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OLED APPLICATIONS FOR DIGITAL MODEL RAILWAY SYSTEMS

Mircea-Petru Ursu[1], Dragoș-Adrian Condruz[2]

[1]University of Oradea, Faculty of Electrical Engineering and Information Technology,
str. Universității nr.1, Oradea 410087, Romania
[2] University Emergency Hospital Bucharest - SUUB, Department of Medical Microbiology,
Splaiul Independenței No.169, District 5 Bucharest, Romania

Corresponding author: Mircea-Petru Ursu, mpursu@uoradea.ro

***Abstract*:** The hobbies are now very important components of our lives, and model railroading is one of them. Nowadays, the realism and detailing of both model trains and scenery become more and more important. The medium-sized and big-sized railway stations of the extended digital model railway systems are the most difficult to replicate, firstly because of their uniqueness (dimensions, shapes, buildings, trackwork, signals etc), then because of the multiple light boards that display the current time (using analog or digital format), the train numbers, routes, arrivals and departures, announcements, advertising etc. For a long time, these important miniature items were completely static and very rarely illuminated, but now, with the occurrence of the new LED lighting technologies, this is about to change. The authors have designed and made some digital microcontroller-driven modules with OLED miniature panels that are able to successfully replicate the above-mentioned dynamic and fully-functional light panels, which can operate either standalone or driven by the DCC signal of the present model railway system. The results are promising and yield a lot of opportunities for future development. The authors have already written a series of papers about improving other aspects of analog and digital model railroading, such as intelligent boosters, sensors, controllers, signal quality detectors, automation devices etc.
***Keywords*:** OLED, microcontroller, digital, display, model railroading.

1. INTRODUCTION

The lighting of devices has become very important nowadays in terms of colour, efficiency, reliability etc. OLED (**O**rganic **L**ight **E**mitting **D**iodes) is a flat light emitting technology, made by placing a series of organic thin films between two conductors. When electrical current is applied, a bright light is emitted. OLEDs are emissive displays that do not require a backlight and so are thinner and more efficient than LCD displays, which do require a white backlight. OLED displays are not just thin and efficient; they provide the best image quality ever and they can also be made transparent, flexible, foldable and even rollable and stretchable in the future. OLEDs are organic because they are made from carbon and hydrogen, [1]. Basically, the OLED structure is shown in Figure 1.
The main component in an OLED display is the OLED emitter, which is an organic (carbon-based) material that emits light when electricity is applied. The basic structure of an OLED is an emissive layer sandwiched between a cathode (which injects electrons) and an anode (which removes electrons). An OLED panel itself is made from a substrate, backplane (electronics - the driver), frontplane (the organic materials and electrodes as explained above) and an encapsulation layer. OLEDs are very sensitive to oxygen and moisture and so the encapsulation layer is critical, [2].
The OLED displays are available in many shapes and sizes. The miniature ones are suitable for model railroading, as they can replicate the multiple railway station light boards that display the current time (using analog or digital format), the train numbers, routes, arrivals and departures, announcements, advertising etc. Driven by adequate microelectronic devices, either standalone or interconnected, they have a great contribution to the realistic appearance of the miniature railway stations. The authors designed and made several such display items by means of commercially available OLED miniature displays, microcontrollers and programmable Arduino boards. This is just a starting point for great future developments, as the OLED technology is rapidly improving and the programming gets more and more intricated, yielding many possibilities for spectacular usage of these devices.

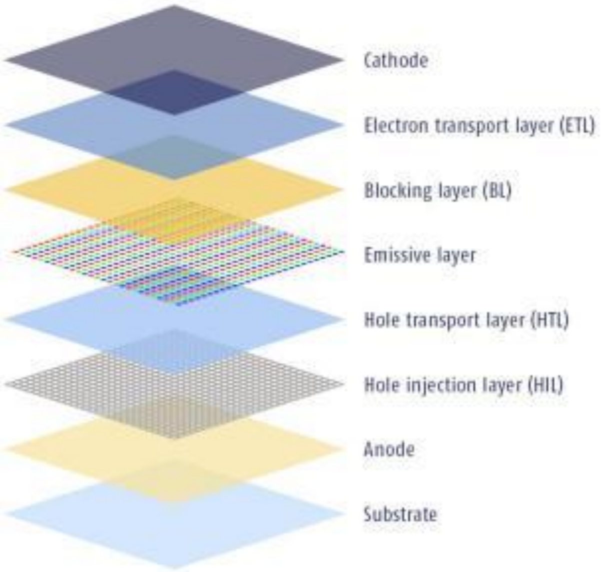


Fig. 1. OLED structure [2]

2. TRAIN TIMETABLE DISPLAY

One such device shows the train timetable on a 0.96 inch OLED display, which is equivalent to a quite realistic 2.12 m plasma display within an 1:87 model railway station. The 128×64 pixel display (Fig. 2) is driven directly by a PIC16F648A microcontroller with 4 kB memory, using the SPI protocol. The electronic diagram of the digital device is shown in Fig. 3 and the PCB project is shown in Fig. 4.

