE EXPERIMENT IN HIGH VOLTAGE LAB

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Abstract: A new remote laboratory system is introduced in order to achieve real-time distant operation. Next to the cameras that permit the viewing of the experiment, it is also possible remotely to control the equipment and to get the results. Only requirements are network infrastructure present close to the laboratory, and communication ready equipment with a serial port for example.

1. INTRODUCTION

Web based laboratories are a well-known topic with new solutions appearing every year [1-4].

This paper introduces a new laboratory monitoring system that enables the remote viewing and control of the experiments. Based on Internet protocol, it communicates over any available networks such as Internet and Intranet, making it accessible worldwide.

2. PURPOSE

2.1. Application field

Two applications fields are of interest.

For the university, a remote monitoring laboratory permits that several faculties follow the same experiment over the network.

For the industry, the same monitoring system enables final product evidence testing to several clients.

2.2. Advantages

First advantage of this monitoring system is to have access to a remote laboratory wherever the end user is located.

Also the software control of the equipment over the network enables that no more local crew is required inside the laboratory.

At the university level, same experiment followed by different teachers, assistants and students leads to a homogenization of knowledge as well overall progress. Another point is that there is no more need for each faculty to purchase same expensive equipment, thus leading to a reduction of the costs.

For the industries, remote equipment experiment permits that final client witness product testing over the network without the need to be physically present inside the laboratory.

The whole test is saved in digital format with cameras for evidence and future viewing. Results of the experiment are saved in digital format as well, and can be used easily later on with common programs such as MS Excel.

3. SYSTEM PRESENTATION

Own developed monitoring system is in charge of generation, acquisition and communication in the remote laboratory. It consists of an industrial motherboard with memory and solid-state disk shown in Figure 1.

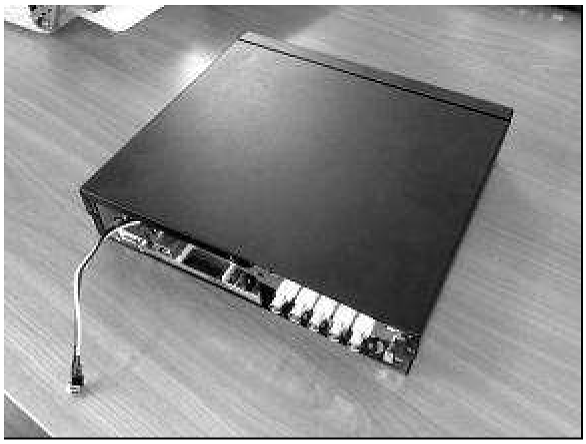

Figure 1: Monitoring system controller and acquisition card.

Whole system is fanless and without any mechanical parts such as hard drives in order to reduce the risk of system failure.

3.1. Generation part

The controller of the monitoring system is connected with the generation equipment toward USB or RS232 ports. This link enables the transmission of the generation parameters from the user software to the equipment. Typical parameters sent are the amplitude and frequency of the generated shape.

3.2. Acquisition part

One or more acquisitions cards are connected to the controller over PCI bus or USB port. Depending of the experiment, different device is used based on

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parameters such as number of analog input channels needed, speed and amplitude.

Next to the acquisition card, current transformers, voltage probes and attenuators are selected according to the test objectives.

3.3. Communication part

The monitoring system is connected to two networks:

The local one, where it is connected with the cameras and laboratory equipment.

This network can be Ethernet based, where all of them are connected by LAN cable to the controller. Another option is wireless where the controller acts as an access point. In that case both of the cameras and equipment shall support this type of communication, with the usage of bridges such as LAN to wireless or serial to wireless converters. Also PowerLine Carrier, or communication over electrical wires is possible.

The external one where the monitoring system connects itself to the Intranet/Internet, thus allowing the clients to access it all over the network.

Also toward this primary connection to the outside the monitoring system allows other devices connected locally to be accessed by the clients. Indeed a client can view the cameras only through the monitoring system's main connection, which behaves as a router between the external and local network (Figure 2). Then any computer connected to Intranet/Internet with appropriate software can connect to the monitoring system and the cameras behind it.

