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A LED MATRIX MANAGER SNIFFER

BY

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Abstract. This paper is focused on presenting the simulated solution for synchronizing the CAN communication, which is signal based, with the Pulse Width Modulation (PWM) for each LED connected to a LED matrix manager device. Using the presented solution, the user is able to read and verify each LEDand represents a very easy and fast testing approach for automotive lighting with LMM (LED Matrix Manager) devices. The information provided by the sniffer improves the error root cause detection time, offers an overview on the requirements compliance, and assures an efficient monitorisation of the LMM behaviour. The LMM sniffer is developed due to the missing of a dedicated standard solution for this purpose.

Keywords: CAN bus, Pulse Width Modulation, Glare Free High Beam, headlamp, adaptive front-light system.

1. Introduction

The LMM, or LED Matrix Manager, has made a valuable contribution to the automotive electronics industry by assisting engineers in tackling crucial

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technical and economic obstacles associated with LED headlights. By incorporating a comprehensive high-brightness LED matrix manager, which can handle numerous LEDs from a single serial port, it reduces the size and expense of adaptive automotive headlight control systems (Barera *et al*., 2018).

By utilizing a digital protocol and a microcontroller unit (MCU), the matrix-manager devices regulate the brightness, on/off state of individual LEDs. This approach enables the implementation of various advanced lighting features that can adapt dynamically to road conditions, ranging from a straightforward sequential turn or welcome light to a sophisticated anti-glaring function. This is feasible because the brightness and on/off state of a LED can be altered in real-time.

Automotive lighting systems known as Adaptive Front Lighting Systems (AFS) are designed to adjust the beam characteristics of both dipped and main beams automatically to suit various conditions. Bending Light (BL), Adverse Weather Light (AWL), High Beam (HB), Motorway Light (ML), Country Light (CL), Town Light (TL), and Front Fog-Light (FFL) are among the common features available with an AFS.

The GFHB (Glare Free High Beam) system is a feature that allows the vehicle to maximize the illumination on the road. To do this it makes use of high beams with multiple segments (or pixels) than can be individually controlled to illuminate the road while avoiding glaring the vehicles in front. The dark areas created by the segments that remain off are commonly known as Glare Free Areas (GFAs) (Luo *et al*., 2021).

Figure 1 shows the capabilities of an adaptive front light when LED Matrix Managers devices are used.

Fig. 1 – Adaptive headlamp with Matrix Manager devices.

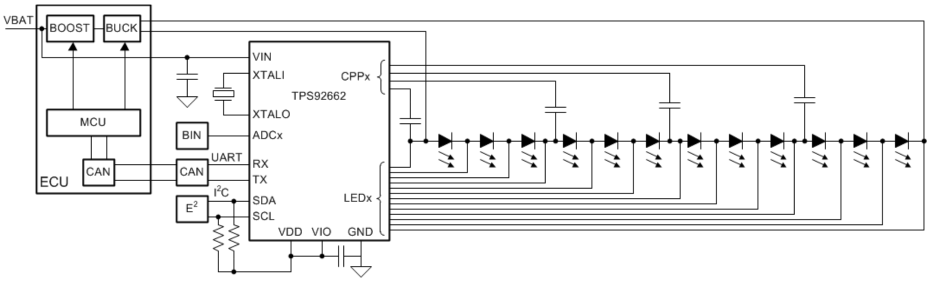


Fig. 2 – ECU- LMM Connection.

