



Adaptable Full Array Local Dimming Solution with FPGAs

A Lattice Semiconductor White Paper.
July 2023



Learn more:

www.latticesemi.com



Contact us online:

www.latticesemi.com/contact
www.latticesemi.com/buy

TABLE OF CONTENTS

Section 1	 Intro	Page 3
Section 2	 Displays Abound In Next-Gen Vehicles	Page 3
Section 3	 Local Dimming	Page 4
Section 4	 Relying on Artificial Intelligence	Page 5
Section 5	 FPGAs For Local Dimming	Page 5
Section 6	 Lattice Local Dimming - System Block Diagram	Page 6
Section 7	 Go With the Leader	Page 7

From a distance, today's automobiles may look like those from a couple of decades ago, but nothing could be further from the truth. What's taking place inside the cabin, under the hood, and even inside the tires, is vastly different, with improvements everywhere.

One current trend is the move toward a software-defined vehicle, where control of many of the vehicle's functions and features are centralized. This is achieved by leveraging microprocessors, sensors, and software algorithms to enhance vehicle performance, functionality, and user experience. Some key aspects of a software-defined vehicle include centralized computing, over-the-air (OTA) updates, and Cloud communications.

Then there's the electrification of the vehicle. This refers to the process of replacing or supplementing traditional mechanical components with electronic components. The largest of these is obviously the motor. The transition to electric vehicles (EVs) largely began with the hybrid model, whereby the automobile was designed with both a gasoline-powered engine as well as an electric motor, but has continued to automobiles powered solely by electric motors. EVs are more environmentally friendly, as there are no local emissions, and they reduce our dependency on fossil fuels, a global ESG issue.

The next step beyond the software-defined and electrified vehicle is the autonomous vehicle. Again, this move is occurring in steps, with advanced driver assistance systems (ADAS) growing in functionality. Today's ADAS systems take advantage of sensors, cameras, radar, and other components to monitor the vehicle's surroundings, collect data, and assist the driver. These systems provide real-time feedback, warnings, and interventions to mitigate potential hazards on the road. Common ADAS features today include adaptive cruise control, lane-departure warnings, automatic emergency braking, blind-spot detection, and parking assistance systems. As these features take on more responsibility, there will eventually come a time where a car's compute system has complete control over the car.

Displays Abound In Next-Gen Vehicles

And then there's the "entertainment" feature which, in terms of modern automobiles, means integrating all the features that you'd find in a next-generation smartphone, such as Wi-Fi, Bluetooth, GPS, streaming audio and video, and so on. To provide these features, appropriate displays are needed in various locations throughout the car, including the central entertainment hub, the instrument cluster, heads-up displays, and the rear displays. In some cases, manufacturers are deploying displays as mirror replacements.

When it comes to those displays, you might think that OLEDs (organic LEDs) are the obvious choice, as vehicle lighting conditions run the gamut from full sunlight to near complete darkness, and viewing angles range from straight on to very wide. But while the OLEDs offer great contrast ratios, they lack in brightness when compared to the backlit LCDs. In addition, OLEDs are known to experience lifetime issues, as their different colors age at different rates, affecting the image quality over time.

For some of those reasons, manufacturers are sticking to the tried and true LCDs, which are widely available in various sizes and resolutions. An important consideration is obviously the cost, and LCDs offer good value due to their mature manufacturing process and reliability in the harsh automotive temperature environment. LCDs also typically have a longer lifespan than OLEDs. The organic materials used in OLEDs degrade over time, which can result in image retention and color shifts. LCDs, on the other hand, are less prone to such issues and can maintain their image quality over a longer period.

In addition, designers strive to remove latencies from their automotive displays, for a host of reasons. For example, they can impact driver safety, and affect the user experience through (lack of) synchronization of multiple displays in the vehicle.

