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Automatization of light-technical measurements

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1. Introduction

We are dealing with development of hardware and software which is used in measurements in our light-technical laboratory. We are using standard measuring devices with serial interface RS232. Digital multi meter PeakTech 4380 made by company METEX for electrical measurements, Radiolux 111 made by PRC-Krochmann and LX-105 made by LUTRON as “luminous sensors” for light-measurements, and web camera for visual measurements. Measurement is controlled by software (which is installed on personal computer) which controls our devices (actuators) and collect (compile and save too) measured data. This software is made for school measuring needs. Like the example for students. In second part we are writing about development of automated goniophotometer realized in our laboratory. Realization is based on results of development and it is running under software introduced at beginning of abstract. In last part we had describe created workplace for measuring of light sources life period. We had tested these light sources for different out effect during the life period. Specifically for this out-effect: voltage overload, fat mess on the light bulbs and switching of light sources.

2. Development of software for multi meters and Light meters

Measuring devices:

- Digital light meter LUTRON LX – 105
- Digital multi meter METEX PeakTech 4380
- Digital light meter PRC RadioLux 111 Krochmann

2.1 Digital light meter LUTRON LX – 105

Fig.2.1: Digital light meter LUTRON LX – 105

2.1.1 Connection

Connection PC with light meter is from computer side made by serial port. From light meter side is made by Jack connector 3,5mm. Signal wire is from connector connected to PIN #2 in 9 PIN ports, which is used for reading. Ground wire is connected to PIN #5 in 9 PIN port.

2.1.2 Reading

After start device starts to send 16 digit strings. In this string is coded information about measurement. Transfer rate is 9 600 baud per second. Sting carry 8 bits, 1 stop bit and none parity bit. Read sting is saved at buffer, from which is later decoded.

2.2 Digital multimeter METEX PeakTech 4380

Fig.2.2: Digital multi meter METEX PeakTech 4380

2.2.1 Connection

Connection between computer and digital multi meter is from PC side made by serial port RS232. Serial port can by 9 PIN or 25 PIN. From multi meter side is connection made by connector which you can see at the figure.

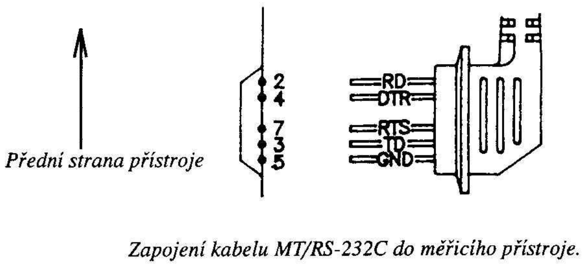

Fig.2.3: Connector for Digital multi meter METEX PeakTech 4380

2.2.2 Reading

For start sending data it is necessary to setup RST request to send. After that multi meter automatically starts to send 14 digit strings. Transfer rate is 1200 Baud per second. Difference to the other devices is that this digital multi meter has 7 data bits, 2 stop bits and none parity bit. Read sting is saved at buffer, from which is later decoded.

Datový formát se skládá ze 14 bytů a vypadá následovně:

BYTE)	1	2	3	4	5	6	7	8	9	A	B	C	D	E
Př. 1)	D	C		-	3	.	9	9	9		V			CR
Př. 1)	O	H			3	.	9	9	9	M	o	h	m	CR

Fig.2.4: Data string for Digital multi meter METEX PeakTech 4380

2.3 Digital light meter PRC RadioLux 111 Krochmann

Fig.2.5: Digital light meter PRC RadioLux 111 Krochmann

2.3.1 Connection

Connection between PC and digital light meter PRC Radiolux 111 Krochmann is made from computer side by serial port RS232. Serial port is 9 PIN. From light meter side is made by special connector with three wires. Send data, receive data and ground.

2.3.2 Reading

Light meter communicate with transfer rate 9600 baud and carry 8 data bits, 1 stop bit and none parity bit. Main difference is that if I want to receive measured data first I have to send request. Request can be sent for measurement, back light, help or information.

A	-	Automatic mod
B	-	Backlight
C	-	Current calibration
H	-	Help
I	-	Information
M	-	Measure
S	-	Sensor calibration
V	-	Version software
1	-	Detection of device
2	-	save calibration to EPROM
3	-	Test internal EPROM
7	-	Shut down device

Tab.2.1: Table of key word for Digital light meter PRC RadioLux 111 Krochmann

2.4 Connection measure devices thru USB

For individual access to each device I had to transform each connection to USB. It is impossible to change old devices for USB directly. That's the reason why I am using adapters for transformation from serial port → USB port. Or parallel port → USB port.

Fig.2.6: Components for USB connection

2.5 Program Light Master

The software Light Master is helping tools for making basic light technical measurements. Software is programmed for systems Windows 98/ME/XP. It is full compatible with minimal hardware requests. This software contains from three main windows. The first is Main table with measured data. The second is Display with real time measured data and last one is real time changing chart.

