Spectacular Building Lights with PLC Technology

Attila Sáfár, János Lohner, Máté Menczel

Alba Regia Technical Faculty

Óbudai University

Budai Str. 45, H-8000 Székesfehérvár, Hungary

safar.attila@amk.uni-obuda.hu
l.jani29@gmail.com
mencike99@gmail.com

Abstract - It is always a fashion to light up facades with particular emphasis on special historic and tourist priority buildings. Due to the more and more light power provider LED lights we can make it cost-effective, not to mention the longer operating times. To illuminate a building according to the exigencies of the era, modern control solutions should be applied. It is also important that aesthetic issues and demands arise when implementing a dynamic play of light.

I. INTRODUCTION

As it can be read in the abstract, we wanted to make a stylish floodlight for our institutional building. Due to its historic nature was especially important to use aesthetic solutions. A good idea was given by several major city public buildings, respectively the Palace of the Arts. We had to think about a solution that the play of lights can be varied as possible and do not cause a cheap "Vegas casino action" by the dynamism. There was a significant aspect of the surrounding residential buildings to respect the peace of the occupants. We should consider a remarkable additional light pollution and interference effects by using of any decorative lighting. There was another important consideration in the operation: energy-saving and reliable operation at the same time.

Under the constructing and designing a great care has been taken to seek the most simple, but modern and affordable solutions. Our choice fell on PLC technology. With this device we can operate safely our equipment with long operating times under all circumstances. We selected the appropriate LED light sources too. We planned and made advanced driver circuitry which was designed to ensure the continuous and aesthetic light transitions.

II. About the Operation

The PLC device controls the operation in daily / weekly resolutions. It is possible to manually set the terms by a twilight switch beside an automatic operation as well. In this solution the control unit generates the required time pulses which controls the channels of every different colors (RGB). To ensure the continuous gradients in the colors, our three pulse are shifted with 120 degrees relative to each other. The driver/interface circuit board is driven by the drive produces a relatively large time period sinusoidal signal for all three channels to make the slow but steady transitions. Therefore we had to design and dimension a special oscillator circuit. Although low-power LEDs are used, in the end amplifier we should use high-current FETs to toggle the light sources. Despite all solutions require correct LED driver current generator, we were operated with the voltage levels too. In many cases, such solutions can be seen, where the LEDs are driven by pulses. Here is one of the best methods of applying a PWM, where the LEDs are switched on/off with a relatively high frequency, thus reaching the same effect. The outputs are also usually an open drain FET circuits. These methods have a significant drawback which is in the slow transitions where there will not be a continuous change in the brightness and the colors. The human eye can easily be perceived that the transitions have a cascading effect. In our solution, we used not quasisinusoidal signals, but also correct sine wave signals to control the gates of every FET. In this way, the luminance transitions can be much nicer and more continuous, whether changing one or all of the colors brightness. Depending on the modes we can control all of the tree color components to saturation thus to blend a warm white hue, or to change the red-green-blue color gradient. This technological solution is currently not capable of providing the steady brightness, when we manipulate the color saturation separately, or together during the play of light running. To do this, a precise and controlled automatically backlight is required.

III. Simulation

During the construction, each step is required a careful planning and testing procedure. Here, of course, we had to adapt the technical specifications of the available LED ribbon. The first devised solutions for circuits were checked by simulations. This software was mostly the MicroCap, where time domain so-called transient analyzes were run, resulting unfortunately we had to change our ideas to another concept.

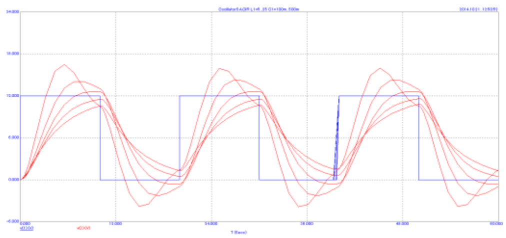

Fig. 1. Simulation of transients in MC9

IV. About the LED ribbon in nutshell

Choosing the light source our care was taken that it can be used outdoors. We selected a warm white color temperature, dust and moderately waterproof, 15m long, high brightness RGB LED strip. The power requirement of the strip is 12V and max. 3A per channel.