In Fig. 2 it is presented the schematic of an LMM with 12 LEDs and its connection with an Electronic Control Unit. The TPS92662EVM6-900 consists of 66 individually controllable LEDs configured into a six-channel application:

- 3x12 AFLS/ADB LED Array (in Fig. 2 is presented only one channel)
- 1x12 Sequential Turn Light
- 1X12 Daytime Running Light
- 1X6 High Power Race Light

This evaluation module shows the versatility and configurability of the TPS92662-Q1 LED Matrix Manager Device. With the capability of providing individual pixel-level LED control, the TPS92662-Q1 LED matrix manager device enables fully dynamic adaptive lighting solutions. This device has diverse applications, including automotive headlight systems, high-brightness LED matrix systems, ADB or glare-free high beam, sequential turn, and animated daytime running lights. The TPS92662-Q1 devices can be controlled and managed using a master microcontroller through a multi-drop universal asynchronous receiver transmitter (UART) serial interface. The serial interface supports the use of CAN transceivers for a more robust physical layer.

CANoe is a software tool for development and testing that is utilized by automotive manufacturers and suppliers. It offers a range of capabilities including development, analysis, simulation, testing, diagnostics, and start-up of ECU (Electronic Control Unit) networks and individual ECUs. The CANoe simulation is connected to a real ECU using a HW interface from Vector, like VN1640A (Fig. 3).

Fig. 3 – ECU to USB Connection.

For testing phase of an ECU, the entire network is simulated into CANoe, excepting the real ECU which is connected to the simulation (Kobbert *et al.*, 2019).

2. System presentation

LMM is used in Automotive industry for Adaptive Lighting Solutions, as part of the adaptive automotive headlight system. LMM is a compact device for large arrays of high-brightness LEDs in automotive applications. This device provides an opportunity for designers of high-performance automotive matrix lighting applications to shift to higher current devices while simultaneously shrinking the solution size and enhancing design flexibility.

In most of the actual cases the LEDs are controlled using an LMM device (LED Matrix Manager device). It communicates with ECU trough UART (Universal Asynchronous Receiver-Transmitter) via CAN hardware interface. The communication (a part of interest for ECU requests and LMM response) can be tested using a CANoe simulation designed in this way. The CANoe simulation is connected to the CAN bus, between ECU and LMM trough a CAN to UART communication convertor. This implementation offers the possibility to synchronize the CAN communication (signals) with PWMs values for each LED.

A connection set-up schematic is presented in Fig. 4.

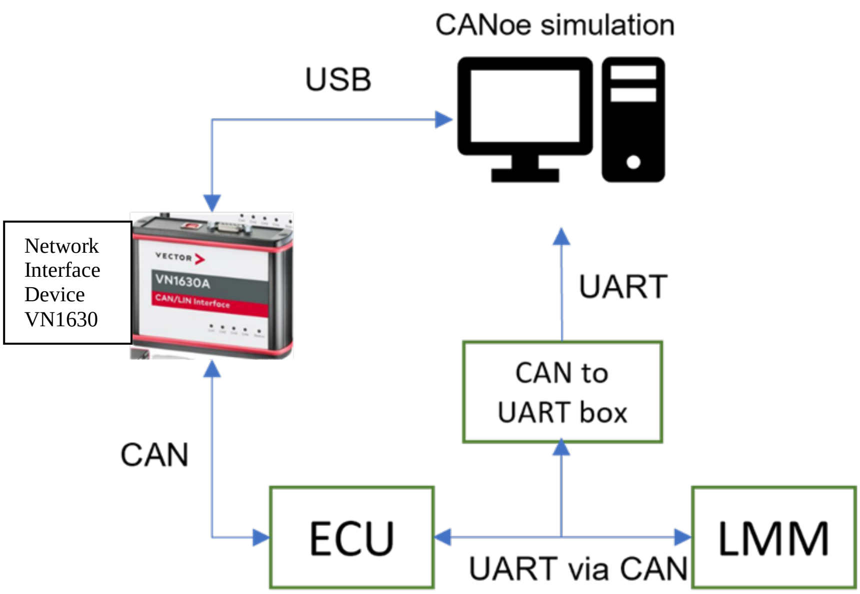


Fig. 4 – CANoe -LMM sniffer connection.

CAN to UART device is an HW interface used to connect CANoe simulation to the UART line between ECU and LMM device.