Local Dimming

Standard LCD displays typically use a backlight, which is a uniform light source positioned behind the liquid crystal layer. To create an image, the liquid crystals open or close to control the amount of light that passes through each pixel. However, even when the crystals are closed, some light from the backlight can leak through, resulting in less-than-perfect black levels and reduced contrast.

Consumers have become accustomed to the high contrast displays of their smartphones and TVs, and automotive displays must live up to that standard. Local dimming is one popular option to produce high contrast, brilliant images that consumers have come to expect, which is especially beneficial in the tough lighting environment of vehicles.

As the trend of adding more, higher quality LCDs to the automobile continues, local-dimming technology is finding itself in the car. Local dimming is designed to enhance the contrast ratio and improve black levels by selectively dimming or turning off certain areas of the screen's backlighting. This is accomplished by dividing the backlight into multiple zones. Each zone can be independently controlled to adjust its brightness or turn off entirely. When a particular part of the image requires a darker area, the local dimming algorithm reduces the backlight intensity in that specific zone, effectively darkening the corresponding pixels.

There are two main types of local dimming technologies, full-array and edge-lit. With edge-lit local dimming, the LEDs are located along the edges of the display panel, illuminating the entire screen using a light guide or diffuser, and local dimming is achieved by dynamically adjusting the brightness of different LEDs along the edges. Full-array local dimming, which offers more precise control and can produce better contrast and black levels, involves an LCD panel with an array of LEDs positioned directly behind it. The LEDs are divided into zones, which can be individually dimmed or turned off. The number of zones employed directly affects the performance, but makes the design more complex.

Local dimming in automotive applications can be a compute-intensive function, as the algorithms required are relatively complex. In addition to accounting for the various zones, the software must continuously monitor the lighting conditions, which obviously change continuously as the automobile is driven, potentially from daylight to darkness, through different weather condition, through tunnels, etc.

The local dimming algorithms consider the detected ambient light levels and adjust the display's backlighting accordingly. In addition, the algorithms must monitor the content being displayed and adjust the brightness and contrast accordingly based on the specific elements within the content. Glare reduction is also a key factor, as glare from external light sources, such as sunlight or oncoming headlights, can impact the display's visibility. Local dimming algorithms minimize that glare and improve visibility.

Some manufacturers are incorporating Fourier series-based optimization of the LCDs, a technique that uses the principles of Fourier series analysis to optimize the display's output. This approach involves analyzing the desired signal's output characteristics, such as the intensity and color distribution, and then determining the appropriate electrical signals to drive the displays to achieve those characteristics.

Many of the same local-dimming techniques can be used for the car's heads-up display (HUD), which is typically used to project driver information onto the windshield, such as the car's speed, navigation instructions, or warnings. Local dimming for the HUD not only enhances viewability, it also removes the so called "post-card effect," providing a more seamless experience.

Relying on Artificial Intelligence

Like so many areas of design today, artificial intelligence has impacted different facets of local dimming, particularly what is known as deep controllable backlight dimming, which analyzes the content, makes intelligent decisions, and dynamically adjusts the backlighting to enhance image quality and improve the user experience. The AI algorithms continuously adapt and adjust the backlighting based on the changing content and lighting conditions. The AI and ML models can quickly analyze and respond to variations in the content, ensuring that the backlighting remains optimized and in sync with the displayed images.

Those same algorithms can enhance the user experience by improving image quality and reducing artifacts. By leveraging AI and Machine Learning (ML), the algorithms can adapt to different content types, such as videos, games, or text, and optimize the backlighting accordingly to provide a visually pleasing and comfortable viewing experience.