Adapting to the specifics of the building windows we cut equal length sections and prepared the 4-pin pin connection system. Unfortunately, the market doesn’t provide multi pinned microelectrical connectors which have swivel design, small footprint and protection against polarity change. The correct polarity plugging needs special care, if for some reason we need to disconnect the connections later. Considering the shape of the tape it can be cut in several points, where other power connection places are applied to the flexible soft silicone-coated plastic strip. The ribbon has self-adhesive layer on the backside. Of course, any part of the circuit is SMD technology.

The entire length of the building had to be wired in to make the power connections in each room. We had to calculate the correct wire diameters. We tried diameters as thin as possible, but safely oversized.

V. The used PLC device

Safe operation and control of the system is performed by a Siemens LOGO PLC device. Of course, other manufacturers PLC modules may be suitable for similar and simple control tasks.

Some features:

• The compact, easy-to-use and low-cost solution for simple control tasks
• Compact, easy to operate, universally applicable without accessories
• "All in one": Integrated display and operator panel
• 36 different functions can be connected at the click of a button or by means of PC software; up to 130 times over
• Functions are easily changed at the press of a key. No more time-consuming rewiring
• Space-saving basic versions
• Interface for the connection of expansion modules, up to 24 digital inputs, 16 digital outputs, 8 analog inputs and 2 analog outputs can be addressed
• With connection option for LOGO! TD text display (can be connected to all LOGO! 0BA6 basic versions)

VI. THE DEVELOPING SOFTWARE AND PLC CODE EXAMPLE

LOGO!Soft Comfort V6.0

For programming on the PC in LAD/FBD; executes under Windows 98 SE and higher, Linux, MAC OSX; on CD-ROM. The user-friendly software for creating control programs on a PC.

• Creation of control programs in Function Block Diagram (FBD) or Ladder Diagram (LAD)

• Plus testing, simulation, online testing and archiving of control programs

• Professional documentation via numerous comment and print functions

The connection between LOGO! and the PC is made using the LOGO! PC cable (serial interface) or the LOGO! USB PC cable
(USB interface).