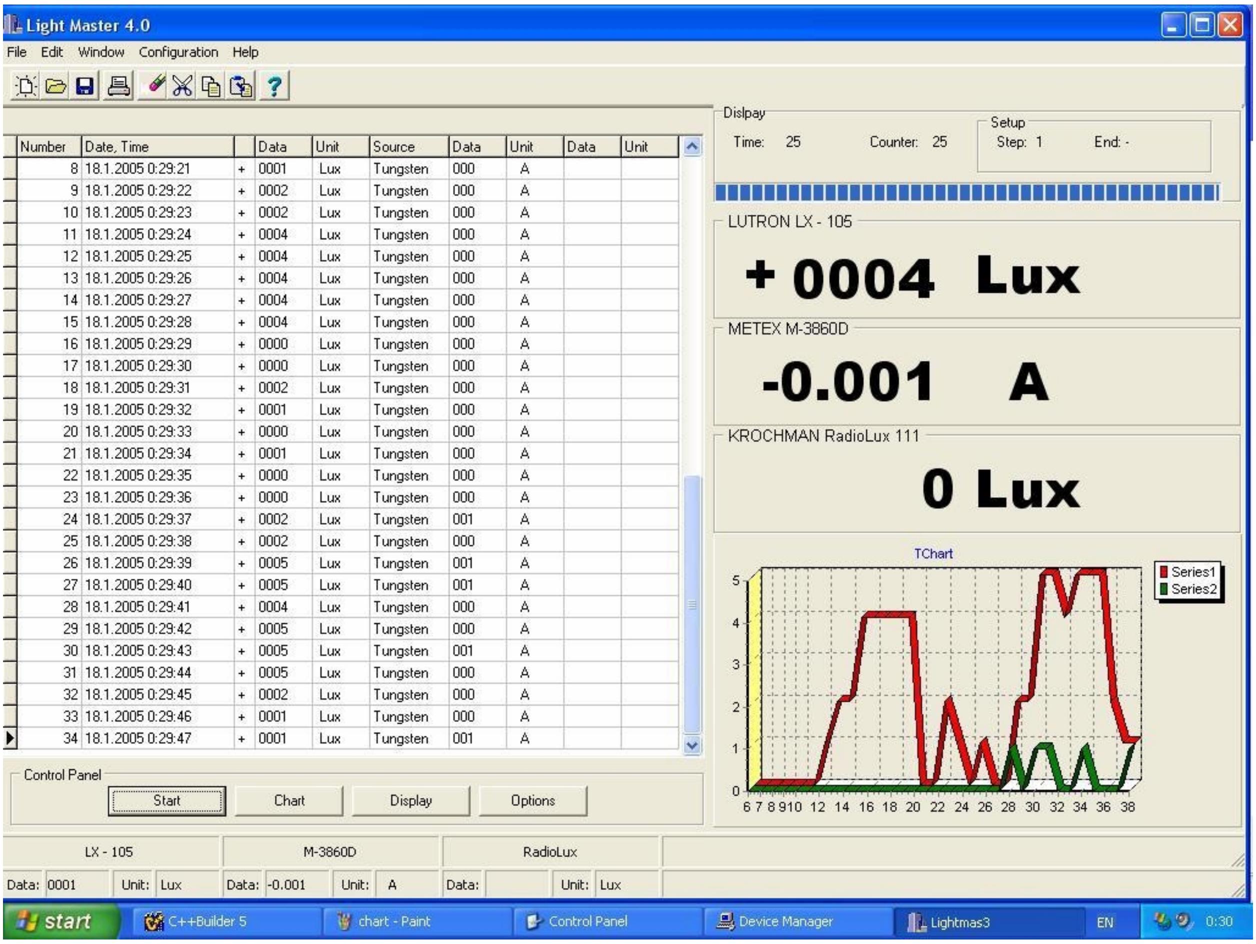

Fig.2.7: Software Light Master

2.5.1 Main menu

Light Master is programmed user friendly and with basis Microsoft layout. It is showed in menu, where are File, Edit, Window, Configuration and help. Each of them has their own roll down menus. For example File has: New, Open, Save, Save as, Print, Print setup and Exit. You can see menu on figure.

Fig.2.8: Main menu

2.5.2 Configurations

On the configuration it is possible to setup connection of the measuring devices. It is possible to setup Port, Baud rate and control of the bits. In the Options is also possible to setup length of measurement, step time, language and chart type and basic chart settings.

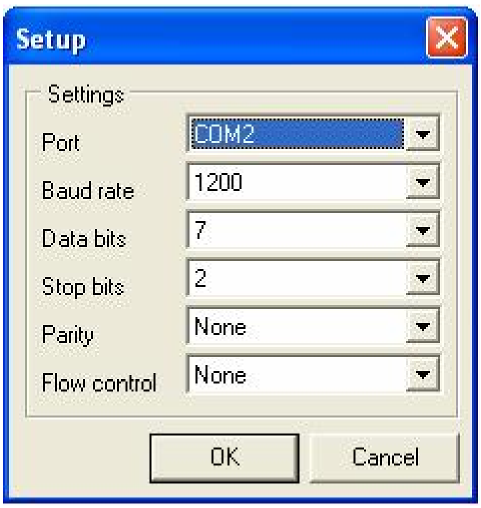

Fig.2.9: Setup of the connection

In the chart options it is possible to choose one of six types. Also is possible to adjust rotation, elevation and 3D level if is 3D chart selected.

