Design and realization of light modules for miniature model passenger coaches

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Abstract. This paper shows the main steps to design and realize an original light module for miniature model passenger carriages, with the possibility to switch on and off individual lights and to operate the lights according to certain patterns, which improves greatly the visual appearance of miniature passenger trains. This continues the previous work of the authors concerning the model railroading and the implications of nonconventional technologies in this field of activity.

1. Introduction
Nowadays, hobbies have become very important human activities, and the fabrication of hobby items requires high-tech designing, engineering and machining, performed by high-skilled and carefully trained operators. The miniature train hobby items, such as locomotives, wagons, railroads and accessories, have become very complex and they are now produced in world renowned factories at astoundingly high quality levels, using cutting-edge technologies, machines and software, both conventional and nonconventional. So, the model railroading hobby has now turned into a very serious and important activity from the point of view of both manufacturers and railway enthusiasts.

Due to their increasingly complex features, the miniature model trains resemble more and more to their real-life counterparts and they behave like them. The new locomotives are fitted with direction-dependent headlights, sounds, conventional or dynamic smoke generators, spark simulators, functional couplers etc, and the passenger carriages are fitted with interior lighting, tail lights, functional doors, sounds and other features that increase their visual and functional appearance. These modern trains and their components can be individually commanded by means of the digital command control (DCC) system [5].

The light modules are very important for the appearance of the passenger coaches (figure 1). First, there were no lights at all, then one or more incandescent bulbs were mounted on the ceiling, electrically connected to the wheel collectors. These lights were permanently on as long there was voltage at the rails, and their intensity depended greatly on the voltage value. So the light increases when the train speeds up, it decreases when the train slows down, and goes off when the train stops, which is not life-like. The modern digital light modules, as the one described in this paper, contain LED’s which can be individually switched on and off and their light intensity does not depend on the train speed. These light modules can be commanded by means of the DCC system, but they can also
be used on analog railways. However, in order to fully use their capabilities, the DCC system is more suitable.

![Passenger carriage, with interior lighting and tail lights.](image1.png)

**Figure 1.** Passenger carriage, with interior lighting and tail lights.

2. **The Shine Plus Maxi light module for passenger carriages**

Briefly, the light module (figure 2) consists of an 8-bit ATMEL microcontroller unit [6], which receives, decodes and executes the DCC commands, the adequate peripheral LED drivers and the white LED’s, which can be individually commanded – switched on/off, dimmed, flickered etc.

![The Shine Plus Maxi light module.](image2.png)

**Figure 2.** The Shine Plus Maxi light module.

All the components of the light module are surface-mounted-devices (SMD), and they are placed on a double-plated printed circuit board (PCB). Adequate conductive pads are designed for the connections to the wheel current collectors and to the external outputs, such as cockpit lights, tail lights or other additional light modules, individual or not.

As all other DCC devices, the light module has an individual address which is set by the user via the digital command station. Thus, each passenger carriage can be addressed individually, in order to switch on/off all the lights or any of the LED’s, tail lights or any other additional lights. Furthermore, if programmed accordingly, the lights can emulate the behavior of good or defective neon lights, can be individually dimmed or flickered and they can be automatically operated following a random pattern. These features increase the life-like appearance of the miniature passenger carriages that roll along the railway layout, as if individual travelers operate the lights of their compartments.

In order to avoid the voltage dropouts caused by imperfect electrical contacts between rails, wheels and current collectors, the light modules are fitted with external buffer electrolytic capacitors, which are connected by the user to the PCB by means of adequate conductive pads.

This light module can be operated on digital or analog railway systems. By adequate programming, the digital operation mode can be partially emulated on analogue systems, but the features of this light module can be fully used on digital railway systems.

3. **Design and realization of the Shine Plus Maxi light module**

Due to the complexity of the Shine Plus Maxi light module, the design of the electronic diagram and PCB was carried out by means of TVision software, an internal application of Tehnologistic [7] (figure 3, figure 4). The microcontroller was programmed in compliance with the National Model Railroad Association (NMRA) [8] and DCC requirements, and its software can be updated whenever necessary without the need to dismount the module from the passenger carriage. The outputs of the
microcontroller are connected to the LED drivers that supply the required voltages and currents for the 14 low-current high-brightness white LED’s of the light module and for the two additional outputs. All electronic components are SMD type.

The PCB’s are double-layered, copper plated, and are manufactured by a partner company according to the TVision project of Tehnologistic. Modern technologies are used, such as photo-etching, galvanizing, tampo printing, computer-aided drilling and cutting etc, so that the resulted PCB’s can be taken over by the computer-driven pick-and-place machines that assemble the SMD electronic components according to the design.

Figure 3. Design of Shine Plus Maxi light module.

Figure 4. Design of Shine Plus Maxi light module (detail).

According to the project, the solder paste is deposited on the soldering pads of the PCB’s by means of a computer-driven Sony SiP850 paste printing machine (figure 5), then the pasted pads are optically checked (figure 6).

Figure 5. Sony SiP850 machine for solder paste printing.

Figure 6. Vision system for optical checking of the pasted pads of PCB.

Figure 7. Siemens Siplace robot, picking up SMD devices from feeders.

Figure 8. Siemens Siplace robot, placing SMD components on pasted PCB’s.
Siemens Siplace robots (figure 7) pick up the SMD devices from their feeders and place them on the pasted PCB’s (figure 8). Then automated conveyors (figure 9) carry the PCB’s to the Rehm Nitro reflow oven (figure 10).

The firmware of the Shine Maxi Plus light modules was developed by means of WinAVR application [9], with Eclipse Integrated Development Environment (IDE) [10] and AVR plug-in [11]. After the completion, the firmware is loaded into the microcontrollers, and the finished light modules are tested by means of a custom self-made tester, according to the pads and functionality of the batch that has been ordered and manufactured (figure 11). The properly functioning modules are then wrapped and sent to the customers.

The design of the Shine Plus Maxi light module features alternate soldering pads for the LED’s at 3mm pitch, in order to allow the experienced users to fine-tune the positions of the LED’s according to the specific passenger carriage to be illuminated (figure 12). By means of adequate soldering equipment and skills, the LED’s can be removed from the factory default positions in order to be re-soldered on the pads of the alternate positions, so that the light module would fit better in the specific passenger carriage.
4. Conclusions
The modern technologies, both conventional and nonconventional, provide quality, accuracy, reliability and reproducibility of the products, so they proved themselves to be very useful for the manufacturers of model railroading items. The railway enthusiasts appreciate greatly the true-to-life miniature models of the real trains, which nowadays can be manufactured at much higher standards than before. The realistic appearance of the model trains is enhanced by additional functional features that can be individually addressed via the DCC system, and one of the most spectacular additions is the interior lighting of miniature passenger carriages. The life-like behavior is achieved by the complex design of the light modules, and the manufacturing requires cutting-edge technologies, machines and software. Further developments of the Shine Maxi Plus light module will be carried out in the future, as the firmware will be periodically updated, and new hardware features will be implemented as the project will be adapted to the requirements of the customers.

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