Fig. 2. The developing software interface

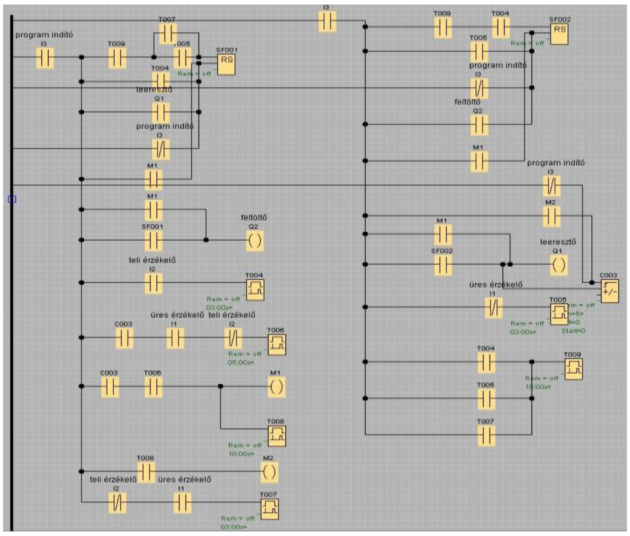

Fig. 3. An exaple for “ladder” codes

VII. Description of the PLC code

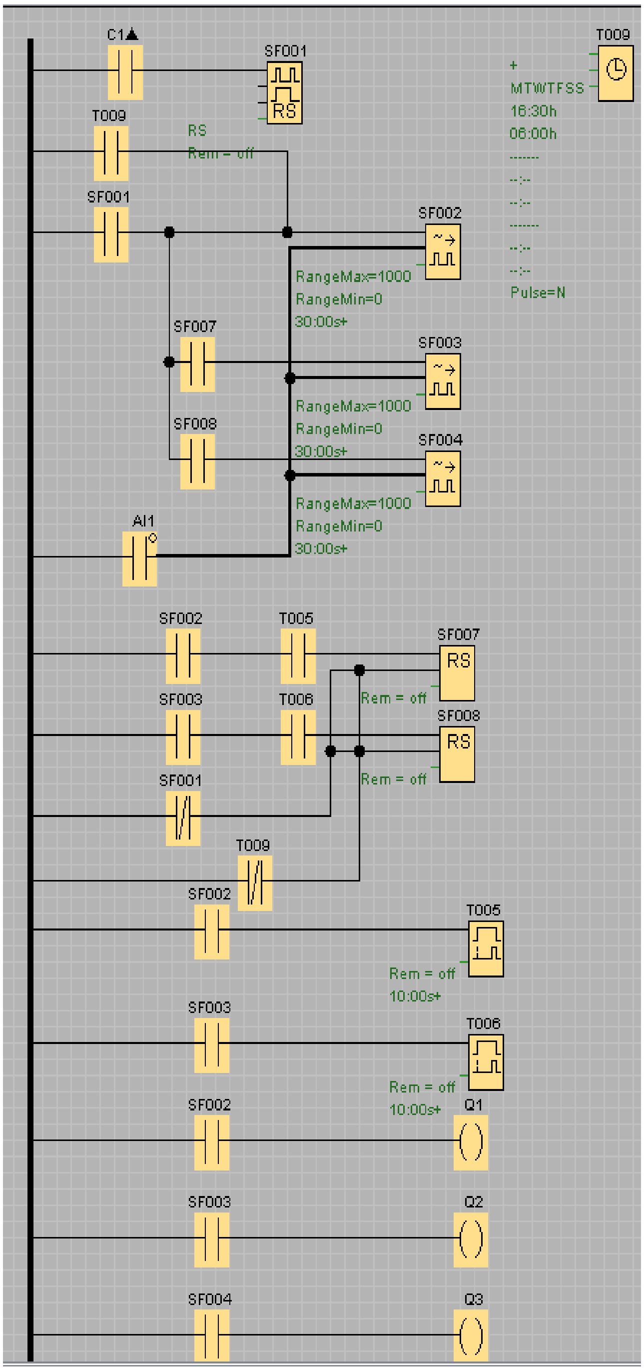

Fig. 4. The ladder source code of LOGO

During the run the program starts a 30 second time priod PWM signal (SF002) which can be manual (C1) or weekly timer (T009). This signal triggers a switch delayer timer (T005). If t5 is active, then it starts the second PWM signal (SF003). This PWM will launch an other PWM signal switch delayer timer (T006) and when t6 is active, the third PWM signal (SF004) will start. The duty cycle of the 3. PWM signal can be manually adjusted to the desired value by A1 analog input.

The 3 PWM signal activate the 3 outputs (Q1-Q3) or unlock it. The outputs of the PLC close or unlock the 3 ground wires of the LED strip, resolved as a function of Q outputs. If the duty cycle is 50%, it can pick up 6 states, but when we set to 100%, after the expiration of 3 PWM signals, the 3 RGB LEDs provide continuous white light.

VIII. The circuit design

We needed a LED driver circuit, which changes the brightness for each color according to a sinusoidal function. Several possible solutions come into play for the circuit which makes the low-frequency sinusoidal control signal. The most appropriate circuit has proved to be: the active Wien-bridge oscillator.