The CANoe simulation runs on a PC which receives the information from the HW device (CAN to UART device) on serial port (RS232). The computer sends the commands to the ECU via USB, using a Vector Network interface device (VN1630A). The ECU communicates serially with LMM via CAN (Hartono *et al*., 2018). LMM can be driven via a dedicated ECU or via a virtual or simulated ECU (Bidkar *et al*., 2021).

Fig. 5 presents the list of functions implemented in CAPL (CAN Access Programming Language) for the LMM sniffer simulator.

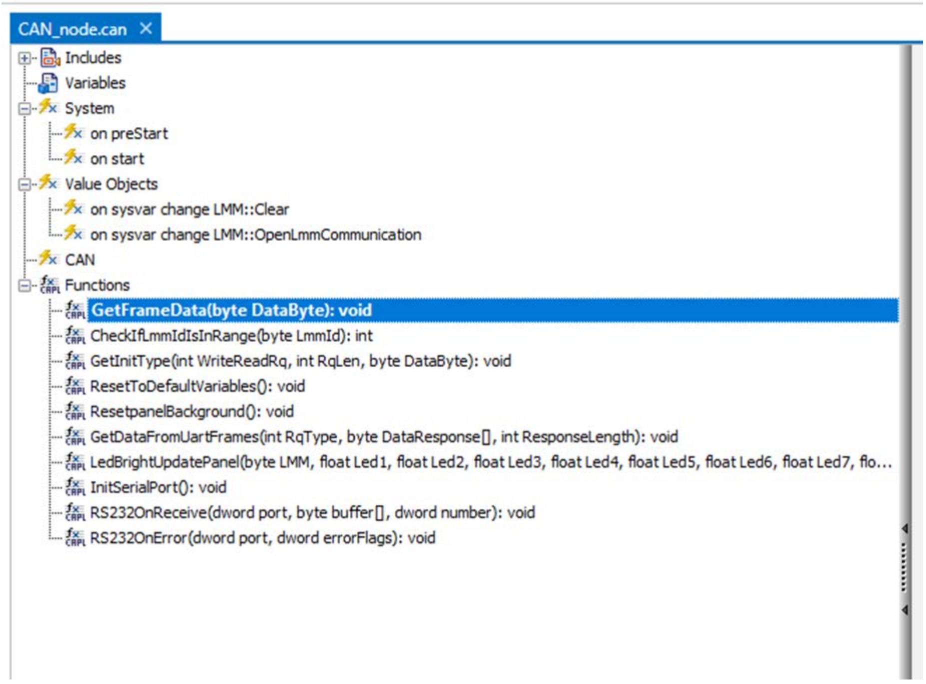


Fig. 5 – Implemented CAPL functions.

Table 1 describes each function and the connections between them.

Table 1
CAPL Functions

Function Name	Description
GetFrameData	*The function detects the presence of a CAN frame and reads the information from known frames based on Can ID.* *The function calls GetInitType function for*

	each known data byte. *The function calls CheckIfLmmIdIsInRange for checking the LMMs IDs.*
CheckIfLmmIdIsInRange	*The function is checking if the LMM ID is valid.*
GetInitType	*Performs and initialization when a frame is received.*
ResetToDefaultVariables	*The default values for PWMs are set to -1.*
ResetpanelBackground	*Set the initial stat of the panel. Reset the Panel LEDs color to Grey (All LEDs are initially turned OFF).*
GetDataFromUartFrames	*Get and store the PWM value received on UART for each LED.* *Call LedBrightUpdatePanel function.*
LedBrightUpdatePanel	*Display into the panel the PWM value of each LED and set the corresponding color (brightness)*
InitSerialPort	*Serial port initialization*
RS232OnReceive	*Handles received packages*
RS232OnError	*Error handler and display user information*

In Fig. 6 it is presented a block diagram of the sniffer in one execution loop. The diagram contains 3 different categories of functions:

•Functions for Serial Port handling (*InitSerialPort*, *RS232OnReceive*, *RS232OnError)*

Those functions are handling the information traffic through the serial port, including the error management task.

