AUTOMATIC CALIBRATION OF THE GANZFELD STIMULATOR

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Introduction:
Reliable ERG measurements can not be performed without periodic calibration of the Ganzfeld stimulator (1). Manual calibration of programmable stimulators can be very time-consuming and inaccurate. All parameters of a programmable Ganzfeld stimulator, e.g., stimulus strength, uniformity of the stimuli, filter attenuation and background luminance can be measured automatically. The large amount of accurate measurements required to calibrate a programmable Ganzfeld stimulator can only be done using a computer-controlled measurement method.
Nicolet sells it's Ganzfeld stimulator as a calibrated system. A previous study (2) has shown, that the calibration of the flash intensity in the factory is inaccurate. This is also my personal experience. Due to multiple constructional errors, it is impossible to calibrate the background intensity of the GS2000 Ganzfeld stimulator. Most of the problems with the GS2000 Ganzfeld stimulator can be fixed by modification of the hardware and using software programs controlling stimulation parameters.
Results of the calibration measurements of the Nicolet GS2000 system were compared to those of a Grass PS22 stimulator.

Methods:
A GS2000 programmable Ganzfeld stimulator (Nicolet Biomedical Systems, Madison, USA) and a PS22-based Ganzfeld stimulator (Grass Instruments, Quincy, USA) were used for stimulus generation. Stimulus and background intensity was measured with an IL1700 radiometer/photometer (International Light, Newburyport, USA). The Nicolet GS2000 was controlled over a RS232 interface of a personal computer (Fig 1).

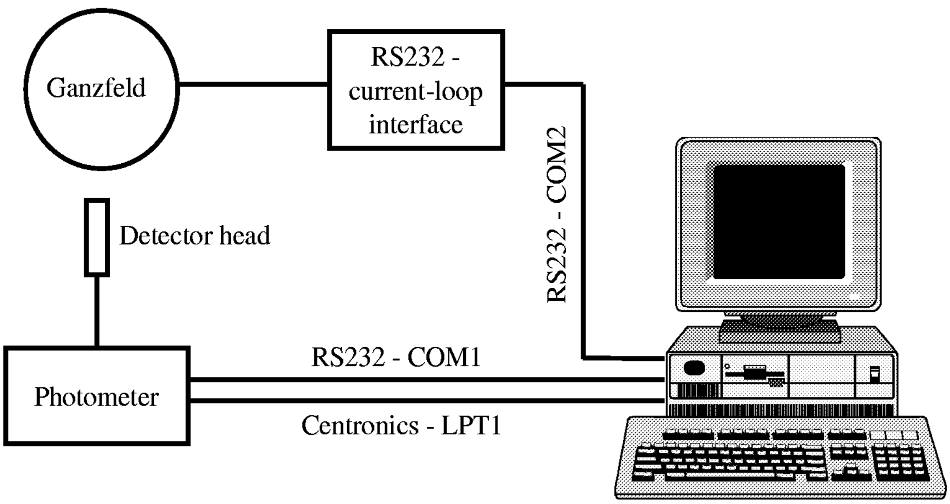

Figure 1. Automatic calibration of the Nicolet GS2000 Ganzfeld stimulator. Except of the stimulator only a photometer and a personal computer is required for the measurements. Stimulus and background intensity settings and filter postioning were controlled by a PC over a RS232 line (COM2) using a simple interface circuitry (Fig. 2). The photometer was connected to the PC over an RS232 (COM1) interface. Measurement modes (start, stop, integrate, hold) were controlled by the line printer interface.

Since the GS2000 has a proprietary current-loop interface, it was necessary to develop a simple RS232-current-loop converter (Fig. 2). Low-level driver software was developed using the C-language (based on a Pascal code developed by Michael Bach).

