Simplifying the Design of Bigger, Higher Resolution Automotive Displays

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Abstract

Much like living room TV screens, automotive displays are getting bigger and delivering higher quality resolution. Infotainment and instrument cluster systems are driving this trend. Delivering the performance expected by consumers calls for compact electronic components that support low-temperature polysilicon process (LTPS) panels, address electromagnetic interference (EMI) concerns, and provide the dimming capability needed for better readability. This paper discusses the challenges of designing bigger, higher resolution automotive displays and how light-emitting diode (LED) backlight driver technology can help simplify the process.
Introduction

Enabling High-Performance, High-Definition Displays

When you step inside a new car today—especially an electric or hybrid vehicle—you’ll be greeted with large, razor-sharp screens displaying everything from vehicle performance metrics to blind-spot views to your music playlist. You currently control them via touch or voice and in the future, they’ll support new interactive capabilities, much in the way that smartphones and tablets are evolving. Connected cars provide safety functions as well as a more engaging ride. While displays larger than 8 inches are quite common now, analysts project that by 2023, we’ll begin to see screen sizes greater than 34 inches inside our cars. Screens that are greater than 10 inches will show a variety of different content, with touch- or mouse-based controls and even split-screen formats. On the resolution front, 4K and, eventually, 8K will become standard. Not only are screens getting larger and sharper, there will also be more of them in tomorrow’s vehicles, especially as the industry progresses toward Level 5 fully autonomous vehicles. Already, many cars have up to eight displays inside for features like the instrument cluster, the center information display (CID), the smart back mirror, heads-up display (HUD), rear seat mount on the head support, and rear seat mount on the roof. According to IHS Market, by 2025, nearly half a million side-view camera display systems will replace side mirrors each year in new vehicles. So, cars with up to 10 displays inside are coming. Figure 1 shows the rate of growth of the automotive display market over the next few years.

In this paper, we’ll highlight key design challenges associated with designing bigger, higher resolution displays and discuss what to look for in LED backlight driver technology to overcome these challenges.
Achieving Optimal Display Performance

Automotive displays, particularly the center stack and the instrument cluster, are commonly based on thin-film transistor (TFT) liquid crystal display (LCD) technology (See Figure 2). In 2017, TFT LCD displays had a 60% share of the market, according to the Automotive Display Market Tracker. Inside these types of displays are tiny switching transistors and capacitors that are arranged in a matrix pattern on the display glass. The action of the TFT element is similar to a switch, and the role of the liquid-crystal element is similar to that of a capacitor; i.e., the switch of the ON/OFF updates/holds the stored voltage values of the capacitor. When the switches turn on, the signal on the source line is written (added, recorded) on the liquid-crystal capacitor. The source line signals the capacitor (in the form of voltage) in order to control the deflection angle of the liquid-crystal molecule to realize the display. When necessary, the holding capacitor is connected in parallel with the liquid-crystal capacitor to improve its retention characteristics. The gate line controls the TFT ON and OFF. When the switch is off, the switch prevents the signal from leaking out of the liquid-crystal capacitor. In this section of the paper, we’ll highlight some of the key challenges that can hamper display performance and present some ways to overcome these challenges.
**Screen Size and Current Levels**

The larger the screen size, the more current is required to drive these higher voltages. At these levels, the timing controller (TCON) is unable to provide the currents needed. In smaller screens, the TCON can easily meet current supply requirements. For displays over eight inches, a separate TFT bias or PMIC is needed. As a result, an LED driver integrating TFT bias can save customers board size and lower the BOM cost. For displays in the range of 8 to 14 inches, LEDs 10-11 in series with 4 in parallel and up to 130mA per channel are usually needed. Thus, an LED driver with four channels, output maximum of 52V, and up to 150mA per channel, is ideal for this application.

**Supporting LTPS Panels**

Another display trend that is creating a new challenge is the move from amorphous silicon to LTPS panels. With amorphous silicon, the grain size in the TFT technology is quite small, so the electrons moving through these grains will move through slowly. LTPS, on the other hand, has a larger grain size, which increases mobility of the electrons and allows for faster responding panels.