•Functions for Communication frames (*GetFrameData*, *CheckIfLmmIdIsInRange*, *GetInitType, GetDataFromUartFrames)*

Those function are responsible with the CAN frames analysis, with checking the IDs of the nodes involved into the CAN network and with the identification and collection of the target data.

•Functions for user interface control (*ResetToDefaultVariables*, *ResetpanelBackground*,*LedBrightUpdatePanel*) are responsible for real time update of the information available for the user.

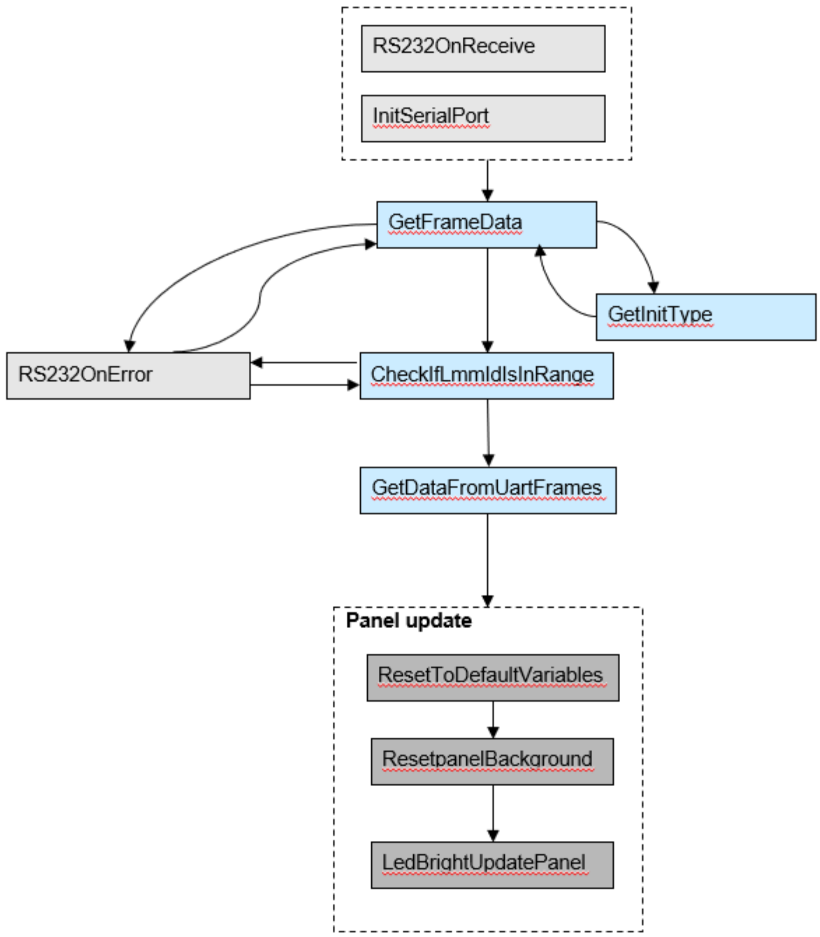


Fig. 6 – Block diagram for one the execution loop.

3. Results and discussion

The presented simulation can read in parallel 7 LMM devices with 12 LEDs each. The panel is configurable, and it can be used also for less than 7 LMMs or for smaller LMMs.

When it comes the need for more LMMs or for a higher number of LEDs, the panel needs to be updated but the technical solution is limited only by the communication speed.