FPGAs For Local Dimming

An FPGA is an excellent choice for implementing local dimming in automotive LCD panels for a bevy of reasons, which include:

- **Real-time processing capability.** Local dimming in automotive LCD panels requires the fast and responsive processing afforded by FPGAs to analyze the content, adjust backlight zones, and control LED brightness.
- **AI and ML.** FPGAs provide the necessary horsepower to run these complex algorithms.
- **Customization and flexibility.** Designers can implement custom algorithms and control strategies specific to the requirements of local dimming in automotive LCD thanks to the characteristics of the FPGAs.
- **High-speed interfaces.** FPGAs typically support a range of high-speed I/O, which is required for the myriad content being displayed on the panels.
- **Resource optimization.** FPGAs allow designers to allocate hardware resources specifically tailored for the local dimming operations. This is done using the FPGA's extensive I/O, as well as local memory that can efficiently handle the complex computations involved in local dimming.
- **High reliability.** Automotive applications require robust and reliable solutions that can withstand harsh environmental conditions, temperature variations, and shock and vibration.
- **Future adaptability.** Automotive displays and local dimming algorithms continue to evolve. FPGAs offer adaptability and upgradability, allowing for the implementation of new algorithms, control strategies, or system enhancements. In addition, FPGAs enable easy migration and flexibility in choice of vendors for LCDs and LED backlighting controllers.

Lattice Semiconductor FPGAs offer all of the features and specifications needed to handle the local dimming application in automotive LCDs including low power, small package size, scalability, appropriate process nodes, and adequate robustness. Lattice Drive™ enables rapid adoption of FPGAs for automotive applications and complements Lattice's history of developing low-power, compact FPGAs that are optimized for automotive applications.

For the first release of Lattice Drive, display interfacing and processing is a focus, providing reference designs and demos, custom design services, software tools, IP cores, and hardware platforms. As an example, the Lattice Nexus CertusPro-NX™ FPGA enables flexible interfacing, including DisplayPort at up to HBR3 (8.1gbps), which is used to connect multiple screens at high resolutions and refresh rates over a single cable. The CertusPro-NX is scalable and adaptable for the use of multiple zones and different panels and permits the inclusion of control for various LED driver ICs.

Lattice Local Dimming - System Block Diagram

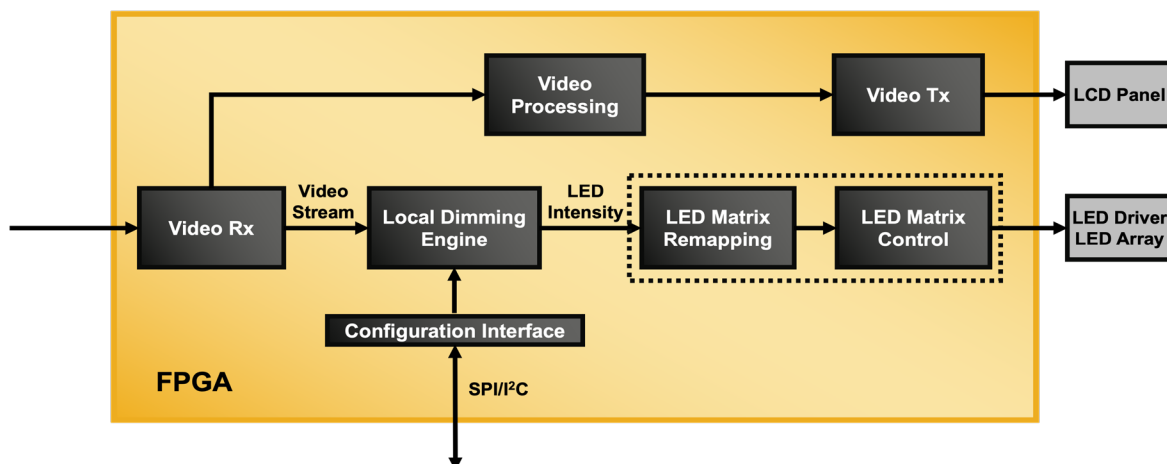


Figure 1
Single Chip Flexible Customized Solution

Using the Lattice CertusPro-NX FPGA, one IC can handle almost all of the required functionality to implement local-dimming in automotive-based LCD panels. The Nexus FPGA platform permits the use of hundreds or even thousands of zones, if needed.