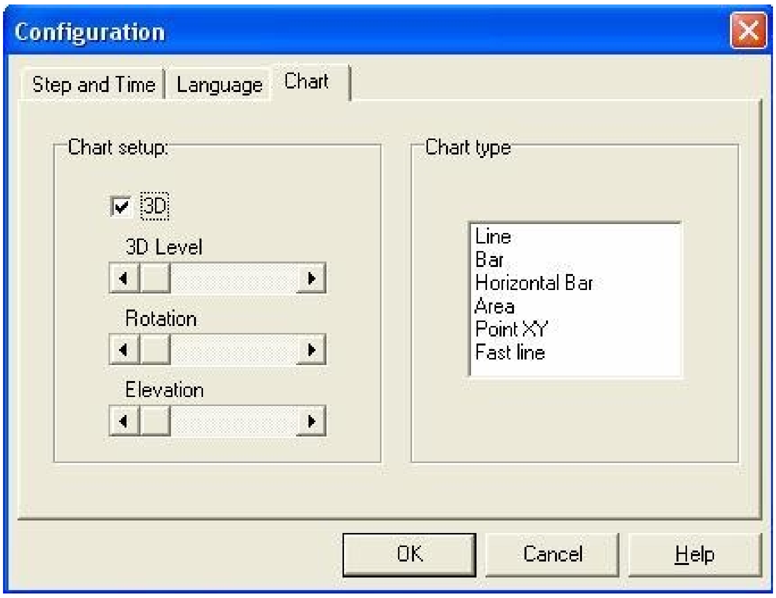

Fig.2.10: Chart setup

2.5.3 Fast access

For easy and fast access there is a tray icon close to windows clocks. It has its own icon which can be, the light bulb ON or OFF. That means measuring is on or off. If is clicked on icon there will be menu with simple control of the software. Fast access is on the figures bellow.

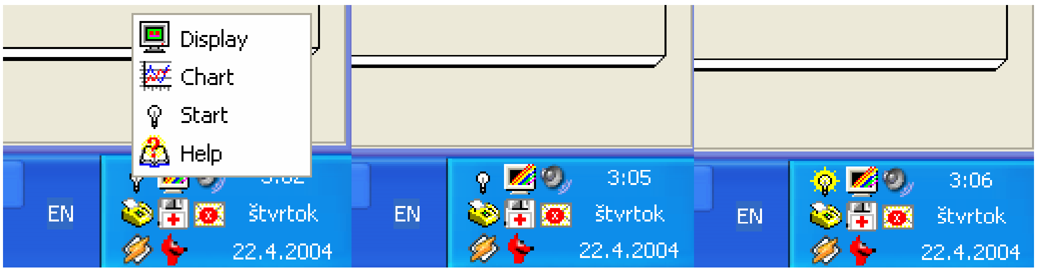

Fig.2.11: Fast access icons: Menu, measure OFF and ON

3. Development of goniophotometer

Luminous intensity distribution is one of the most important parameters of luminaries. Its measurement is time-consuming and exigent for precision – it is useful to automate it. If automated measurements are required, standards for measurement procedures have to be implemented.

Luminous intensity distribution curve is a curve that one can imagine as a line formed by luminous intensity end-point vectors lying in the same plane (types of coordinating systems identified by the CIE and labeled as A-, B- and C-planes). The C-plane system is to be considered as the recommended standard system. C-planes are bounded with angles C_x ranged $0° \leq C_x < 360°$. Within a plane, directions are given by the angle γ in the range $0° \leq \gamma < 180°$. The direction $\gamma = 0°$ is oriented toward the nadir. The resolution of the angular measurement shall be 0.1° or less. The angular deviation for the correlation of the luminaire axes to the rotation axes shall be 0.5° or less in all measurement positions. The luminous intensities emitted by a light source in different directions (deriving the luminous intensity I_α from the measured illuminance E_α as $I_\alpha = E_\alpha \cdot r^2$ where r is measurement distance) are measured with a goniophotometer and shall be expressed for luminaries usually in units of candela per 1 000 lumens ($I_{\alpha 1000} = [I_\alpha/\phi] \cdot 1000$) and for lamps in candelas.