Fig. 2. OLED 128×64 pixel display

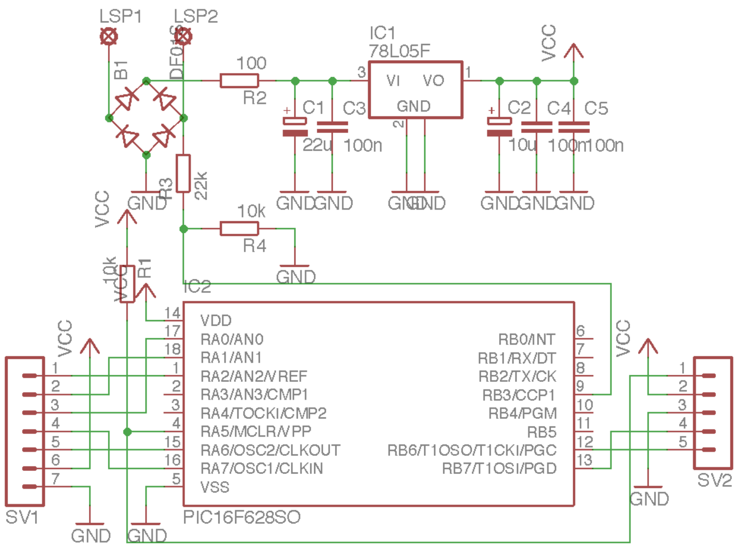


Fig. 3. Electronic diagram of the digital train timetable display

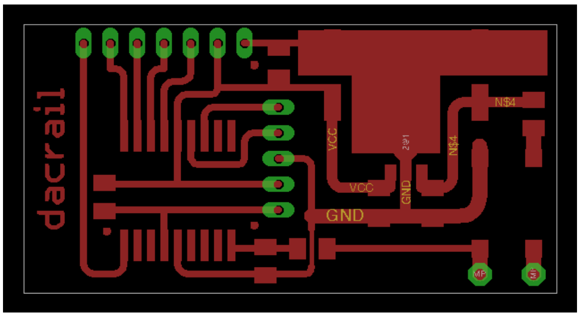
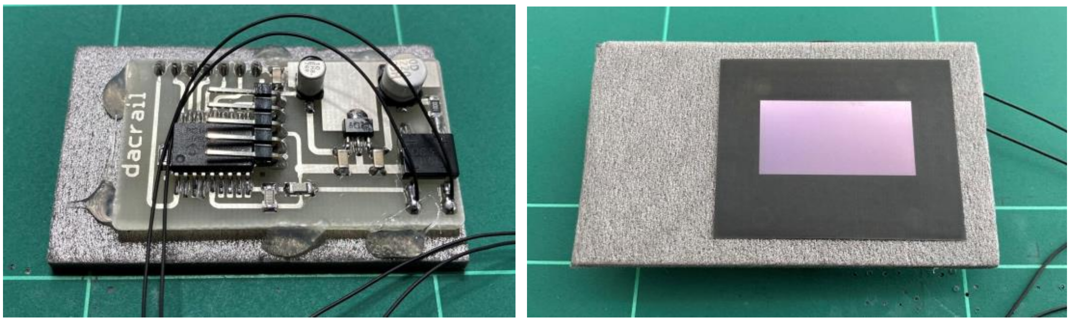


Fig. 4. PCB of the digital train timetable display

Fig. 5 shows the front panel of the device, with the OLED display, SMD components, programming connector and DCC signal input, and Fig. 6 shows the assembled digital train timetable display in operation. The casing is made of 3 mm thick polystyrene, cut to appropriate size and stamped with a hard lead pencil in order to replicate plastered stone walls. Of course, next such casings will be made by 3D printing to be even more realistic.



a *b*

Fig. 5. Front panel of the digital train timetable display (*a* – PCB, *b* – OLED display)