A key challenge that the designer faces today in this application includes having a high number of LEDs that need to be controlled, no standard LED driver interface, and different board designs and layouts. The Lattice Nexus™ FPGA platform helps solve these issues thanks to higher precision timing control for scan-line switching, a rich mix of I/O interfaces, support for most LED driver ICs, and the ability to remap the LED matrix.

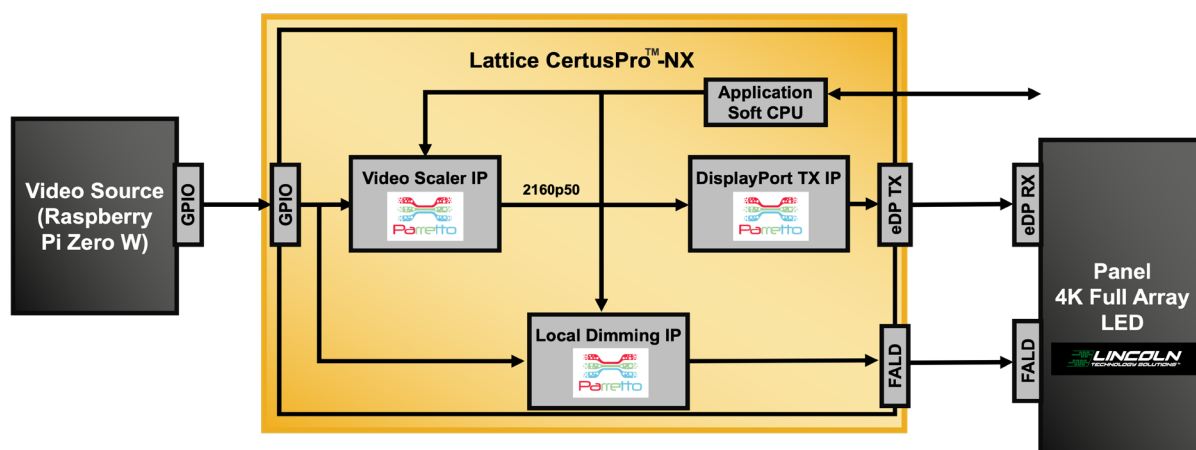


Figure 2

Shown is Lattice's DisplayPort, video scaler, and local-dimming demonstration that was designed and created in partnership with Parretto and Lincoln Technologies Solutions.

Lattice has assembled a demo that clearly shows how local dimming can work. It is built around a Raspberry Pi board that streams a 720p video at 50 Hz over GPIO to the company's CertusPro-NX FPGA. The internal video scaler takes that video data and scales it up to 720p at 50 Hz. Simultaneously, the local-dimming feature dynamically controls the panel's full LED array backlight. From there, the DisplayPort transmit IP takes that upscaled video and streams it in an HBR2 (by 4) format to the 4k-pixel panel. Finally, the panel displays the video while the full LED array backlight is under constant control.

In summary, the reasons to go with the Lattice Nexus platform for automotive local-dimming applications are many. They include a cost-effective, single-chip solution that maximizes flexibility, support for all popular video interfaces, including LVDS, eDP, MIPI, and V-by-One, etc., low processing latency, 8.1-Gbit/s transmissions, and 12-bit internal processing precision.

Go With the Leader

As the leader in low power programmability, Lattice has set the standard for what low-power, small form factor FPGAs can do in terms of performance and power consumption. And the company has earned and maintained that position through a culture committed to customer support and consultation.

Lattice has made available innovative solutions based on Nexus that combine design software and pre-engineered soft IP blocks with evaluation boards, kits, and reference designs. To learn more about the Lattice Nexus platform or its Lattice Drive stack, contact your local Lattice sales representative.



Learn more:

www.latticesemi.com



Contact us online:

www.latticesemi.com/contact
www.latticesemi.com/buy