For luminous intensity measurements according to the inverse square law the measurement distance shall be at least 5 times the maximum dimension of the luminaire light emitting area. However, for luminaries with distributions significantly different from a cosine the above ratio will give rise to errors in excess of 1 %. For such luminaries a measurement distance ratio in excess of 10: 1 may be needed. The minimum measuring distance for a floodlight is a function of the focal length f of the reflector, the radius of the reflector aperture and the diameter s of the smallest element of the light source (arc stream or filament). The point at this minimum distance is called the "beam cross over" point and is the location where the optic is seen to be completely flashed. Only at distances greater than this does the inverse-square law apply. The distance D_{min} to the "beam cross-over" point can be calculated by the formula (1).

$$D_{\min} = \frac{a^2}{4f} \cdot \left(1 + \frac{2a}{s}\right) + \frac{2af}{s} \qquad (1)$$

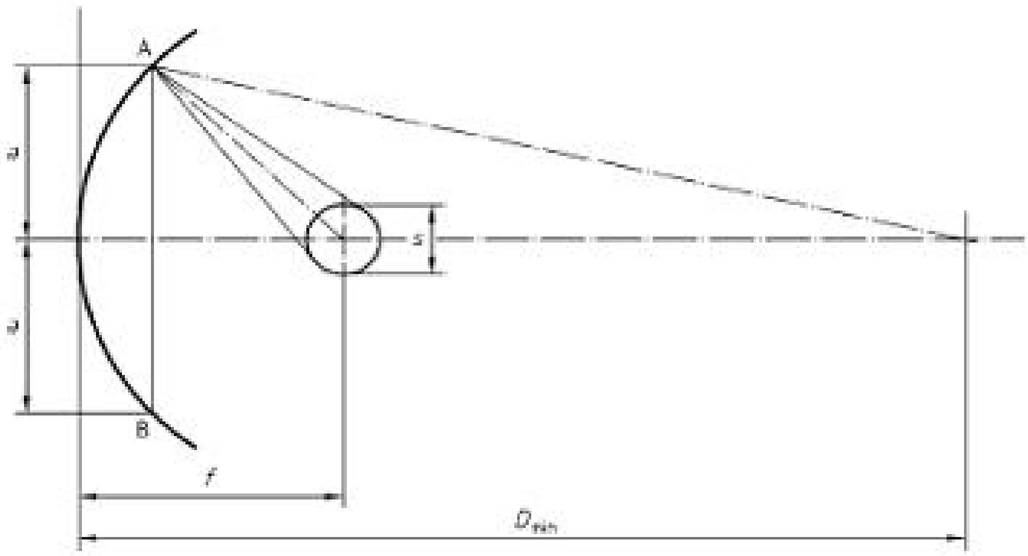

Fig.3.1: Meaning of variables in (1)

Measurements of luminous intensity distributions are usually made with goniophotometers. Usually one of two principles is used – Photometric distance law (measurement of illuminance at a distance exceeding the limiting photometric distance) - Luminance integration (measurement of local luminance distribution on the luminaries surface within the limiting photometric distance).

Development of an automated goniophotometer is an interdisciplinary task. Different problems must be solved such as mechanical construction, drives, electrical-units and software for hardware (microprocessor) and control-PC. Optimal solution is a matter of research, which is compromise between quality (resulting parameters shall conform the requirements of standards) and price of this device. Mentioned problems are described in following paragraphs.

3.1 Selection of the type of goniophotometer

The main types of goniophotometers are described in the standard [1]. Each of the four types (described above – excluding the luminance integration type due to its higher price) different requirements and limitations are applied. Required photometric distance (PD) between the light source and photometer is dependant on the dimension of the luminaire light emitting area – so if measurements of light sources with higher measures are to be performed, PD may exceed 15 meters or yet more. For measurements of big light sources the lighting laboratory should have appropriate space, but for type1 goniophotometer a tunnel with length equal to PD plus technological dimensions can be used. This leads to conclusion that Lighting Laboratory located at the STU FEI, only the type 1 goniophotometer is acceptable. All mechanical simulations of mechanical construction that were the subject of design process have been discussed with Department of Mechanical Engineering at the STU FEI.

Our case of goniophotometer is Type1 (by [1]) – The light source is rotated around a vertical as well as horizontal axis. The photometer head is in a fixed position (see fig.3.2). Type 1 goniophotometer is only applicable for those light sources, which can be operated in any orientation and whose relative luminous intensity distribution does not change with burning position. Measurements of light sources with luminous flux dependent on burning position are allowed. If the operating orientation differs from the standard burning position, a correction of the measured data is necessary. Correction factor can be determined by means of auxiliary photometer, as long as its photometer head does not change direction and distance to the light source during movement, so that changes of the luminous flux by a change of burning position result in a proportional photo current.

