WHITE PAPERS 7328

HOW AUTOMOTIVE DISPLAYS CAN COMPLY WITH FUNCTIONAL SAFETY REQUIREMENTS

By: Szukang Hsien

Abstract: Automotive displays have become key features inside cars, providing important information about vehicle performance, entertainment options like music playlists, and navigation and connectivity functions. Some carmakers are even replacing side and back mirrors with displays. Given the critical role these displays are playing, it is essential that they comply with automotive functional safety standards. This white paper, which was adapted from an article that originally appeared in Power Systems Design on July 9, 2020, examines what is required from a design standpoint to meet these safety standards.

Introduction

Inside most new vehicles today, you'll find a touchscreen that's larger than a tablet computer. The screen, serving as the center information display (CID), might share data such as the car's speed, driving directions, preset radio stations, the driver's phone book, the location of surrounding vehicles, and, for electric vehicles, the remaining charge. As automotive displays get bigger, they're also getting sharper, much like TV screens. Analysts are projecting healthy growth in displays greater than 8 inches, with the potential for in-vehicle screens as large as 49 inches becoming a reality by 2021. 4K and, eventually, 8K resolutions will become standard, while higher contrast technologies are also coming into play. What's more, many vehicles already have up to 8 displays inside, and cars with up to 12 displays are on the horizon to accommodate the CID, heads-up display (HUD), the instrument cluster, mirror replacements, and more.

With so much riding on the clarity and reliability of these displays, what's needed from a design standpoint to ensure that your modules will meet automotive functional safety standards? In this paper, we'll guide you through the qualities to seek in light-emitting diode (LED) backlight drivers and automotive power management ICs (PMICs) in order to produce large, razor-sharp vehicle displays (**Figure 1**).

Figure 1. Automotive displays are getting bigger and sharper, delivering critical driving and road condition information that makes compliance with functional safety standards critical.

Key Challenges to Address in Display Module Designs

Thin-film transistor (TFT) liquid crystal display (LCD) technology is commonly used in automotive displays, especially for the center stack and the instrument cluster. These displays feature tiny switching transistors and capacitors arranged in a matrix pattern on the display glass. The TFT element acts like a switch, while the liquid-crystal element serves in a role similar to that of a capacitor. When the switches turn on, the signal on the source line is added or recorded on the liquid-crystal capacitor. To produce the display, the source line signals the capacitor (in the form of voltage) to control the deflection angle of the liquid-crystal molecule. The holding capacitor can be 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, it prevents the signal from leaking out of the liquid-crystal capacitor.

Aside from the requirements to achieve functional safety compliance (which we'll discuss in a separate section), let's first take a look at several common challenges you may encounter when designing automotive display modules.

- Preventing flickering in cold-crank conditions: Obviously, flickering is quite undesirable because it interferes with the integrity of the display. However, when a vehicle starts up from a cold state, the car's battery voltage drops as the engine cranks due to the very low ambient temperature, which can lead to flickering in the display. The LED driver powering the LEDs in the display backlight must be equipped to handle the voltage drop to prevent flickering.
- Providing higher current for larger displays: The larger the display, the more current needed to drive the voltages to power the LEDs. For small screens, a timing controller (TCON) easily supports the current supply requirements. But displays over eight inches need a separate TFT bias or PMIC. Generally, displays that are 8 to 14 inches, with LEDs 10-11 in series with 4 in parallel, need up to 150mA per channel.
- Achieving the right levels of dimming to allow a readable screen under different ambient lighting conditions: when a car is traveling through a very bright, sunny environment, its displays will need more current to deliver the visibility the driver will need. Conversely, if the car is going through a dark area, like a tunnel, that high level of current will result in screens that are too bright. So, the current levels need to be adjustable to dim the display to a level that is readable.
- Passing electromagnetic compatibility requirements: For vehicles, electromagnetic interference (EMI) stems from internal and external sources of RF electrical noise and can compromise display performance. LED backlight drivers that provide features like spread-spectrum frequency modulation, phase-shifting, and gate slew rate control can help reduce EMI.
- Reducing BOM costs and solution size: Of course, cost and solution size are on the minds of many automotive engineers. Small components integrated with multiple functions can help meet these targets.

The Importance of Functional Safety Standards for Displays

While you're backing your car out of a driveway, you want the display showing what the rear camera is seeing to be as sharp as possible. Frozen images or flickering screens could cause you to miss a passing pedestrian or cyclist, for instance. Similarly, if you're driving along a very dark road at night, you don't want a screen that will be too bright to see. And, especially for HUD or cluster applications, it's critical that the same illuminance is maintained even when the LED strings in the lighting systems have errors. These are just a few scenarios that illustrate why functional safety is important for automotive displays.