3.4. Cameras

Internet protocol cameras enable the remove viewing of the experiment.

The Pan-Tilt-Zoom (PTZ) feature of the camera offers the possibility to move it in order to view a larger area inside the laboratory (Figure 3).

The optical zooming capability permits a detailed viewing of the experiment, even at distance. Therefore hazardous testing can be realised as well.

Figure 3: Pan-Tilt-Zoom Internet protocol camera.

3.5. Software

Software is installed on any computer running Microsoft Windows operating system. This client application operates the monitoring system. It is charge of the following tasks:

- Cameras viewing, moving and video recording.
- Generation and acquisition parameters sending to the laboratory equipment.
- Reception and display of resulting shapes acquired by the monitoring system.
- Exportation of the results to standard formats such as MS Excel for later display and edition.

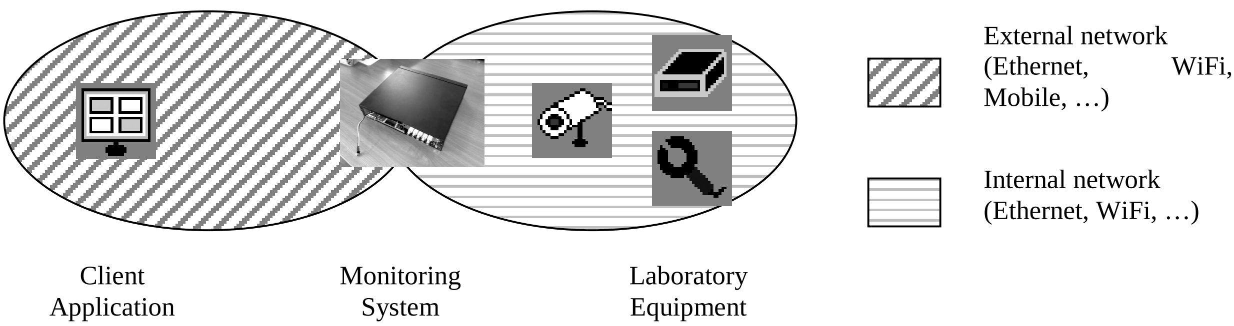

Figure 2: Network architecture of the system.

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4. OPERATION DESCRIPTION

4.1. Requirements for existing laboratory

In order to equip an existing laboratory, following requirements must be fulfilled.

4.1.1. Communication ready equipment

Ideally with an Internet protocol network port such as Ethernet or wireless. USB is also an option but requires the connection to the controller for the parameters transmission. Otherwise serial port is fine since it can be converted to a network one with a serial to Ethernet bridge.

4.1.2. Network infrastructure

Ethernet port present to connect the controller to the Intranet or Internet. Wireless access point is also an option.

If none of the above is available, mobile communication is also possible in order to connect the laboratory system to the outside world. A card supporting GPRS/EDGE/3G/HSPA protocols connects the monitoring system to a telecom base station and allows its control over the network.

Rest of the equipment has access to this connection toward the main controller, which acts as a router.

However for proper operation of the monitoring system, chosen network has to meet bandwidth requirements. Since one camera with medium quality consumes 256 kbits/s, an upload speed of 300 kbits/s and more is required for correct transmission of video and acquisition results. Therefore in the case of mobile communication only the HSPA protocol is of interest for remote laboratory operation.

4.2. Working principle

The laboratory is equipped with the monitoring system, as well some cameras. An authorised user can control both of them with adequate software in order to realise the experiment. This client application is installed on any computer supporting Microsoft Windows operating system, and communicates with the monitoring system towards any available Internet protocol network.

Software user sends the generation parameters to the generator equipment, such as amplitude of the impulse. Also the acquisition parameters are defined such as trigger levels or input voltage range. Once ready, user can fire the impulse command.