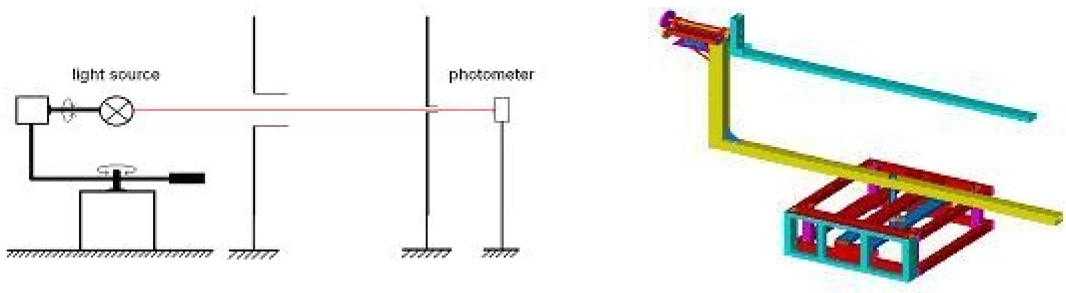

Fig.3.2: Type of goniophotometer - the light source is rotated, photometer head is fixed

Goniophotometers type1 require that the influence of temperature through position changing or luminaire movement shall be compensated by an auxiliary detector or other means.

3.2 Selection of the drive

The goniophotometer device requires two motors with gearbox for the role of drives. Endless screw driven gearbox without a clearance can be used – because after the motor stops its rotation, output angle of gearbox should not change its value. Each device must have a feedback for check of the real position angle with accuracy of angle reading more than 0.1°. DC motor can be used (they are relative low-cost and easy-to-control), possibly supplied with PWM (Pulse Wave Modulation) or alternatively a DC regulator with active brake. Feedback can be realized e.g. as incremental position protractor. Pulses from protractor give the required angle to be set for the drive and this required angle is given from the control-PC from which its value is received. The device then transmits a status word back to control-PC after required angle is reached. The best position for reading of angle is at output of the gearbox because mechanical inertia of goniophotometer's construction can cause an oscillation. Supply unit (regulator) of motor need to be controlled by a different electronic circuit - for example via communication channel COM or USB port of the control-PC or via a multiplex communication device. Block diagram of drive configuration is depicted on fig. 3.3.

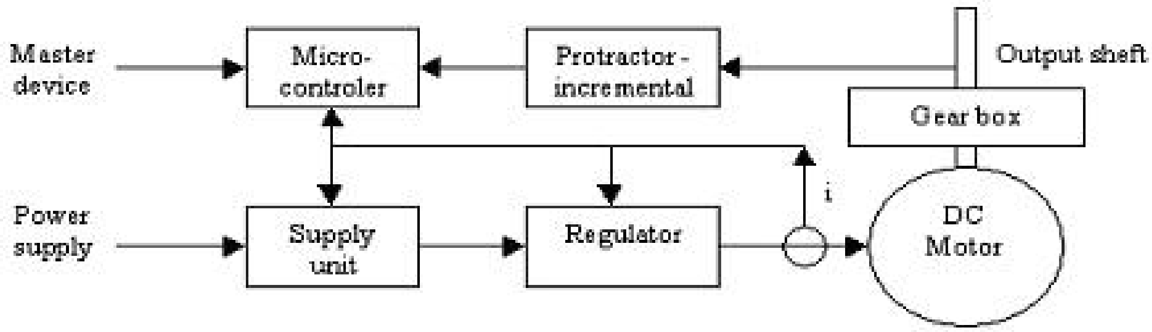

Fig.3.3: The block diagram of drive configuration

3.3 Development of communication and control electronic circuits

Goniophotometer drives and other instruments which are used for measurements of luminous intensity distribution (illuminance meters, voltmeters, ampermeters, wattmeters, thermometers, humidity-meters, atmospheric pressure meters, harmonic analyzers, power supply unit for light sources etc.) need to have possibility to transmit data via any communication channel (COM, USB or other) with control-PC (master device). Via such channels devices are able to send measured data towards the control-PC and master device in return can set parameters for connected slave devices. For example, such parameters can result in change of the range of luminance meter, voltmeter, ampermeter, thermometer etc., output voltage on power supply unit for light sources or set-up values for other devices which can increase the measurement precision in any way – e.g. HVAC system and so on. It is useful to connect all the mentioned devices to one special device which establishes connection of selected device (bidirectional multiplex) to the control-PC depending on a status-word receive from the control-PC. This device should be placed in the same room as goniophotometer and control-PC can be then installed in another room from which monitoring of measurement (visualization) can be performed. Block diagram of communication device is on fig.3.4.