Fig. 6. Digital train timetable display

The authors created the function library for driving the display, as well as the font for the messages. All these, together with a 20 text lines table, took 1.8 kB of the PIC available memory, so there is enough place for future development. The program (Fig. 7) includes a subroutine that recognizes the DCC standard for digital miniature railways systems [3, 4, 5], thus the device can receive and decode the DCC signal from the digital railway system along with the trains and the other accessories (signals, turnouts etc). When activated by a specific DCC command, similar to a turnout, the device displays a scrolling list of trains with their indicatives, destinations and departure times. This list can be rewritten according to the requirements of a well-established miniature digital railway layout.
For example, at FREMO meetings [6] there are schedules to be observed, such as passenger trains that must always be on time, freight trains that must be shunted, composed, recomposed and driven with priority given to the scheduled passenger trains, other railway-related operations etc. The schedule is handed to each participant, with the observation that the responsibility for compliance belongs to him/her, and the operation of the entire digital railway layout depends on how everyone performs his/her duties, similar to the real-life railway systems. This digital train timetable display can be reprogrammed any time to suit such requirements.

```
;DCC packet
packet  clrf    bytes
        clrf    byte1
        clrf    byte2
        clrf    byte3
        clrf    byte4
        clrf    byte5
        clrf    byte6
sync    movlw   .12                     ;look for preamble
        movwf   count2
sync1   call    dccbit
        btfss   newbit
        goto    sync
        decfsz  count2,f
        goto    sync1
sync2   call    dccbit                  ;12 DCC-1 counted
        btfsc   newbit                  ;wait for DCC-0
        goto    sync2
;get up to 6 DCC bytes
sync3   movlw   .6
        movwf   count1
dcc2    movlw   .8
        movwf   count2
dcc1    call    dccbit                  ;(max 80uS)
```

Fig. 7. Programming code for the microcontroller of the digital train timetable display (excerpt)

3. REAL-TIME CLOCKS

Within miniature railway stations, FREMO meetings or not, the platform clocks and/or building clocks that do show the real time are precious additions to the realism of the railway layout. Such real-time clocks can be built by means of OLED displays that are driven by Arduino boards fitted with WiFi and/or Bluetooth connections.
The authors built one such real-time clock with another OLED 128×64 pixel display, driven directly by an Arduino Nano ESP32 board by means of I2C protocol. This board is factory-fitted with an ESP32 WiFi module, thus it can pick the accurate time from the Internet by means of an NTP server (**N**etwork **T**ime **P**rotocol). Then, by adequate programming and computing, the Internet time is converted from Unix format (seconds elapsed from January 1st 1970) to local time, date and day-of-week. These pieces of time information are converted to the graphic image of an analog clock with rotating hands for hours, minutes and seconds, and the day of the week and current date are displayed next to it (Fig. 8). An excerpt of the program is shown in Fig. 9.
Briefly, the Arduino board contains a microcontroller similar to the above-mentioned one, supported by other digital electronic devices (input/output, timebases, voltage regulators, analog-to-digital and digital-to-analog converters etc). According to its content, the Arduino board can be programmed by means of sketches written with the Arduino IDE software [7]. The I2C protocol is one of the easiest to use because it requires only two wires between the Arduino board and the peripherals, named SDA (**S**erial **Da**ta) and SCL (**S**erial **Cl**ock). Considering the two additional wires for power, all it takes is four wires to make an I2C bus, to which several I2C peripherals can be simply connected in parallel to make spectacular Arduino projects.
This project can be further developed by adding the above-mentioned train timetable, of which the incoming and/or outgoing trains will be displayed next to the analog clock. This idea is also valuable for the FREMO meetings, where the miniature digital trains are driven by human operators, as in reality, which must observe the timetables they have been handed. In case of delays, such additional information can be also displayed next to the train indicator etc.

