Open source data acquisition system for visual electrophysiology

Béla Török, Department of Ophthalmology, KSSG, St. Gallen, Switzerland

Purpose:

1. To develop a PC-based data acquisition system for ERG, PERG, EOG and VEP measurements.
2. Construction of a video stimulator from standard PC components..

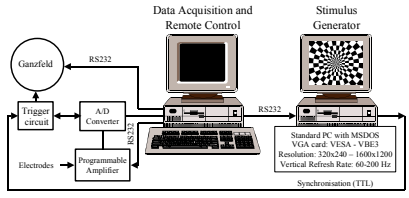
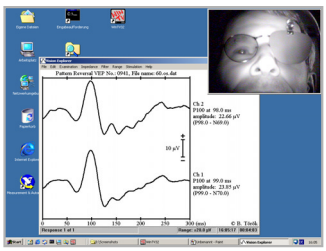


Fig. 1 Schematic diagram of the system. A standard PC running the Windows operating system is used for data acquisition. The programmable amplifier, Ganzfeld and video Stimulator are controlled using standard RS232interfaces. The video stimulator is a standard PC with a VESA VBE3-compatible VGA card. For an optimal synchronization between the data acquisition system and multiple stimulators (up to 4) a simple trigger circuit consisting of 4 integrated circuits was developed.

Methods:

Data acquisition: a software program running under different versions of the Windows operating system (95 - XP) was developed using the C language (Microsoft Visual C). Analog signals were digitized with a 12-bit A/D converter card (PCI-6023E, National Instruments, USA). External devices like programmable amplifier, Ganzfeld stimulator, video stimulator and photometer were controlled through RS232 lines. Due to the limitations of the trigger circuit of the A/D converter cards a simple four channel trigger circuit was developed. Images of the electrophysiological signals can be transferred to other applications using the clipboard. Measurement data can also be exported to other applications as comma or tab delimited text files. Peak time and amplitude of the signals are calculated automatically. Manual measurements using the mouse are also possible. Digital filtering of the recorded signals can be activated using a simple graphical user interface. An adjustable bandpass filter based on the Fourier transformation or 3-15 point smoothing can be activated. Different parameters of data acquisition and external devices can be controlled by simple intuitive dialogs.

Video stimulator: An inexpensive personal computer-based video stimulator consisting of standard PC components (motherboard, CPU, RAM, VGA-card) was developed for VEP and PERG measurements. Most of the parameters, e.g., stimulus type, stimulation timing, screen resolution (320x240 – 1600x1200), fixation point size and color, vertical refresh rate (60-150 Hz) are programmable. The current version of the software supports luminance, pattern reversal and pattern onset/offset stimulation. Checkerboard, vertical and horizontal bar, windmill and dartboard patterns are available. The printer port of the PC is used as synchronization output.



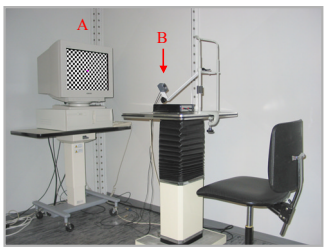


Fig. 2 Screenshot during VEP measurements (left image). Fixation of the subject is controlled in a window (upper right corner) showing the live video image of the head of the subject. Video stimulator (A) and video camera with built-in infrared (LED) illumination

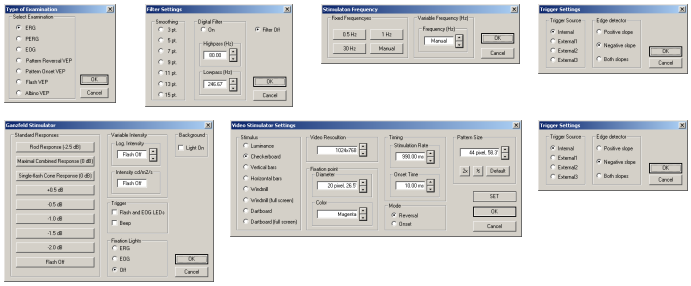


Fig. 3 Parameters of data acquisition and stimulation are controlled with simple dialogs. Due to the modular design of the software existing dialogs can be modified and new dialog can be added without difficulties.