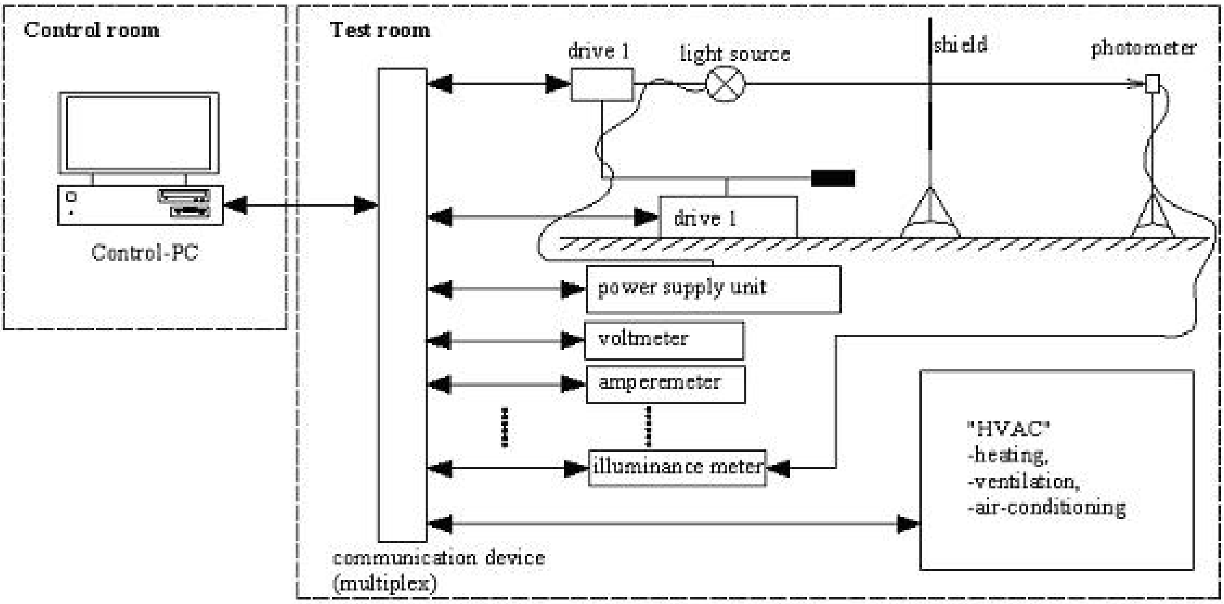

Fig.3.4: Block diagram of measurement configuration

3.4 Development of software for hardware and control-PC

Organic part of the automatization system of a goniophotometer is software. Software for hardware is subject to development – i.e. program for microcontrollers of drives and program for the control-PC.

Flow chart of program for microcontrollers of drives is depicted on fig.3.5 and flow chart of program for the control-PC is given on fig.3.6.