During the whole process, the cameras enable the remote viewing of the experiment in order to make sure that it is proceeding correctly. Also the user can decide to save this video on the computer for future viewing (Figure 4).

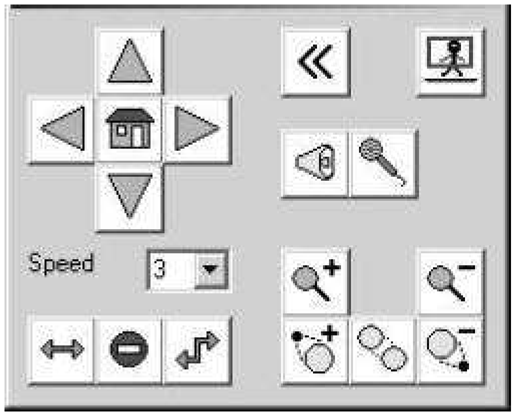

Figure 4: Client application window for the Internet protocol camera operation.

The acquisition card starts to acquire data in the controller's memory based on the trigger criteria. The resulting shape is saved on the solid-state drive of the monitoring system, ready to be sent to the client application. Over the available network the controller sends to the software the acquired results.

Finally user has the possibility to display the received shapes and analyse them. They can be exported to standard formats, as well the camera video.

5. REMOTE EXPERIMENT

A remote experiment is realised in order to demonstrate the monitoring system capabilities.

5.1. Equipment used

Following equipment is used in this experiment:

- Monitoring system with a PCI acquisition card
- Haefely Ecompact 4 impulse generator
- Current transformer
- PTZ Camera

Their main characteristics are given in the tables below.

Table 1: Acquisition card main characteristics.

Parameter	Value
Analog input channels number	4
Maximum acquisition speed	20 Megasamples/second/channel
Vertical resolution	12 bits
Absolute maximum voltage input	15 Volts

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Table 2: Haefely Ecompact 4 main characteristics.

Parameter	Value
Maximum surge impulse voltage Maximum surge impulse current	4.2 kV 2.1 kA

Table 3: Current transformer main characteristics.

Parameter	Value
Maximum input current Output ratio	20 kA 0.025 Volts/Amp

Table 4: PTZ Camera main characteristics.

Parameter	Value
Pan Tilt Optical zoom	270 degrees 90 degrees 10 times

5.2. Test setup

Proposed experiment is the generation of a fast transient similar to the lightning current shape shown in Figure 5. Haefely Ecompact 4 produces so called 8/20 us impulse, with amplitude of 1 kA.

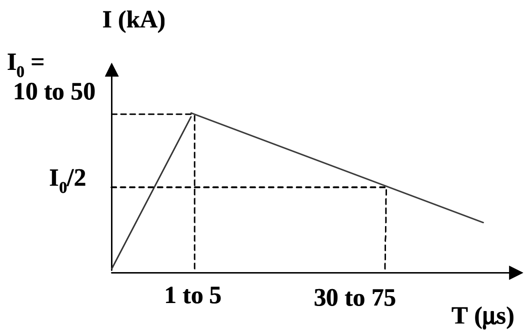

Figure 5: Typical lightning current shape.

The generated shape has a rise time of 8 us, during which its amplitude changes from 0 amp to 1 kA. Then during the next 20 us the value of the current falls to half the peak value, from 1 kA to 500 A.

A current transformer is used in order to acquire the generated impulse shape. Chosen model has an output ratio of 0.025 volts per amp, which means that the impulse peak of 1 kA produces 25 Volts at the coil output.

However the acquisition card has an absolute maximum voltage input of 15 volts, thus the generated shape may destruct it. Therefore a voltage divider is used at the current transformer output. Its attenuation ratio is 10/1, which means that the acquisition card measures 2.5 volts when 1 kA is applied through the coil.

This experiment demonstrates the acquisition of fast transients having a short duration and high amplitude (Figure 6). In order to acquire it high speed data acquisition is required. Sampling frequency of 10 MHz is used, meaning that the card acquires 10 data points in 1 us. This acquisition speed is more than sufficient for this type of transient application, since the rise time of the lightning impulse has a typical duration of few microseconds.

