Technical support for ciliary apparatus diagnostics

Dušan Koniar[1], Libor Hargaš[1], Miroslav Hrianka[1], Anna Simonová[1]
Peter Ďurdík[2], Marta Jošková[2], Peter Bánovčin[2]

[1)] Faculty of Electrical Engineering, University of Zilina, Zilina
[2)] Jessenius Faculty of Medicine in Martin, Comenius University in Bratislava

Research projects co-financed by European Union - Centre of Experimental and Clinical Respirology and Measurement of Respiratory Epithelium Cilium Kinematics between Jessenius Medical Faculty of Medicine in Martin, Comenius University in Bratislava (Slovakia) and University of Zilina (Slovakia) focus on modern diagnostic methods in the area of respirology.

Cilium in respiratory apparatus is beating with frequencies in range to 30 Hz. Following Shannon-Kotelnik theorem for sampling, we must use high speed imaging for proper frequency analysis of cilium motion. Generally each imaging with frame ratio bigger than 30 fps is called high speed imaging. Microscopic objects investigated by light microscopy cannot be equipped with standard cinematic sensors, so high speed camera with some powerful tools for signal processing "become non-contact test-device, analogous to oscilloscopes".
In the case of high speed imaging and light microscopy – suitable illumination and its parameters are key elements for generating and acquiring good images.
The first, exposition time for high speed camera is often too short and the intensity of illumination source inversely depends on sensor exposition time:

$$I \sim \frac{1}{\Delta T_{EXP}} \sim \mathrm{FPS}$$

where ΔT_{EXP} is a time 1/FPS (frame rate) decreased by the time of reading the digital image from C-MOS sensor.

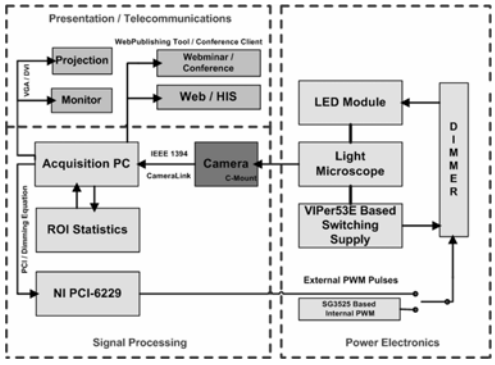
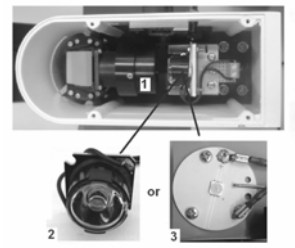


Figure 1. A design of high speed imaging workstation with light microscope

ILLUMINATION SOURCES

Main condition in illumination unit design for high speed imaging is to concentrate high optical flow to relative small area (part of specimen). This condition can be achieved by using LED module with collimator. LED or another illumination unit is placed into microscope condenser Fig. 2 – (1), where the light cone is conditioned for optimal specimen lighting (intensity maximum is focused on object).
In design were used PG1N-3LWC-SD module (3 W) Fig. 2 – (2)for slower rates (up to 100 fps with Allied Vision AVT Marlin F046-B camera). Second LED module was Pro-Light PFM6M-18LXP-6SC (17 W) Fig.2 – (3) for higher rates (> 100 fps with Basler A504kc camera).



Parameter	PG1N-3LWC-SD	PFM6M-18LXP-6SC
I_{nom}	700 mA	800 mA
I_{max}	1 A	1 A
U_f	3,5 V	23 V
Opt. flow	110 lm	750 lm
Angle	30°	160°
Color temp.	5500 K	5500 K

Figure 2. Illumination units for high speed imaging and their main parameters

ILLUMINATION REGULATOR

Optimal parameters of acquired images and video sequences depend on correct configuration of acquisition hardware and light conditions. In case of ultra high frame ratio of camera we can meet these essential problems: if the illumination of specimen is too low, frames in video sequence are underexposed and dark; if the illumination of specimen is too high, frames are overexposed and too bright. The main goal of regulation algorithm is to distribute image intensities around centre of histogram.

ACKNOWLEDGMENT

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Automatic intensity regulation uses image features (histogram statistics) for computing optimal duty cycle of external control PWM signal with frequency 55 kHz. This PWM signal is generated in LabVIEW I/O PCI card NI PCI-6229 (or USB NI MyDAQ card). Internal PWM signal for manual illumination control is generated with SG3225 (Fig. 3).

Signal part of regulator (dimmer) is isolated by optocoupler from LED module. Current limiter (current source) limits maximal switching MOSFET drain pulse current for LED. All the parts are supplied with AC/DC Flyback (Fig. 5).

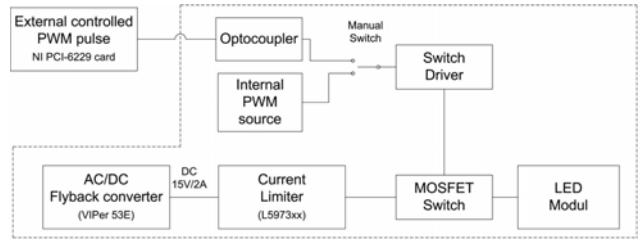


Figure 3. Block diagram of manual / automatic LED intensity regulation for 3W module

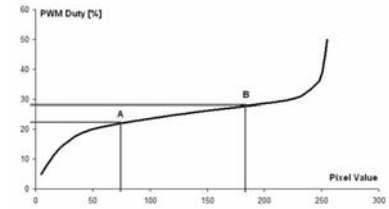


Figure 4. Illumination characteristics for 60 fps framing (calibration / testing mode)

Optimal μ_0 corresponds with $d.c_0$ = 25%. Acceptable duty cycles lies in range 20-30% (Fig. 4), all duty cycles under or over this interval brings under or overexposed image

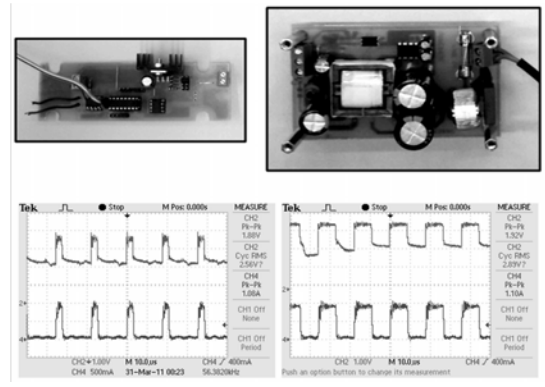
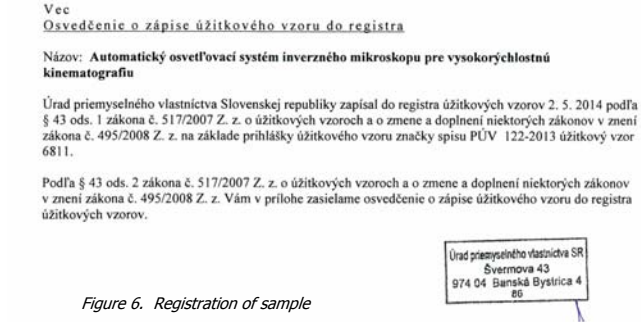


Figure 5. Dimming board, Flyback supply and two impulse drain currents, measured power illumination characteristics



Vec
Osvedčenie o zápise úžitkového vzoru do registra

Názov: **Automatický osvetľovací systém inverzného mikroskopu pre vysokorýchlostnú kinematografiu**

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Úrad priemyselného vlastníctva SR
Švermova 43
974 04 Banská Bystrica 4
86

Figure 6. Registration of sample

E-mail contact: dusan.koniar@fel.uniza.sk