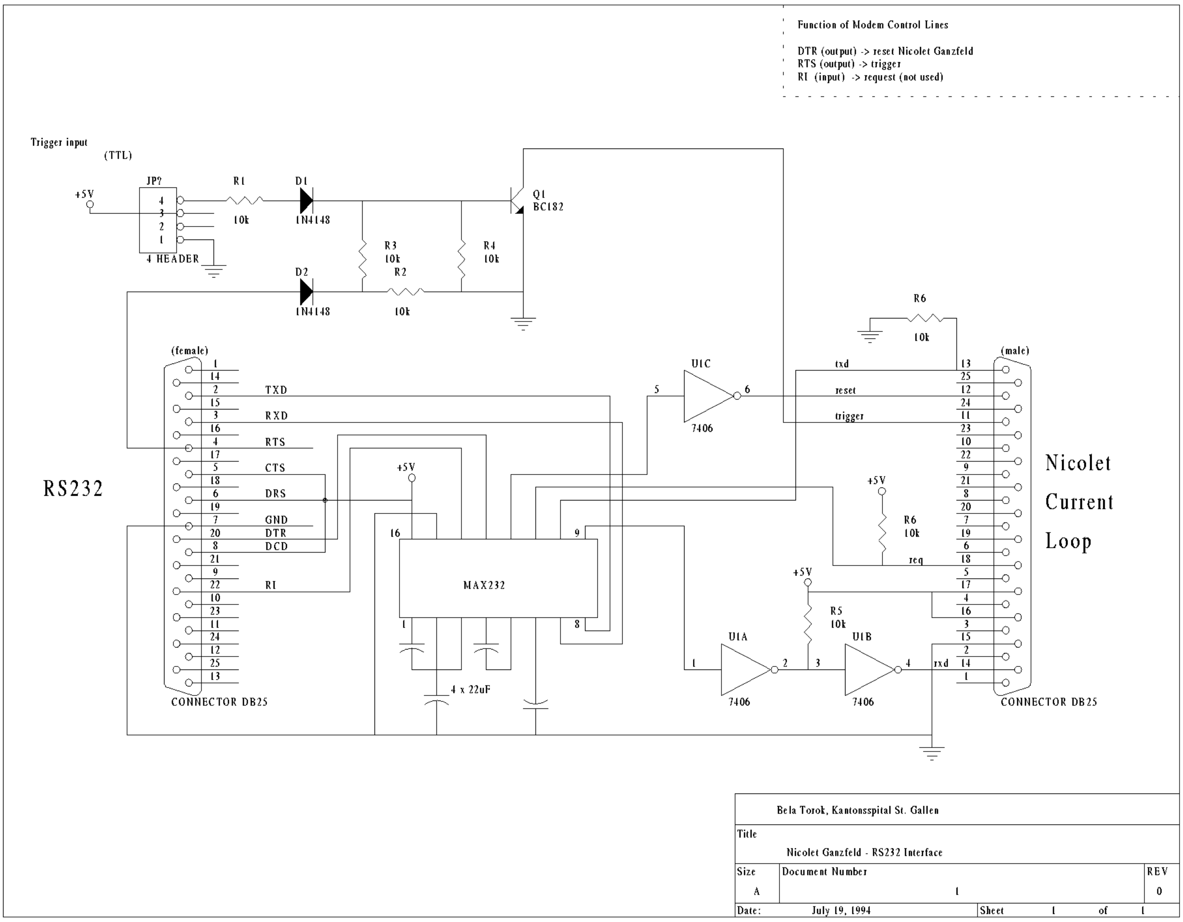

Figure 2. Circuit diagram of the RS232 – Nicolet current-loop interface.