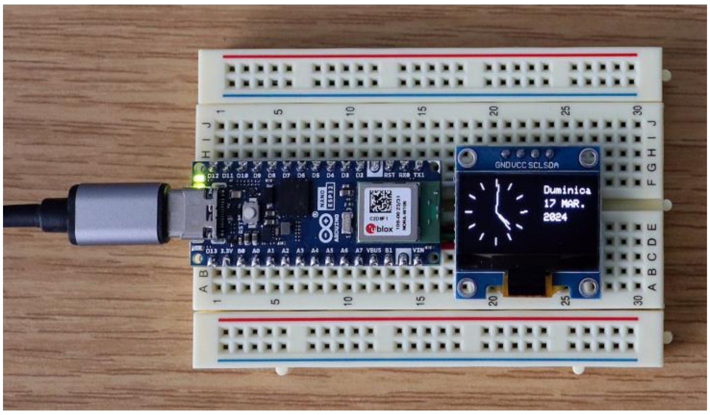


Fig. 8. OLED real-time clock with analog display

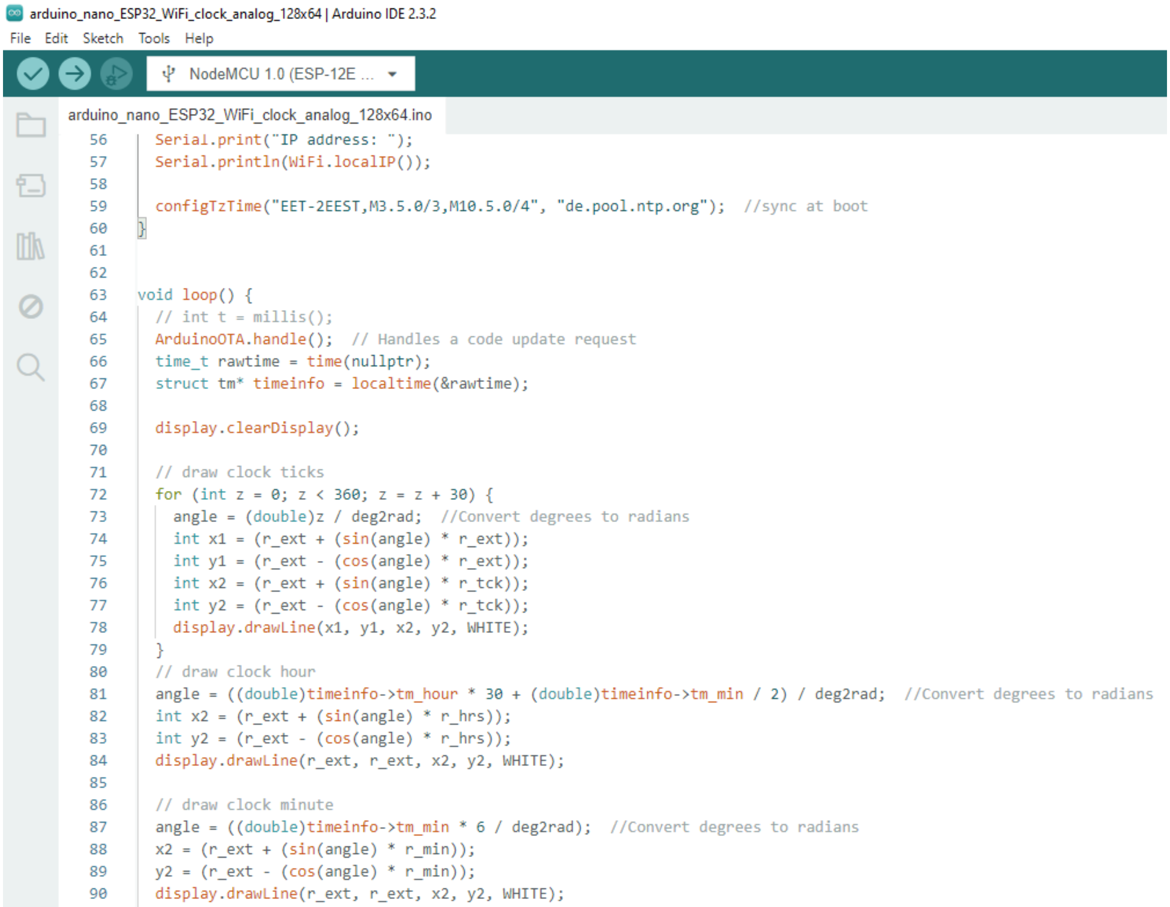


Fig. 9. Programming code for the Arduino Nano ESP32 analog real-time clock (excerpt)

Another real-time clock shows the accurate time using a digital format on an OLED 128×32 pixel display, directly driven by a NodeMCU V1.0 compatible board factory-fitted with an ESP8266 WiFi module (Fig. 10). The display is also connected to the board by means of an I2C bus. The program is similar to the above-mentioned one, except for the digital display of time and date. Both programs feature an update procedure that automatically launches every hour at 59 minutes and 0 seconds.
This OLED 128×32pixel display can also be used as a functional platform clock, either fully digital as shown before or by adapting the previous program to attain an analog look by means of the round clock with rotating hands (Fig. 11). As in the previous case, the program can be adapted to the specific requirements of the digital miniature railway system where the clock device will be used. Another interesting feature is the possibility to perform OTA (**O**ver **T**he **A**ir) programming, which means that these digital devices do not need to be removed from their places if reprogramming is required.

