

# Design and Implementation of a Light Information Panel for Safety Car

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**Abstract**—Car racing is dynamic and exciting sport, but there is a significant risk. Safety of racers, teams and spectators is on the first place always. A safety car is special vehicle designed for control of situations on the track, it has an indispensable role in this process. For effective communication with riders is essential to use clear and distinct visual signals, that are visible for riders which drive in high speeds. In this project we are created display panel from matrix displays, which allows different messages to be displayed according to the current needs. The current solution uses Arduino controller and buttons to manually switch messages. Although this system is functional, its limitations motivated us to look for more modern and flexible solutions that would better suit the needs of the racing environment.

**Keywords**—safety car, light information panel, visual signals, Arduino

## I. INTRODUCTION

Car racing is one of the most demanding sports where speed and precision play a key role. However, safety on the track must always come first. The Safety Car, a special vehicle deployed in critical situations, is an essential tool for race management during accident situations or other threats.

Although that safety car communicate effectively with drivers, it is necessary to use a reliable and clear visual signals, which are easy to read in high speeds. As a result for these needs, we decided to create display panel from matrix display. This project has a goal to improve safety elements racing environments with help this technology, that is simple, flexible and adaptable to needs of every events.

## II. CURRENT SOLUTION

In the current version we used components:

- Controller Arduino Mega 2560
  - o This controller is the heart of this system. This microcontroller board has a lot of I/O pins and equipped powerful ATmega2560 processor. The original solution was based on the Arduino Uno, but it was insufficient due to low RAM.
  - In this system it is used for:
    - o Signal processing from the pushbutton
      - Control of LEDS panels
      - Signaling status changes via LED
    - o Advantages:
      - Reliable operation in simple applications.
      - Availability and support in the Arduino community.
    - o Disadvantages:
      - No integrated support for WiFi or Bluetooth.
      - Limited options in dynamic applications.
  - Stepdown inverter XL-4016 [1]
    - o This is DC-DC stepdown inverter, which reduces voltage from source (for e.g. car

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battery) on the level acceptable for the power supply to Arduino and LED panels. This component is very important for ensuring a stable power supply to the system.

- o Technical parameters:
  - Input voltage: 5 – 36 V.
  - Output voltage: adjustable 1,25 – 35V.
  - Maximal output current: 8A.
- o Main function:
  - Reduces voltage from 12V to 5V
  - ensuring a stable current for sensitive components.
  - The WS2812B LED panels have specific power requirements (5 V) that must be accurately met for proper operation.
- LED panels: WS2812B[2]
  - o WS2812B are addressable RGB LED panels, that every LED has own integrated drive. This can create a different light effects with minimal count of wires. The system uses four panels combined into one large display device.
  - o Main features:
    - Addressable LED with full color spectrum RGB
    - Communication via single wire protocol
    - High luminance that is sufficient even through blackout films in vehicles
  - o Advantages:
    - Flexibility in displaying messages or graphic elements.
    - Simple control via microcontroller.
    - Low power consumption compared to traditional LED systems.
    - Price
  - o Disadvantages:
    - Sensitivity to voltage deviations.
    - Need to ensure good cooling under prolonged high loads.
    - With the WS2812B LED, the signal is propagated serially through each diode. If one LED is damaged, the data to the others in the chain will be interrupted, causing them to become inoperable.
- Button and LED diode
  - o Button is as simple control element for switching messages on the display. Each push moves show message to next message in the list. The LED serves as feedback for the operator - it flashes each time the message changes.
  - o Advantages:
    - Ease of use.
    - Simplicity of implementation.
  - o Disadvantages:
    - Limited functionality (sequential switching only).
    - Manual counting of positions of displayed messages may be impractical.

How these component work together:

1. Power supply: The XL4016 stepdown converter reduces voltage to 5V, which supply Arduino and LED panels.
2. Control: Arduino Mega 2560 processes signals from button and controls the LED panels according to a preset program.
3. Display: WS2812B panels display messages based on signals from the Arduino. Each message is assigned a specific text
4. Signaling: LED diode provides visual feedback on changes in system status.

Control panel is located at the driver's side of the safety vehicle. The system is powered on via a switch that activates the stepdown converter, Arduino and display. The messages are toggled via a button, with each change confirmed by flashing LEDs.