Client application sends to the monitoring system the following parameters:

At the generation level (Haefely Ecompact 4):

- Peak voltage value of 2 kV. This value corresponds to 1 kA at the current level.
- Number of impulses: 1

At the acquisition level:

- Input channels: 1
- Acquisition speed: 10 Megasamples/s/channel
- Input range: -5 to +5 volts
- Trigger level: -/+ 100 mV

With the chosen trigger level and speed, the 8/20 us generated impulse with 1 kA peak will for sure meet the trigger criteria since the voltage at the acquisition card input will be higher than 100 millivolts.

Monitoring system starts the acquisition process and waits for the software command to generate the impulse. If the trigger criteria are met, client application receives the information of the successful acquisition.

5.3. Results

Once the monitoring system has acquired the resulting shape, it sends it back to the remote laboratory user. Impulse shape is received by the client software connected to it, and displayed on its screen (Figure 7).

Then remote laboratory user has the possibility to realise another experiment by sending new generation and acquisition parameters to the monitoring system.

6. CONCLUSION

A new monitoring system is presented enabling remote laboratory operation. Experiment is realised in real-time and at distance over Internet protocol based networks. Software user operates it with own computer. This new system is a step toward a fully automated laboratory.

Applications of interest are industrial company remote equipment evidence test for the clients, teaching courses for multiple classrooms and schools. Main advantages are the reduction of the costs, rationalization of the equipment, evidence of the test saved in digital format for future viewing.

7. ACKNOWLEDGMENTS

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8. REFERENCES

[1] S.H. Chen, R. Chen, V. Ramakrishnan, S.Y. Hu, Y. Zhuang, C.C. Ko, Ben M. Chen "Development of Remote Laboratory Experimentation through Internet", Proceedings of the 1999 IEEE Hong Kong Symposium on Robotics and Control, Hong Kong, pp. 756-760, July 1999.
[2] H. Benmohamed, A. Leleve, P. Prevot "Remote laboratories: new technology and standard based architecture", 2004 International Conference on Information and Communication Technologies: From Theory to Applications, Damas, Syria.
[3] T. Zimmer, M. Billaud, D. Geoffroy "A remote laboratory for electrical engineering education", IMCL2006 Conference - April 19 -21, 2006 Amman, Jordan.
[4] C. Buiu, N. Moanta "Using Web services for Designing a Remote Laboratory for Motion Control of Mobile Robots", Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2008.