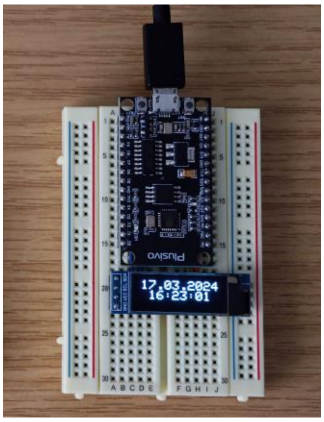


Fig. 10. OLED real-time clock with digital display

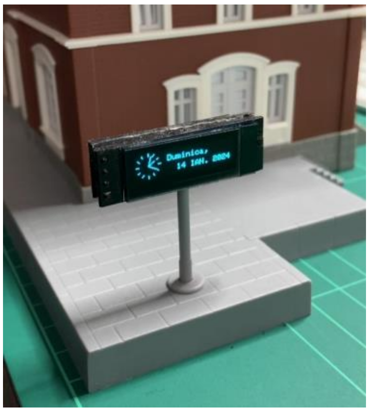


Fig. 11. Platform OLED real-time clock with analog display

3. RESULTS AND DISCUSSION

The bright light, the excellent contrast, the dimensions and the proportions of these miniature OLED displays make them perfect to replicate platform clocks and other illuminated dynamic boards within 1:87 miniature railway networks. Also, the currents absorbed by these devices are quite low, some 60 – 80 mA for 5 V supply voltage. The flexibility of these devices is astounding due to their software that can always be developed and adapted to specific requirements. The weak point of the current OLED consists of the burn-in risk for the over-used pixels, which can be avoided by periodically reversing the display from positive to negative and vice versa. The OLED panels presented in this paper are monochrome, but on the market the coloured OLED panels start to appear more and more frequently, and they can bring even more realism to the miniature railway networks. In either case, the possibilities are endless and their usage depends only on the user's imagination, observation of reality and programming skills.

4. CONCLUSIONS

The OLED technology is developing very fast, yielding better and better results. Due to their minute dimensions, these above-mentioned OLED panels (and not only) fit perfectly on miniature railway systems, such as H0 (1:87), TT (1:120), G (1:22.5) etc. For example, these modules can show the real time accurately, are entirely programmable (wired or wireless), can be further developed and can be set according to the requirements of the model digital railway system which they will serve, which will be a major step forward in terms of accuracy, realism and even safety. Furthermore, the study and the operation of these modules will help the users to get easily acquainted to the use of microcontrollers, programming languages and environments, and can be a good starting point for aligning with the new IoT trends. Also, let's not forget that miniature train kits have been marketed as educational science kits and many have been used in classroom demonstrations for such purposes [8].

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REFERENCES

1. Available from: https://www.oled-info.com/oled-introduction , accessed: 16/03/2024;
2. Available from: https://www.oled-info.com/oled-technology, accessed: 16/03.2024;
3. Available from: https://www.nmra.org/sites/default/files/standards/sandrp/pdf/s-9.1_electrical_standards_for_digital_command_control_2021.pdf, accessed: 17/04/2022;
4. Ursu M.P., (2021), *Digital Electronic Modules for Command and Control of Miniature Railway Systems*, Proceedings of 16th International Conference On Engineering Of Modern Electric Systems (EMES), pp. 211-214, publisher IEEE345 E 47th ST, New York, NY 10017 USA, conference location Oradea/Romania, DOI:10.1109/EMES52337.2021.9484138;
5. Ursu M.P., Condruz D.A., (2017), *Digital Intelligent Booster for DCC Miniature Train Networks*, IOP Publishing Ltd, Article Number 012133, DOI:10.1088/1757-899X/227/1/012133;
6. Available from: https://www.fremo-net.eu/en/home, accessed: 12/10/2020;
7. Available from: https://www.arduino.cc/, accessed: 20/06/2022;
8. D. P. Wicka, M. W. Ramsdell, (2004), *Modeling the motion of a toy train powered with a time-dependent applied voltage: Educational implementation and analysis*, American Journal of Physics, DOI:10.1119/1.1637040.

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