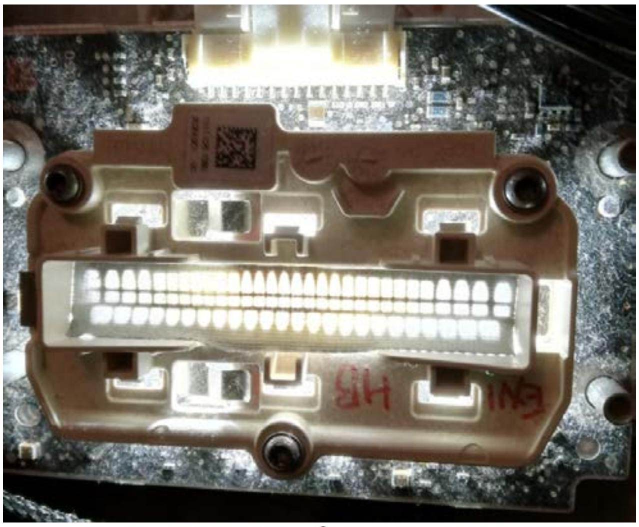
Figure 7 shows the communication information and the PWM value for each LED, values received via CAN UART. The PWM values are set by the user via USB-CAN or can be automatically set by the ECU, according to the implemented light algorithm.

Fig. 7 – PWM values read via CAN UART.

In the pictures below (Fig. 8 a,b and c) are shown 3 different use cases for a real LMM behaviour. The commands are sent via CAN bus through CAN messages, the LMM device performs the commands and LMM sniffer shows the feedback from the hardware device.

The LMM picture from each use case demonstrates that each LED receives the signal correctly and the LED is turned ON with the right PWM value received on CAN bus. In each use case the light distribution is visible and a prediction about light beam could be done.

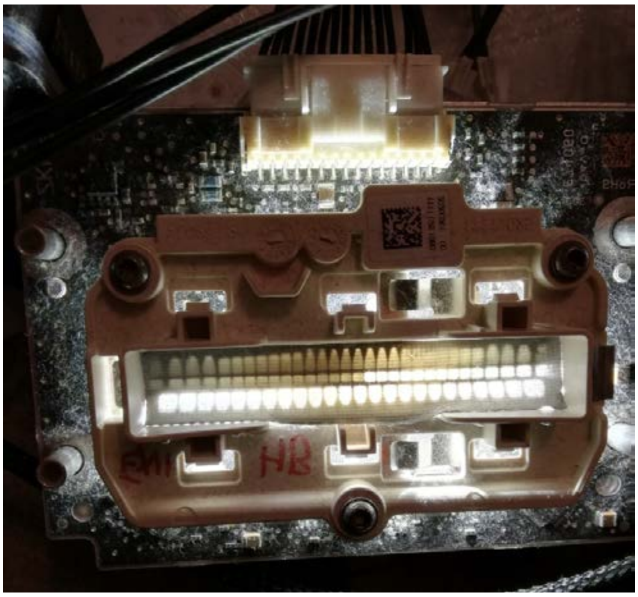
The LMM used for test has 3 channels and it has in total 84 LEDs. In Fig. 8a) it executes the command for High Beam ON. In this case all LEDs have the PWMs higher than 0%. The PWM values are distributed according to the requested beam. Not all LEDs can be ON with 100% PWM due to the consumption and thermal constraints but also due to the beam requested form and focus. In Fig. 8b) only the LEDs dedicated to Low beam are ON with different PWMs value. This light function must not disturb or cause discomfort to oncoming drivers and other road-users. For avoiding that, the light beam must strike the left side and down. In Fig. 8c) are presented 2 glare free areas, due to the detection of 2 objects in front of the car. In the last case, it could be observed that some LEDs in the upper row have the PWM turned to 0, corresponding to the position of the two detected objects. The Glare Free High Beam light function is allowed only on High Beam due the legal contains.



8.0	9.0	10.0	11.5	12.0	13.0	15.5	19.5	22.5	28.5	35.5	44.5	55.0	68.0	82.8	82.8	68.0	55.0	44.5	35.5	28.5	22.5	19.5	15.5	13.0	12.0	11.5	10.0	9.0	8.0
5.0	6.0	7.5	9.0	9.5	11.5	13.0	16.5	21.0	24.5	30.5	38.0	51.5	65.0	83.0	83.0	65.0	51.5	38.0	30.5	24.5	21.0	16.5	13.0	11.5	9.5	9.0	7.5	6.0	5.0

10.0	11.0	12.0	13.0	16.5	21.0	24.5	29.5	30.5	32.5	34.5	34.5	34.5	34.5	32.5	30.5	29.5	24.5	21.0	16.5	13.0	12.0	11.0	10.0

Fig. 8a – High Beam ON.