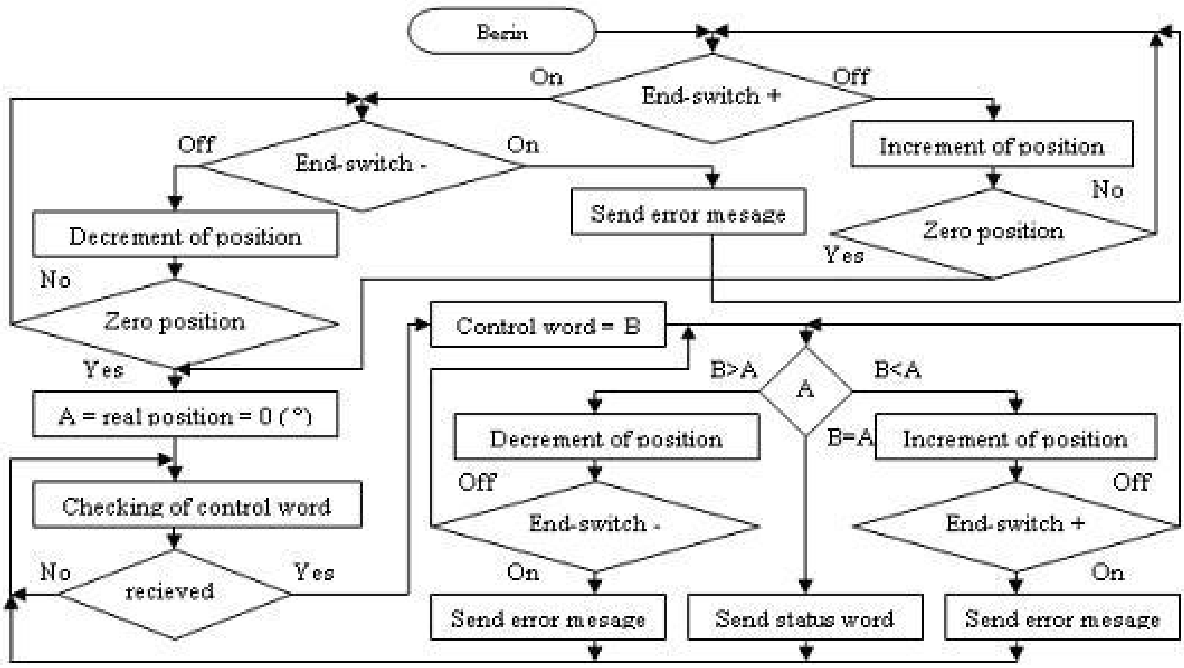

Fig.3.5: Flow chart of program for microcontrollers of drives

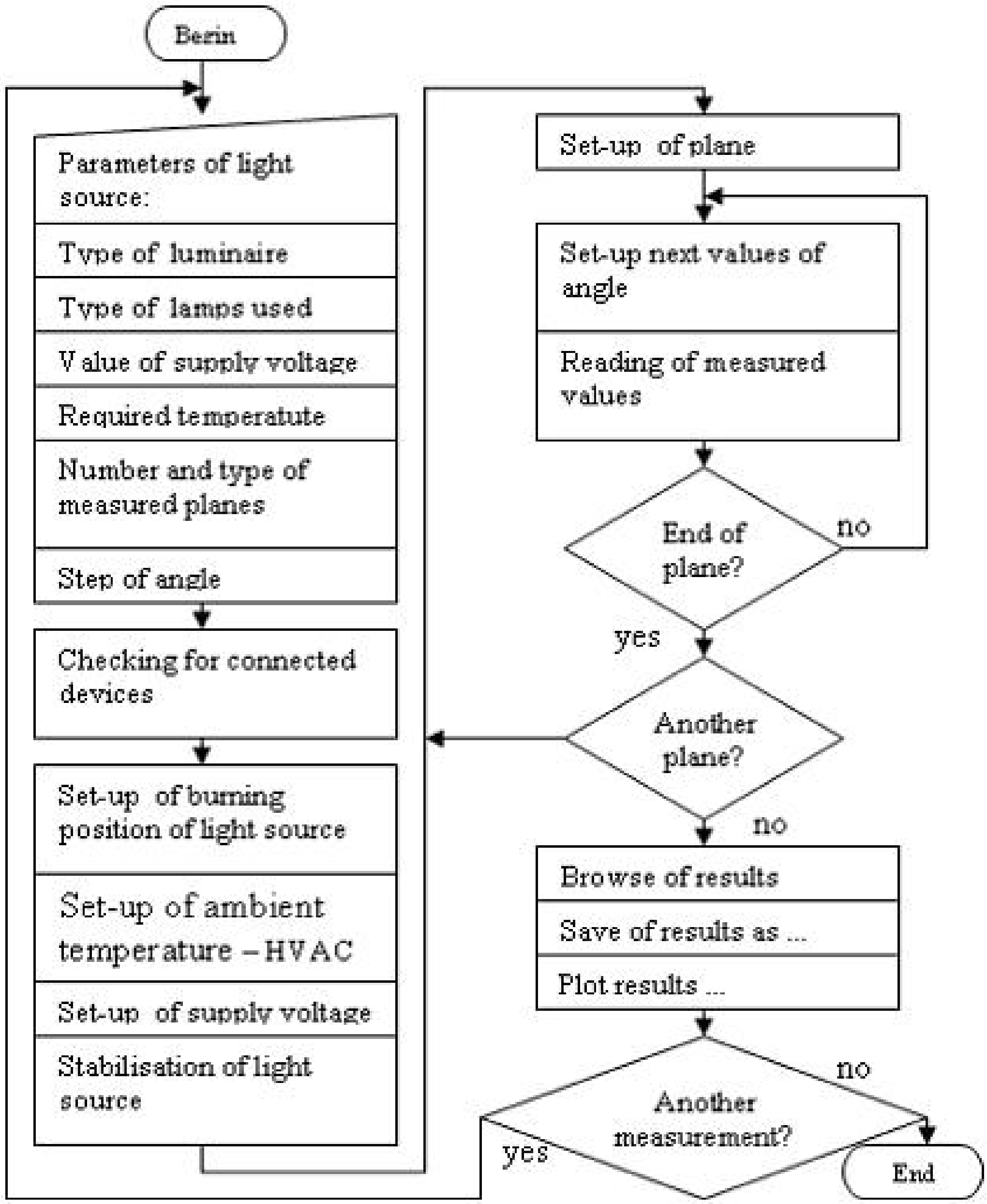

Fig.3.6: Flow chart of program for the control-PC

Principles of drive selection and proposal for the design of communication device as well as flow charts of necessary programs for devices and control-PC, described in this paper, can be similarly used also for goniophotometers of different construction. Recently, works on mechanical construction of type 1 goniophotometer are actually being performed.

Aim of this part of paper was to present some particular results from works performed on development of a device of special construction for measurements of luminous intensity distribution based on automatic operation.

4. Life-time measurements

In this part we would like to present a small control system, which was used in measurement of life time tests on tungsten halogen lamps. Block diagram of the measurement configuration is on fig.4.1.