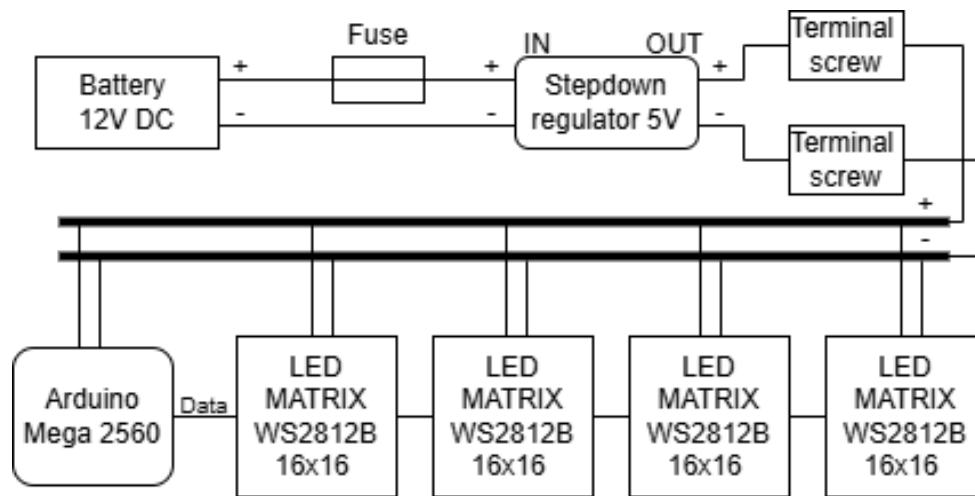


Figure 1: Block Diagram

This program was created in the Arduino IDE, using the libraries from Adafruit, specifically **Adafruit\_GFX Chyba! Nenašiel sa žiaden zdroj odkazov.**, **Adafruit\_NeoMatrix Chyba! Nenašiel sa žiaden zdroj odkazov.** and **Adafruit\_Neopixel Chyba! Nenašiel sa žiaden zdroj odkazov.** to control the LED matrix. These libraries make it easy to render text and graphical effects on the matrix and they provide high flexibility in customizing the display. It was necessary to create a custom font in the required sizes and with clear enough letters even from a distance, which I created using the online Adafruit-GFX Font Customizer tool. **Chyba! Nenašiel sa žiaden zdroj odkazov.**

This solution provides basic functionality but there is a few limitations:

- Wiring installation – Control panel must be positioned within reach of the driver and this adds to the complexity of installation.
- Control with only one button – Each message has predefined order and operator has to count the LED flashes to know which message is currently displayed, which is impractical in a dynamic race environment.
- Complicated adding new messages – Each extension or edit messages need programming and flash new program to microcontroller, what is time-consuming and unsuitable for users without technical knowledge.



Figure 2. Panel functioning example

### III. TESTING THE NEW APPROACH

To overcome these limitations, we started testing a new approach based on the ESP32 **Chyba! Nenašiel sa žiaden zdroj odkazov.** microcontroller. This advanced platform offers several advantages:

- WiFi and Bluetooth connectivity is direct integrated into ESP32, that is eliminating need for additional modules
- Web control – we created simple website, which provides control of panel via smartphone connected via WiFi network created by ESP32. This change remove need of wiring remote control.

This updated system significantly simplified installation because wires for remote control was not needed. Operator could control the panel via an intuitive interface on a smartphone. However, control via smartphone is not the best solution when it is designed to racing environment. In critical situations, the operator requires fast and reliable physical control that touchscreens cannot provide.

### IV. FUTURE

Based on our experiences we will design a new device, which combined flexibility of ESP32 with comfort physical control. The new proposal offers two ESP32 devices, which are communicate via protocol ESP-NOW:

1. Main ESP32 – control matrix display and provides message display
2. Control ESP32 – this includes a lot physical buttons, which are equipped LEDs. These LEDs serve as a backlight and indicator actual active message

The physical buttons will be designed to be easy to feel and use, even in dark or pool light conditions. Communication between ESP32 is wireless, what eliminate the need a wired communication between control panel and display. Installation is simpler and flexible. Also, this system will be provide that operator could add new messages via application without programming. In this way, the user can adapt the messages to the actual needs without technical knowledge.

Advantages and goals:

The new system brings several key benefits:

- Fast and intuitive control – physical buttons minimalize distraction of operator
- Simply installation – wireless communication reduces count of wires and installation is faster
- Customizability – the user could change messages without flashing of new software

### V. CONCLUSION

Lighting panel from matrix display for safety vehicle is a useful thing to ensure safety during racing. Although the current solution provides basic functionality, new proposal with ESP32 and ESP-NOW bring a new possibilities for flexible, user-friendly and efficient solution.

For professional use, for example in the integrated rescue system, this system would require testing and certification, which is very expensive for a small production. However, this project is excellent example of application of modern technology to practical use in the dynamic environment of motor racing.

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