0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.5	35.5	34.0	32.0	30.0	27.5	25.0	22.5	20.0	17.5	15.0	12.5	10.0	7.5

11.0	12.5	14.0	15.5	17.0	18.5	20.0	21.5	16.8	17.8	18.8	30.3	32.3	34.5	34.5	34.5	34.5	33.5	31.5	28.5	25.5	22.5	19.5	16.5

Fig. 8b – Low Beam ON.

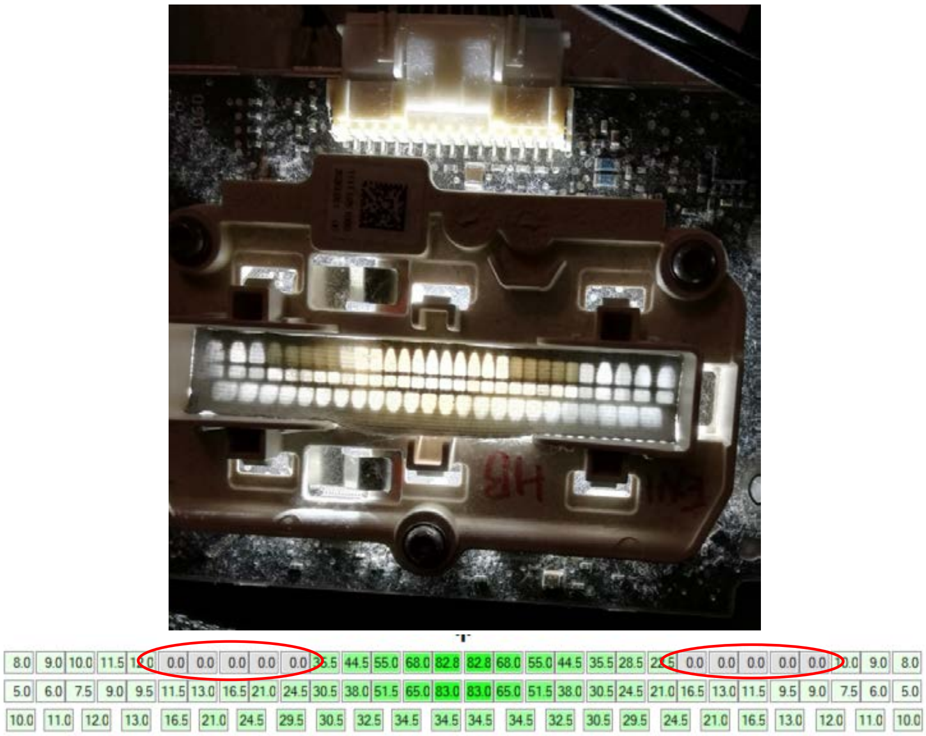


Fig. 8c – GFHB with 2 detected objects.

The LMM sniffer can be used for any LMM format, for multiple LMMs and different number of LEDs. It was developed in a generic format to fit any LMM shape and type (Chen *et al*., 2019).

The presented simulation can be used in the development stage of a light product with LMMs, to analyse and predict the errors that may occur. The most common error is related to the PWM's value: one value is set but another value is reported. Another error is related to the mapping of LEDs on the matrix: the command is sent for LED number x, but it is received by the LED number y. Such errors are often encountered in the development of automotive software, due to human error during the implementation phase.

Fig. 9 shows how the errors are displayed when a difference is detected between the simulation and measurement data. The LEDs colored in orange need further investigation due to the different PWM's value detection.