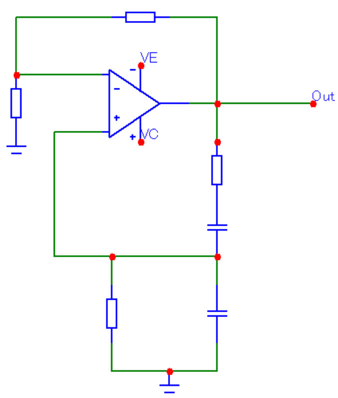

Fig. 5. The Wien-bridge oscillator

IX. The Testing and Measurement, Illustrated with Pictures

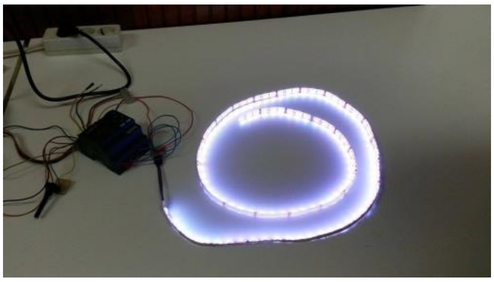

Fig. 6. Warm white at saturation

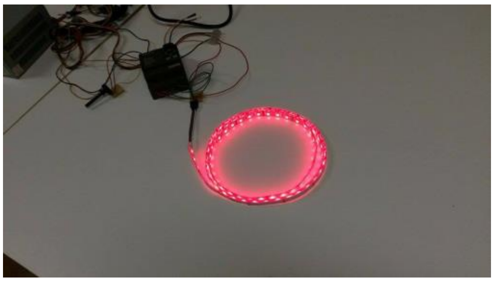

Fig. 7. Full red mode

Fig. 8. Full blue mode

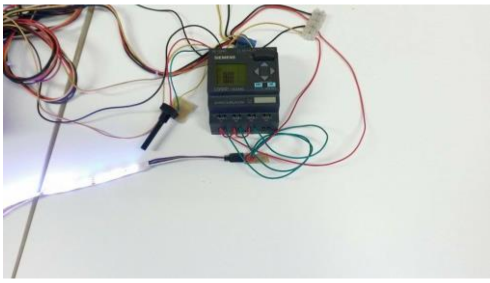

Fig. 9. PLC in operation

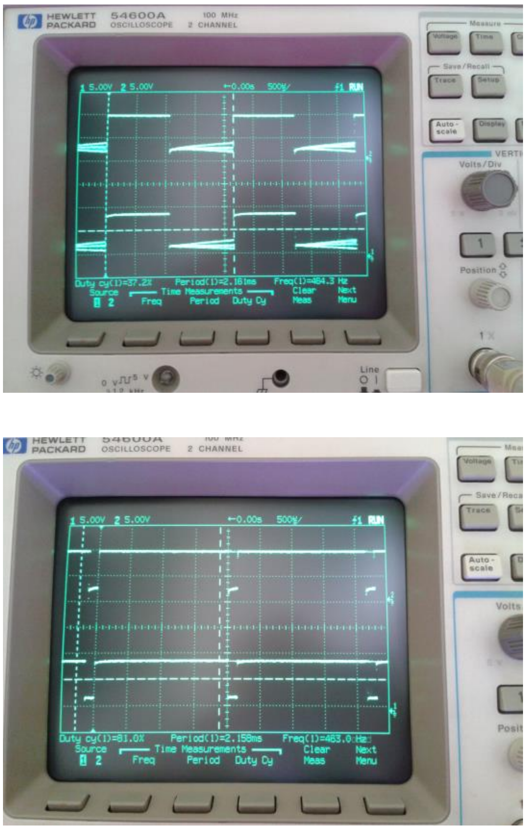

Fig. 10&11. PWM visualization with the scope

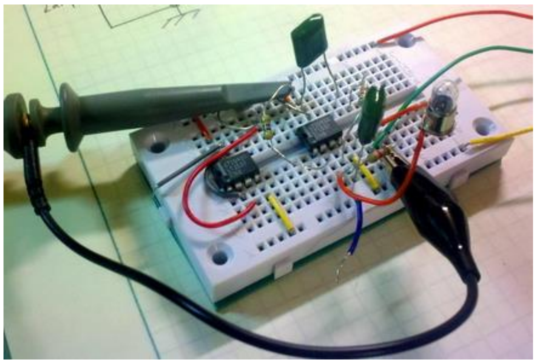

Fig. 12. Testing the oscillator

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http://www.farnell.com/datasheets/1683990.pdf

http://www.electronics-tutorials.ws/oscillator/rc_oscillator.html