The larger and more uniform grains of polysilicon (poly-Si) allow electrons to flow 100x faster than they do through the random-sized grains of amorphous silicon (a-Si), enabling higher resolutions and higher speed. Supporting these faster responding panels, however, calls for both a positive analog supply voltage (PAVDD) and a negative analog supply voltage (NAVDD) as well as regulated output voltages (VGH and VGL) to bias the TFT. While PAVDD and NAVDD aren’t requirements for LTPS panels, the market is trending in this direction.

**Dimming Capabilities**

Dimming capabilities are a consideration that affects display performance. When a vehicle is traveling through a very bright and sunny environment, the displays will require more current to provide the screen visibility that the driver will need. Conversely, when the car is going through a dark stretch, like through a tunnel or at night without much moonlight, that high level of current won’t be ideal because it will result in screens that are too bright. In these cases, the current levels will need to be adjusted down so that the displays can become as dim as possible while still being readable for the driver. An LED driver with a high dimming ratio can address this challenge.

**Mitigating EMI**

EMI is an ever-present challenge for many types of electronics. For vehicles, there are both internal as well as external sources of RF electrical noise that can hamper performance and reliability of the displays in advanced driver assistance systems.
Inside today’s vehicles, there are so many electronic components in various subsystems, all placed close to one another in a relatively confined space, that RF electrical noise is bound to be a factor. AM/FM radio interference is one of the more obvious hindrances. Automotive OEMs are responsible for mitigating excessive EMI from their electronic systems. CISPR 25 from the International Special Committee on Radio Interference provides a standard for conducted and radiated emissions in vehicles. Switching at 2.2MHz, spread-spectrum frequency modulation, phase-shifting capabilities, gate slew rate control as well as hybrid dimming can reduce EMI.

Flexible Sequencing
Some OEMs use displays from different panel makers in their vehicles. This can present challenges from a timing standpoint. Since each panel would likely have different power rails to turn on first, you would need to ensure that you can easily manage the sequence in which each of the displays powers on. Any TFT bias IC which has flexible sequencing can be used across all panel makers’ displays.

Automotive TFT Bias with LED Driver for High-Performance Displays
Maxim has an automotive-grade power IC that brings together a 4-channel, 150mA LED backlight driver and a 4-output TFT-LCD bias. Available in a 6mm × 6mm 40-pin TQFN package, the MAX20069 is ideal for displays 8 to 12 inches and beyond, featuring:

- Integrated TFT bias and LED backlight driver to support bigger panels, reducing solution size and saving bill of materials (BOM) cost
- PAVDD, NAVDD, VGON, and VGOFF to support LTPS panels
- A 10,000:1 pulse-width modulation dimming ratio at 200Hz to support high dimming ratio needs
- Spread-spectrum on the LED driver and TFT, phase-shift dimming of LED strings, and selectable switching frequency to mitigate EMI
- Flexible resistor-programmable sequencing to support different TCON and panel makers
- Boost/SEPIC technology to serve different LEDs in a series

The MAX20069 can enable functional safety via on-board diagnostics through I²C. When the IC detects a failure in a string in the LED, it can alert the microcontroller of the location of the failure via I²C. The microcontroller can then either increase the current of the other channels on the LED or, if appropriate, send the driver an alert of a malfunction in, say, the instrument cluster. Figure 3 provides an example sub-system block diagram. MAX20069 can also be used in standalone mode if the application doesn’t require I²C.
Today’s vehicles are like smartphones on overdrive, with touch- and voice-based controls for a variety of safety and infotainment features. As a result, automotive displays are getting sharper and bigger and will likely continue in this direction as the industry advances toward fully autonomous cars. Designing larger, sharper displays calls for compact automotive lighting ICs that address challenges like current and voltage management, EMI, and functional safety. This paper discussed ICs that integrate a TFT bias with an LED driver to enable larger, high-performance, high-definition in-vehicle displays. With this I2C-controlled, 4-channel, 150mA backlight driver and 4-output TFT-LCD bias, automotive display designers can create bigger, higher resolution displays with a reduced design footprint.

**Summary**

**Learn More**

Learn more about technologies for [automotive infotainment](#) and [ADAS](#).

**Sources**

1. New Camera and Display Mirrors Enhance Vehicle Safety and Fuel Efficiency, Challenging Traditional Mirror Solutions, IHS Markit Says

For more information, visit: [www.maximintegrated.com](http://www.maximintegrated.com)