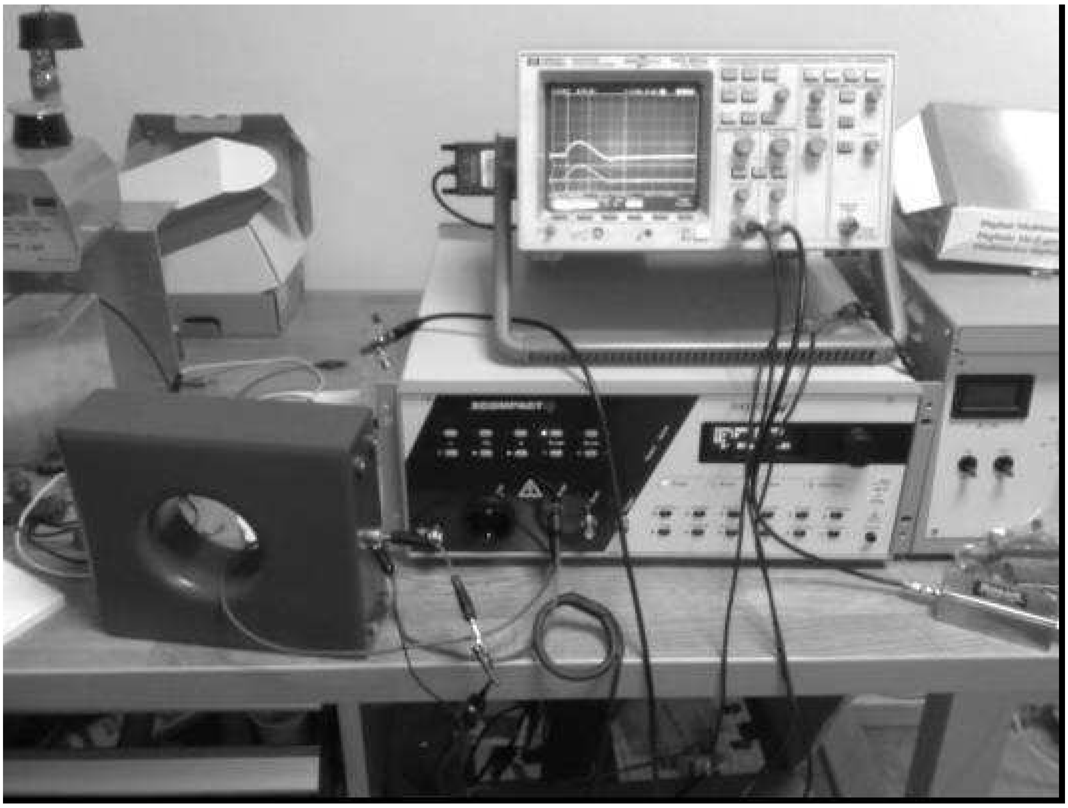

Figure 6: View of the experimental setup with impulse generator and current transformer.

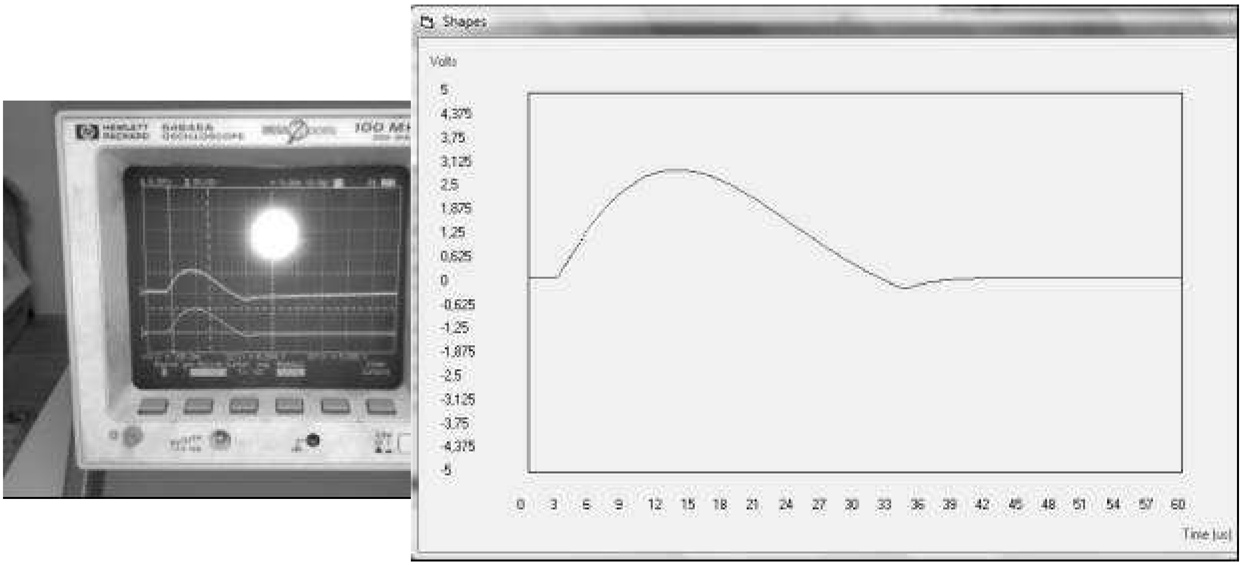

Figure 7: Generated shape in laboratory (left) and received by client application (right).