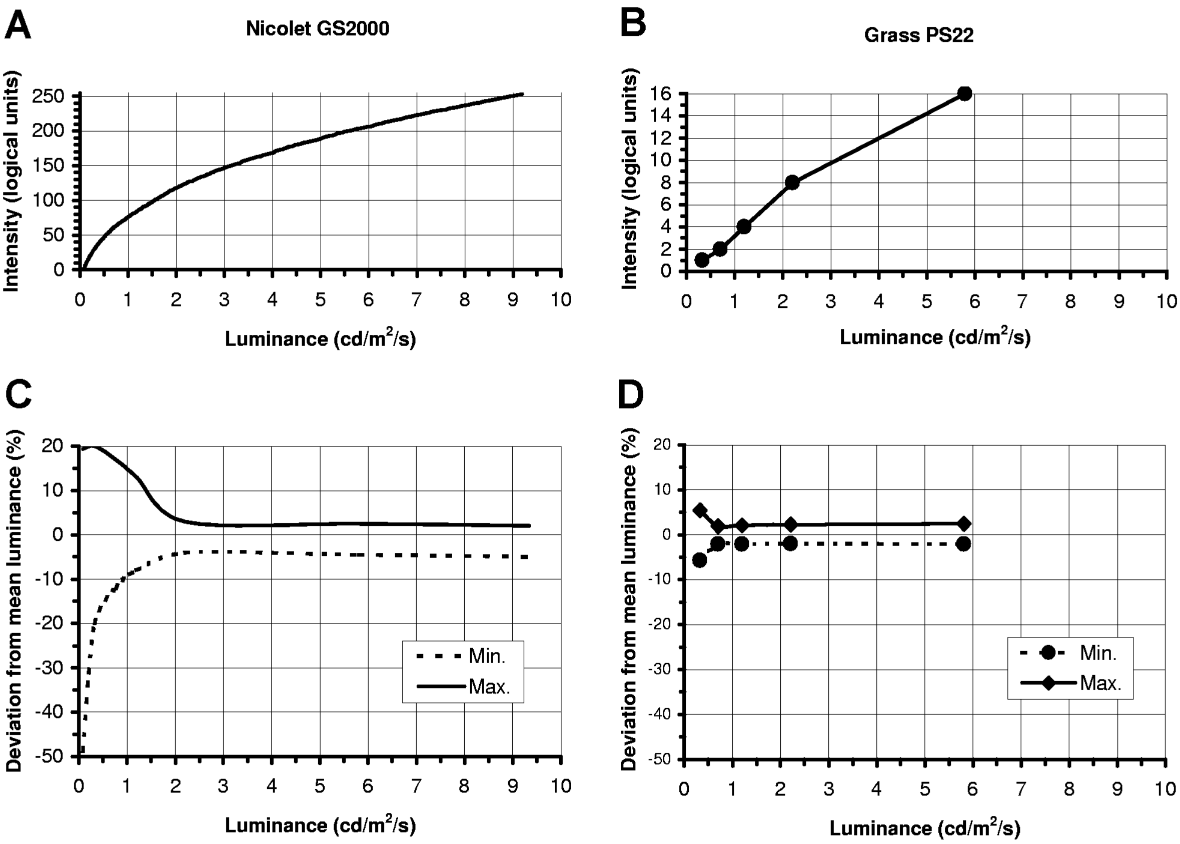

Figure 3. Flash intensity measured at all programmable intesity levels (without filters) of the Nicolet GS2000 stimulator (A) and the Grass PS22 photostimulator (B). Maximal and minimal deviation from the mean intensity in % of the Nicolet (C) and the Grass photostimulator (D).

A computer program was developed for the automatic measurement of flash luminance on all (255) intensity levels of the GS2000 stimulator. Mean luminance, maximal and minimal deviation from the mean of multiple flashes were calculated at all programmable intensity levels. Filter attenuation of the 6 selectable filters was also calculated automatically. The results of flash intensity and filter attenuation measurements were stored on files (Fig. 4).
Based on the measurements of the calibration programs, a software program can adjust background and flash intensity adjustments. This program is used to set stimulus parameters during clinical testing.

Results:
Automatic calibration of the programmable GS2000 Ganzfeld stimulator can be done in about 3 hours. The deviation from the mean luminance of the flashes of the GS2000 stimulator is high (> ± 5%) at the lower 40% of the range and cannot be used for clinical measurements (Fig. 3). The Grass PS22 shows more stable responses at comparable low intensity levels, than the GS2000. To adjust flash intensity the GS2000 uses a programmable voltage generator (256 steps) and a single 2µF capacitor, the PS22 uses constant voltage and five different capacitors. The cause of the inaccuracy in the lower 40% range (300-770 V) of the GS2000 is an unstable discharge in the Xenon arch tube due to relatively low voltage.
This problem can be fixed with a proper selection of neutral density filter and voltage. To minimize the standard deviation of the stimuli, I developed an algorithm for an optimal adjustment of voltage and filter setting. The algorithm uses only the upper 60% of the adjustable voltage range. Different intensities are adjusted using a voltage + filter setting. For an accurate flash intensity adjustment a filter stepping <= 0.8 Log unit required. (E.g., 0, 0.8, 1.6, 2.4 & 3.6 Log units). Due to poor optical shielding, filters with higher attenuation than 3.6 Log unit is not recommended.