ISO 26262 provides an international standard for functional safety of automotive electronic/electrical systems. An important component of ISO 26262 is the Automotive Safety Integrity Level (ASIL), which classifies the inherent safety risk in an automotive system. There are four ASIL levels, each determined by these factors: severity (injuries), exposure (probability), and controllability. Automotive displays are typically in the realm of ASIL B (ASIL D is the most stringent level). In an instrument cluster display, the TFT bias for power management and the LED backlighting driver provide examples of two blocks that should comply with ASIL B guidelines.

The TFT bias consists of AVDD and NAVDD voltages for the TFT source driver, VGON and VGOFF voltages for the TFT gate driver and, sometimes, VCOM voltage for the LCD backplane (which is needed if TCON cannot support the current requirements). This block also has an I^2C interface and fault pin for communicating with the microcontroller. Some common TFT bias fault scenarios include: VCOM out of range, overvoltage situation at VGON voltage, and fail-safe operation with an open enable pin. For ASIL B compliance, the TFT bias block should ideally have:

- I^2C (the data signal and the clock signal) and the fault pin with the microcontroller for performing setting adjustments and diagnostics on each rail
- Undervoltage and overvoltage monitoring on each rail
- Fixed voltage through internal resistors or adjustable voltage through I^2C
- Redundant reference
- Fault enable for additional redundancy

For the LED backlighting driver, the input typically connects directly to the car battery, which has voltage protection when the output is short. The output can either be a boost or single-ended primary-inductor converter (SEPIC), depending on the number of LEDs per string. Communication with the microcontroller is via an I^2C interface and the fault pin. The microcontroller reads the register through I^2C to determine any errors. Common LED driver fault scenarios include: string 1 with LED open and string 1 with LED short. ASIL B features of an LED driver include:

- I^2C (the data signal and the clock signal) and fault pin with the microcontroller for performing setting adjustments and diagnostics on each rail
- Output voltage measurement
- LED current measurement per string
- Fault enable for redundancy
- Redundant reference

The Right Power Management ICs Can Make All the Difference

There are a variety of power management ICs for automotive displays that are designed to comply with ASIL B. Aside from ASIL B requirements, by carefully considering the features of automotive power management ICs, you can address the challenges we’ve outlined earlier regarding the design of display modules. **Figure 2** shows a block diagram of a typical automotive display, for which Maxim Integrated offers various ASIL B functional safety solutions.

