Calibration device for ERG, PERG, mfERG, EOG and VEP recording equipment

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Purpose:

Developing a simple calibration methor for ERG, PERG, mfERG, EOG and VEP measurements.

Methods:

A simple microprocessor-controlled triggerable signal generator was developed producing sinusoidal transients comparable to the main components of the ERG, PERG, mfERG and VEP responses.

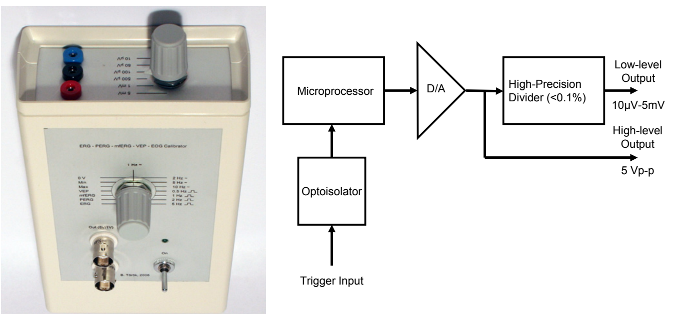

Fig. 1 The Calibrator is a battery-powered microprocessor-controlled signal generator. The operating mode and the output voltage can be selected with the switches on the top and the front side of the unit.

Generated Signals:

Transient Modes (triggerable):

ERG: a-Wave (25 ms) and b-Wave (50 ms)
PERG: N35 (35 ms) and P50 (50 ms)
mfERG: N1 (15 ms) and P1 (30 ms)
VEP: N75 (75 ms) and P100 (100 ms)

Continouos (free-running) Modes:

Mxn: Maximal Nominal Voltage (DC)
Min: Minimal Nominal Voltage (DC)
Baseline: 0 V
Sinussoidal Wave: 1 Hz, 2 Hz, 5 Hz, 10 Hz
Square Wave: 0.5 Hz, 1 Hz, 2 Hz, 5 Hz and 10 Hz

Technical data:

Output Voltage: Nominal Voltage ± ≤ 0.5%
Frequency: Nominal frequency ± ≤ 100 ppm
Time delay (in transient modes): ≤ 0.1 ms

Possible Measurements:

Voltage Calibration
Time delay measurements
Judgement of phase linearity

Calibration of Amplification System

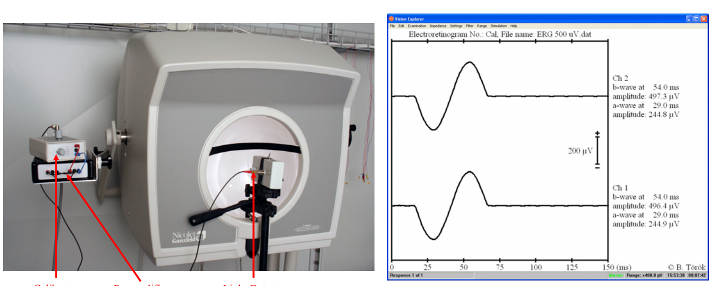

Fig. 2 Calibration of the ERG recording equipment. A light detector triggers the calibration device. The low level signals generated by the calibration device are connected to the inputs of the preamplifier. The sinusoidal transient signal is identified by the recording software as a- and b-Waves. Since voltage and time delay of the generated signals are known (a-Wave 250 µV @ 25 ms and b-Wave 500 µV @ 50 ms), the calibration of the amplification and the calculation of the time shift (4 ms)of the a- and b-Waves can be done without making additional measurements.

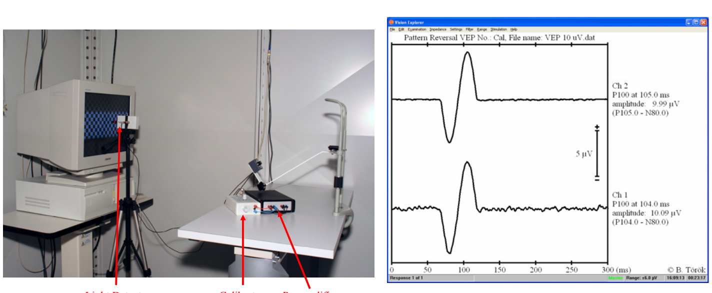

Fig. 3 Calibration of the VEP recording equipment. A light detector placed in the middle of a checkerboard stimulator triggers the calibration device. The low level signals generated by the calibration device are connected to the inputs of the preamplifier. The sinusoidal transient signal is identified by the recording software as N75 and P100 Waves. Since voltage and time delay of the generated signals are known (N75 5 µV @ 75 ms and P100 10 µV @ 100 ms), the calibration of the amplification and the calculation of the time shift (5 ms) of signal can be done without making additional measurements.