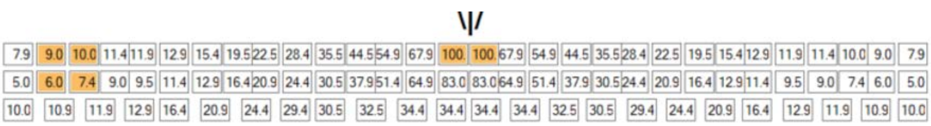


Fig. 9 – Errors display.

4. Conclusion

In present there is no standard solution available for sniffing the UART via CAN communication between an ECU and LMM. The fast evolution of lighting solutions in automotive field leads to the need of developing, in a short time, solutions for testing these new light products.

The benefits of the sniffer are:

- Detects the root Couse of an issue
- Offers performance metrics
- Provides communication details
- Monitors the requirements compliance

The simulation was performed only for 7 LMMs with 12 LEDs but it can be adapted to less or more LMMs according to the needs. Using the LMM sniffer the light distribution for each headlamp is known and could be compared with the optical measurements for the final validation. The main advantage of simulation is that it offers the possibility to modify the original draft before the production, without substantial cost.

REFERENCES

Barrera González A., Castellanos Serrano L.T., Cervantes Bazan J.V., Medel Juárez J. de J., Ruiz Castilla S., *Study for the selection of the optimal method for managing LED arrays, part II programming*, 2018 XXXI International Summer Meeting on Power and Industrial Applications (RVP-AI), 15-20 July 2018.

Bidkar S., Patil S.L., Shinde P., *Virtual ECU Development for Vehicle Diagnostics Software Testing using UDS Protocol*, Published in 2021 Asian Conference on Innovation in Technology (ASIANCON), 27-29 Aug. 2021.

Chen W., Fan J., Qi G., Sun C., Yang W., Cao S., *Optical and Thermal Designs of LED Matrix Module used in Automotive Headlamps*, Changzhou Institute of Technology Research for Solid State Lighting, Changzhou 213161, China., 2019 16th China International Forum on Solid State Lighting & 2019 International Forum on Wide Bandgap Semiconductors China (SSLChina: IFWS), 25-27 Nov. 2019.

Hartono A., Syafrudin H., Hasbi W., Yatim R, *Implementation of CAN Bus Communication to UART in LAPAN-A4 Satellite*, Published in: 2018 IEEE International Conference on Aerospace Electronics and Remote Sensing Technology (ICARES), 20-21 Sept. 2018.

Kobbert J., Kosmas K., Khanh T.Q., Laboratory of Lighting Technology, Technische Universität Darmstadt, Darmstadt, Germany, *Glare-free high beam optimization based on country road traffic simulation*, Article first published online: November 14, 2018; Issue published: October 1, 2019.

Luo C., Xin G. Xu H., Tang W., *Glare-Free High-Beam Control for Oncoming Vehicle Safety in Nighttime*, Published in: IEEE Consumer Electronics Magazine (Volume: 10, Issue: 2, March 1 2021).

ANALIZOR DE COMUNICAŢIE PENTRU MATRICI DE LED-URI

(Rezumat)

Această lucrare prezintă o soluție simulată pentru sincronizarea comunicației pe CAN, care se bazează pe semnale cu modularea în lățime a impulsurilor (PWM) pentru fiecare LED conectat la un dispozitiv de gestionare a matricei de LED-uri. Folosind soluția prezentată, utilizatorul este capabil să citească și să verifice fiecare LED și reprezintă o abordare de testare foarte ușoară și rapidă pentru iluminatul auto cu dispozitive LMM (LED Matrix Manager). Informațiile furnizate de analizor îmbunătățesc timpul de detectare a cauzei principale a erorii, oferă o imagine de ansamblu asupra conformității cerințelor și asigură o monitorizare eficientă a comportamentului LMM. Analizorul de comunicație pentru LMM este dezvoltat din cauza lipsei unei soluții standard dedicate în acest scop.