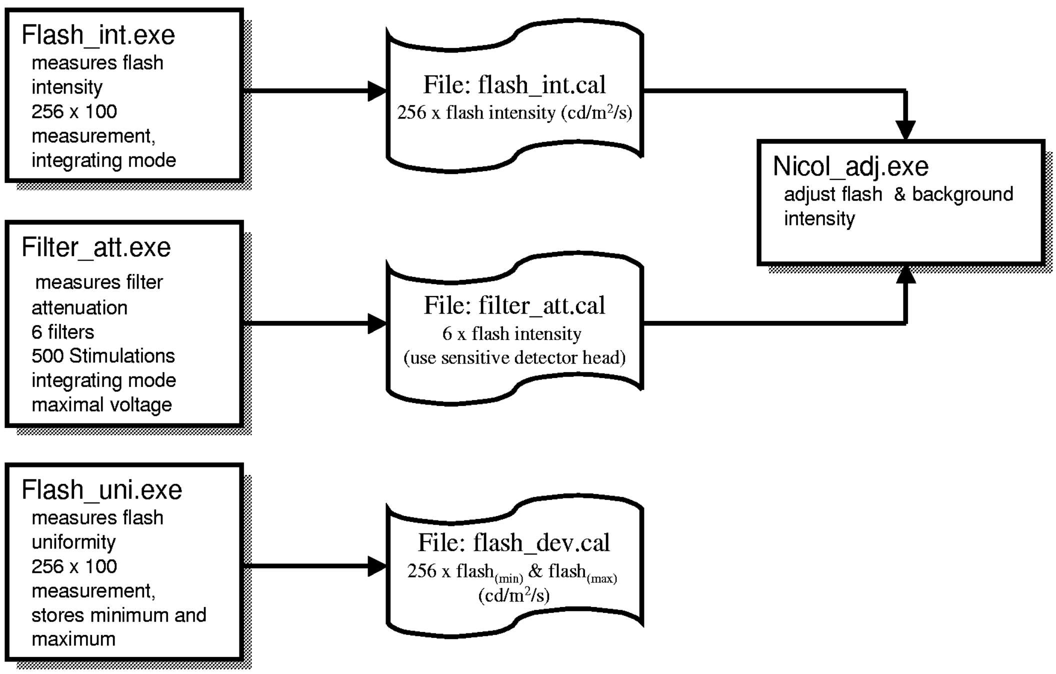

Figure 4. Structure of the programs necessary for the calibration (left hand side) and for the intensity adjustment (right hand side) of the GS2000 Ganzfeld stimulator. Three programs are necessary for the stimulus intensity calibration. The first one measures the stimulus intensity at all programmable flash intensity levels. The second one measures the attenuation of the neutral density filters in the filter slide tray, and the third one measures the minimal and maximal deviation from the mean intensity. The results of the measurements are stored in three files. The program for stimulus intensity adjustments uses the files generated by the calibration programs. A call "`nicol_adj 2.25 25`" will adjust s the flash intensity to 2.25 cd/m^2/s and the background intensity to 25 cd/m^2.

Conclusions:

1. Computer controlled calibration is more accurate, faster and provides much more information, than the conventional approach.

2. The Nicolet GS2000 has serious constructional errors. To fix these problems following steps should be taken:

- attach optical shielding at the right side of the flash-tube assembly
- the background illumination circuitry must be completely rebuild (from constant current to constant voltage mode)
- modify electronic switches of the background illumination
- flash intensity should be adjusted using a suitable combination of voltage and neutral density filter setting:
  - use as high voltage as possible (use only intensities above 100, upper 60% of the range)
  - use neutral density filters with attenuation stepping not larger than 0.8 Log unit

3. Use the software programs presented in this communication, or develop your own programs to calibrate and adjust the Nicolet GS2000 stimulator (requires an interface circuitry – Fig. 2).

Literature:

1. Marmor M.F.: An updated standard for clinical electrophysiology. Arch. Ohthalmol., 113, 1375-1376 (1995)

2. Mäkelä K., Hölttä V., Jääskeläinen S., Könönen M., Jousmäki V.: Inter-hospital comparison of Ganzfeld ERG photostimulators. Electroenceph. Clin. Neurophysiol. 100, 273-274 (1996)

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