Results:

The program supports ERG, PERG, EOG and VEP measurements with pattern reversal, pattern onset-offset, and luminance stimulation. Recording of albino VEPs is also possible. All of the measurements were developed according the ISCEV ERG, VEP and PERG standards. Images of the recorded signals can be transferred to other Windows applications (Word, PowerPoint, Photoshop, etc.) with the copy and paste commands. Measurement data can also be exported to comma or tab delimited text or enhanced metafiles. Since the program works like other Windows applications, most of the functions can be controlled with simple menus and dialogs.

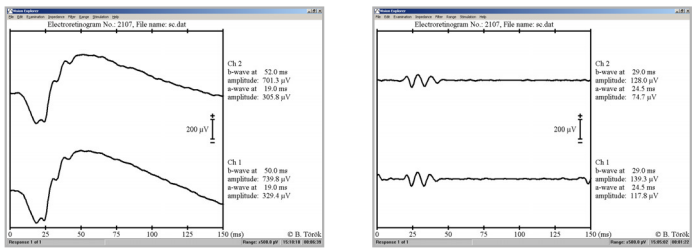


Fig. 4 Electroretinography. Scotopic maximal response recorded according ISCEV ERG standard with a Henkes contact lens electrode (left). Oscillator potentials extracted from the scotopic maximal response with 80-250 Hz digital bandpass filter. Ch1 → left eye, Ch2 → right eye.

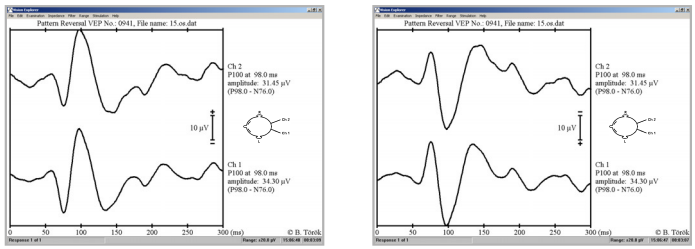


Fig. 5 Pattern reversal visual evoked potentials (VEP). VEP of a normal subject recorded with 15' checkerboard (left). The same signal can also be plotted with inverted polarity (right side). Ch1 represents the activity of the left and Ch2 the right hemisphere.

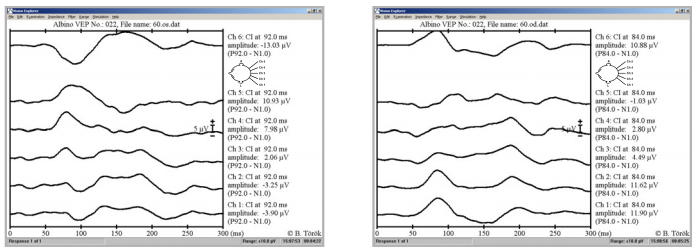


Fig. 6 Pattern onset visual cortical potentials of a subject with ocular albinism. Averaged responses recorded with monocular stimulation of the left eye (left) and the right eye (right). Electrode placement Ch1-Ch5: see upper right part of the figure. Ch 6 is the side difference calculated with the formula: Ch6 = ((Ch1 + Ch2) – (Ch4 + Ch5)) / 2. The polarity change of the calculated side difference (Ch6) shows the lateralization.

Conclusions:

A data acquisition system consisting of standard hardware and software components could be developed for ERG, EOG, PERG and VEP measurements at a fraction of the price of a commercial one. Thanks to the modular design, additional hardware, e.g., A/D converter card, amplifier, stimulator, etc. can be supported by writing only one ore two functions. Since the source code is available, the programs can be improved without difficulties.

Availability:

In case of interest the source code of the programs will be available free of charge under the GNU GPL license: http://www.gnu.org/licenses/licenses.html#GPL.

Co-developers are welcome! Requirements for the data acquisition program: knowledge of the C language (Visual C, Microsoft) & Windows programming, requirements for the video stimulator: knowledge of the C language (Microsoft C for DOS V7.0) & DOS programming.

Béla Török M.D., Ph.D., Department of Ophthalmology, KSSG, 9007 St. Gallen, Switzerland

bela.torok@kssg.ch, bela@torok.info, www.torok.info