Phase-Delay Measurement

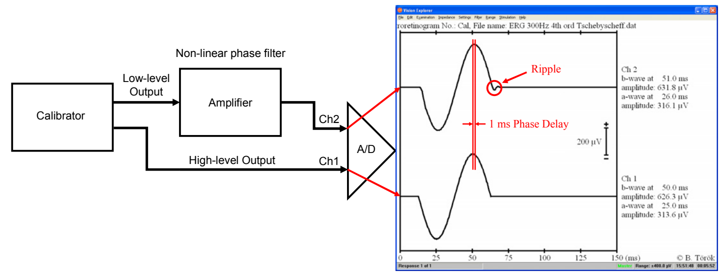

Fig. 5 Phase delay measurement of a 4th-order Tschebyscheff 300 Hz low-pass filter. The lower trace shows the signal coming from the high-level output of the signal generator, the upper trace shows the response coming from the output of the amplifier.

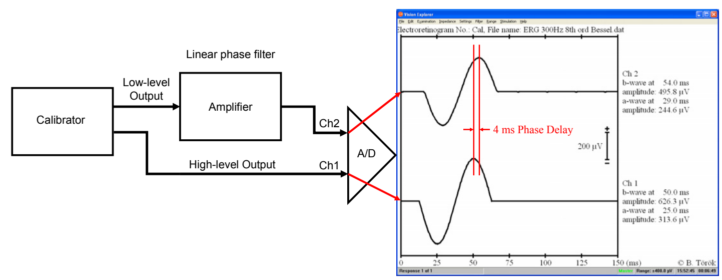

Fig. 6 Phase delay measurement of a 8th-order Bessel 300 Hz low-pass filter. The lower trace shows the signal coming from the high-level output of the signal generator, the upper trace shows the response coming from the output of the amplifier.

Judgement of Phase-Linearity

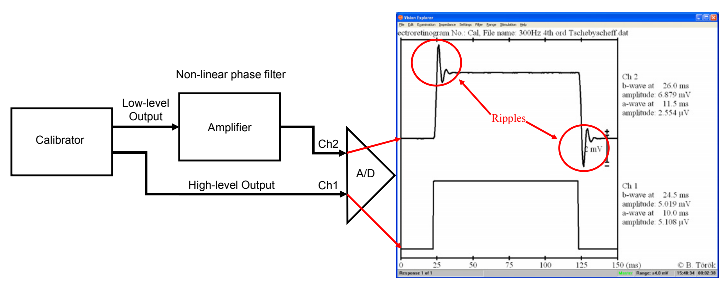

Fig. 7 Phase linearity measurement of a 4th-order Tschebyscheff 300 Hz low-pass filter. The lower trace shows the signal coming from the high-level output of the signal generator, the upper trace shows the response coming from the output of the amplifier. According to the non linear nature of this filter, ripples are generated on the rising and falling edges of the square wave. Non-linear phase low-pass filters (e.g., Tshebyscheff) have a variable group delay especially near the corner frequency providing a poor square-wave transmission behavior. Since the time delay of different frequency components of a given signal is not constant, unpredictable results can occur during the measurements of the peak times of high frequency components of transient signals (e.g., oscillatory potentials).

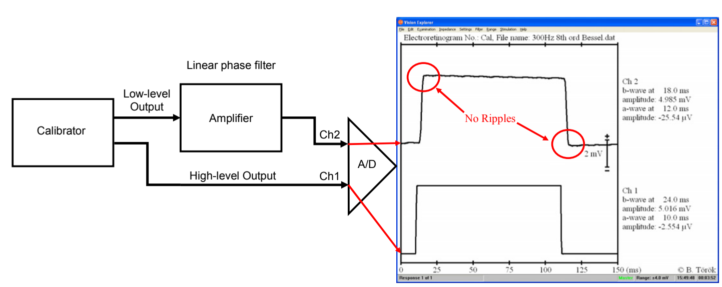

Fig. 8 Phase linearity measurement of a 8th-order Bessel 300 Hz low-pass filter. The lower trace shows the signal coming from the high-level output of the signal generator, the upper trace shows the response coming from the output of the amplifier. No ripples are visible on the rising and falling edges of the square wave. Linear phase low-pass filters (e.g., Bessel) have a constant group delay over a wide frequency range providing an optimal square-wave transmission behavior.

Results & Conclusions:

However basic information on calibration of the recording equipment is documented in the current version of the ISCEV "Guidelines for calibration of stimulus and recording parameters used in clinical electrophysiology of vision", several important issues, e.g., phase-delay and phase linearity, are still not discussed. The vast majority of the laboratories are probably even unable to do the recommended procedure due to the lack of suitable equipment. The device presented here solves this problem; calibration of the recording equipment can be done accurately without experience in electronics.

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