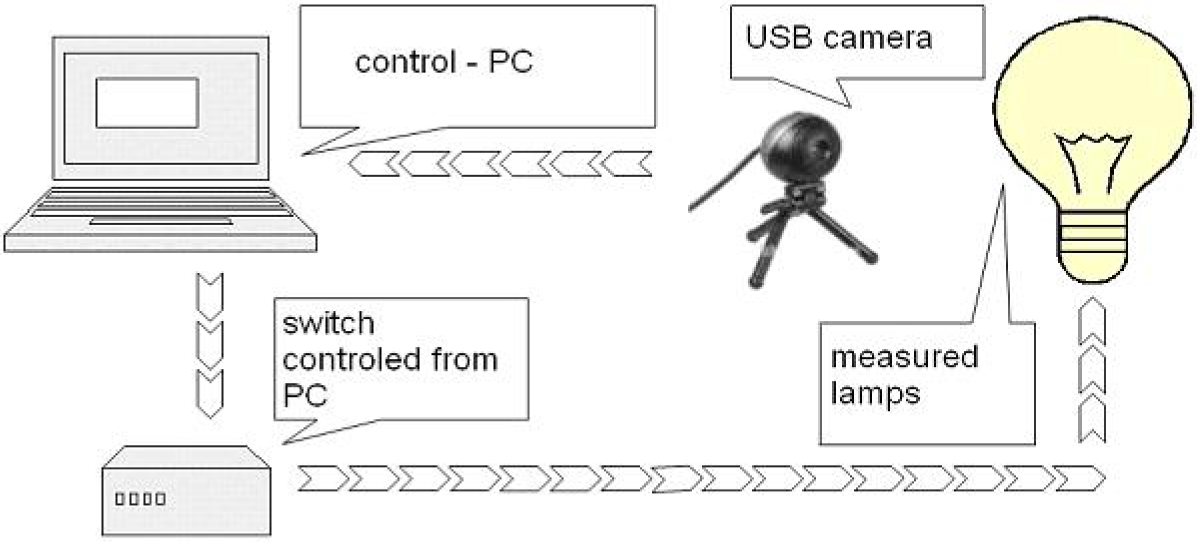

Fig.4.1: Block diagram of the measurement configuration

There is a control – PC, which switches the measures of light sources with support of a power-switch connected to the LPT port of PC. The measured lamps are scanned by USB camera, and control – PC evaluate which lamps is still emit light. Windows of PC-programs we can see on next fig.4.2.

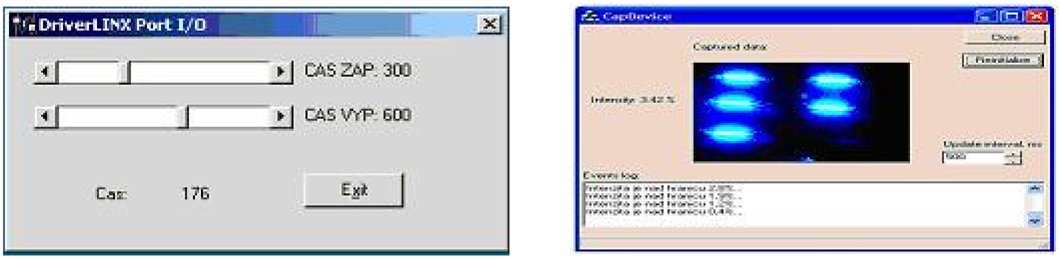

Fig.4.2: Windows of PC-programs

For the measurement we used OSRAM – HALOLINE 150W / 230V light sources, which have a predefined life time of 1500 hours (100% on fig 4.3). We measured influence of 10% power supply overload and impure of light source-bulb, on lamp life-time. The next slide (fig 4.3) describes results of measurements (Un – nominal voltage, impure - light source-bulb impure by human hand smear).

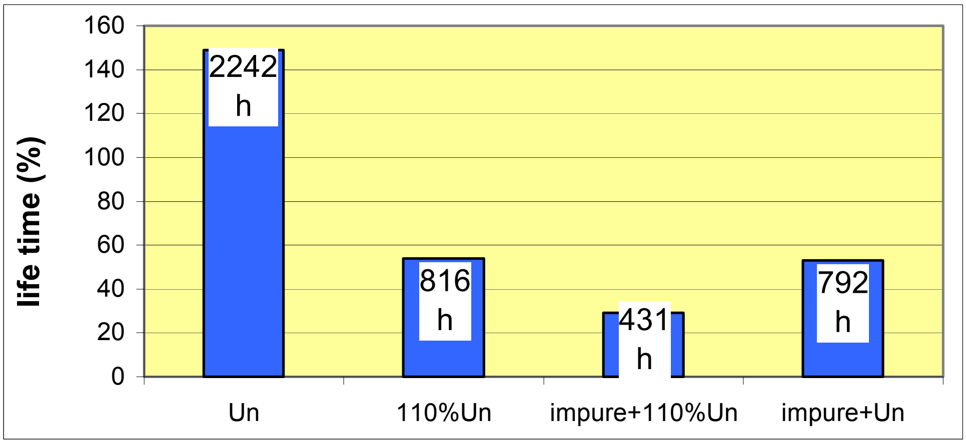

Fig.4.3: Results of life-time measurements

As we can see on fig.4.3, 10% power supply overload has approximately influence as same as impure of light source-bulb, on lamp life-time.

Conclusions

This software and hardware is made for school measuring needs. Like the example for students. After the completion of goniophotometer, significant increase of measurement accuracy and time savings for measurements are expected to contribute to the permanent quality improvement process and technical equipment upgrade of the Laboratory of Lighting Equipments at the Testing Facility of the STU. In last part of paper we present concrete results of measurement where we use our software and hardware in concrete application of life time measurements.

References

[1] EN 13032-1:2004: E Light and lighting – Measurement and presentation of photometric data of lamps and luminaires – Part 1: Measurement and file format 2004-07. 62 p.