Block Diagram: ASIL B Automotive Display

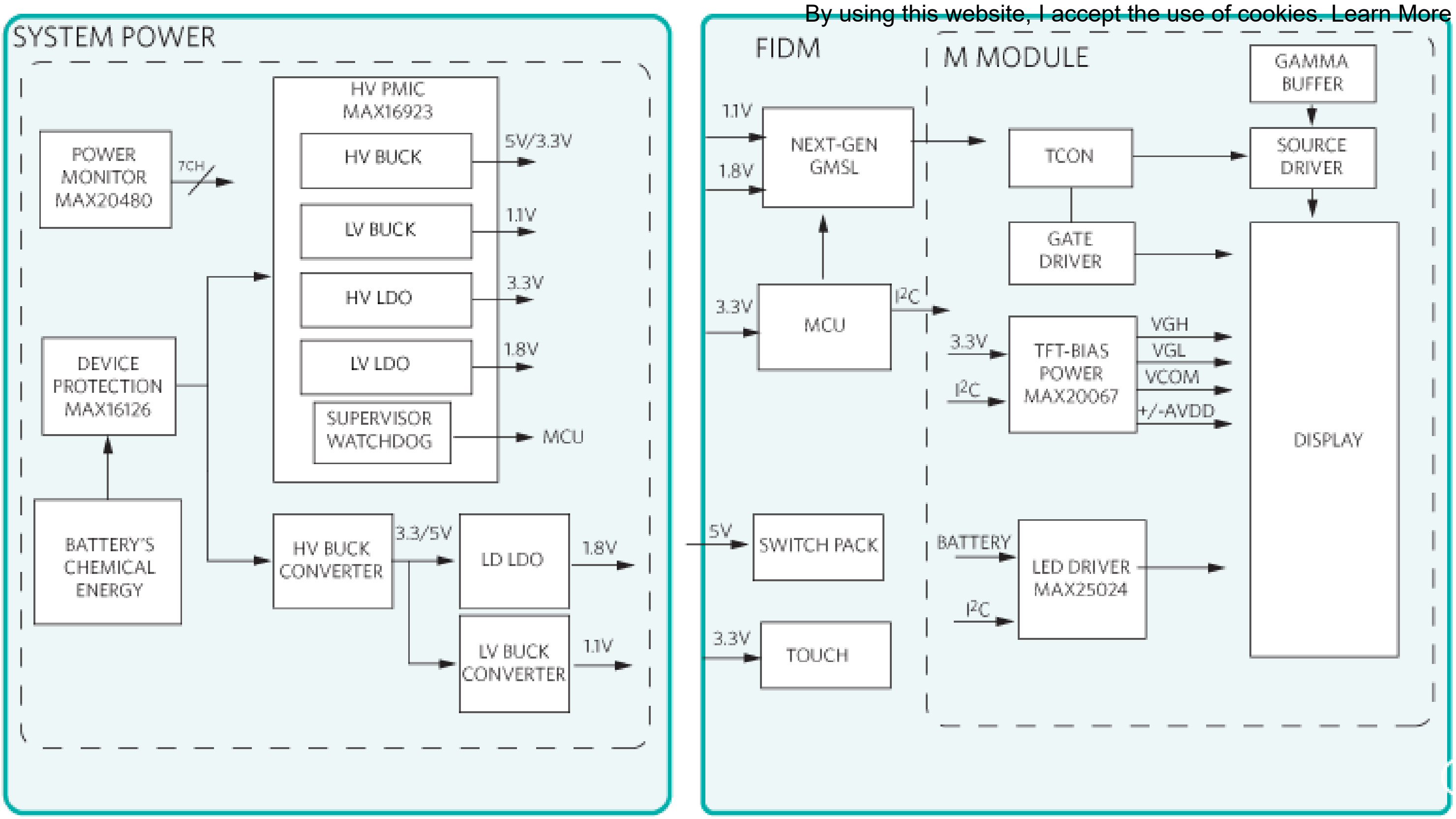

Figure 2. Block diagram of an example ASIL B automotive display.

For LED backlighting, for example, the MAX25024 is an ASIL B-compliant 4-channel backlight driver whose integrated current outputs can sink up to 150mA LED currents each. Its I^{2}C interface provides comprehensive diagnostic information like open/short LED detection, overvoltage/undervoltage on boost output voltage, boost output voltage, current on each channel, and input current measurement. The MAX25024 accepts a 2.5V to 36V input voltage range and can withstand automotive load-dump events. Maxim Integrated also unveiled the industry's first automotive power management IC (PMIC) for display applications. The MAX16923 provides a 4-output display power solution with watchdog, designed to accommodate the main rails in automotive TFT displays. Its integrated high-voltage buck converter transforms battery voltages into a 5V or 3.3V intermediate rail, while a high-voltage, always-on, low-quiescent-current linear regulator supplies power at 3.3V. For TFT-bias power, the MAX20067 provides a three-channel display bias IC with AVDD, VGH, VGL, and VCOM buffer, along with an I^{2}C interface. It has extensive diagnostics to detect overvoltage and undervoltage on AVDD, VGH, and VGL to provide an easier path for the system to achieve ASIL B compliance.

Low-voltage and high-voltage DC-DC converters are also integral components for a functionally safe power system for automotive displays. The MAX20079 provides a 36V, 3.5A buck converter with quiescent current of just 3.5µA. Featuring integrated high-side and low-side switches, the device comes in a 4mm x 4mm SW-TQFN package and provides a low-noise solution with excellent EMI performance. The MAX20077 provides similar specs as the MAX20079, but at 2.5A and in a 3mm x 3mm TDFN package.

For device protection and power monitoring, there are the MAX16126 and MAX20480, respectively. The MAX16126 is a load-dump/reverse-voltage protection circuit that protects power-supply inputs from automotive voltage transients. The MAX20480 is a 7-channel power system monitor with challenge/response watchdog. This enables the whole system to be ASIL B compliant without requiring each power supply to be ASIL B compliant. Maxim also has a low-voltage triple DC-DC converter with diagnostic capabilities that supports an ASIL B-compliant power system. In addition, next-generation Gigabit Multimedia Serial Link (GMSL) SerDes ICs provide ASIL B-compliant solutions to deliver bandwidth-intensive video as well as audio for display-based applications like advanced driver assistance systems (ADAS).

Summary

Carmakers are incorporating bigger and more displays into their vehicles, and these displays are providing drivers with essential information about their surrounding environment, their car’s performance, and more. That’s why functional safety has become an important criterion for automotive displays. Automotive power ICs designed with capabilities like redundancy and diagnostic monitoring can go a long way to ensure that displays in critical applications like ADAS, center information displays, and side mirror replacements will work as intended in all of the environments in which drivers will take their cars.

Related Parts

MAX25024	Automotive Low Input Voltage I^2C 4-Channel 150mA Backlight Driver Supporting ASIL B	Free Sample
MAX16923	Automotive 4-Output Display Power Solution with Watchdog	Free Sample
MAX20067	Automotive 3-Channel Display Bias IC with VCOM Buffer, Level Shifter, and I^2C Interface	Free Sample
MAX20079	Automotive 36V 3.5A Buck Converter with 3.5µA I_Q	Free Sample
MAX20077	36V, 2.5A Mini Buck Converter with 3.5uA I_Q	Free Sample
MAX16126	Load-Dump/Reverse-Voltage Protection Circuits	Free Sample
MAX20480	Automotive ASIL-D 7-Channel Power-System Monitor	Free Sample

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