TFT-BIAS FOR AUTOMOTIVE APPLICATIONS

Solution Guide

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INTRODUCTION

In today's infotainment-centric world, modern consumers appreciate display quality and resolution. The modern automobile is no exception to this trend. Automotive displays have been integrated in applications such as Instrument Clusters, Central Information Displays (CID), Mirror Replacements, Rear-Seat Entertainment Displays, and more, with a total of up to twelve displays per vehicle

Figure 1. Dashboard Display Evolution

Thin Film Transistor (TFT) Liquid Crystal Displays (LCD) offer bright and reliable display options at a reasonable cost. However, as the need for real-time video feed from camera, information, and bigger display size due to the merging of instrument cluster and CID, picture quality needs to be better, thus, the power consumption of these displays rises beyond what the timing controller (TCON) or source driver internal power supplies can provide. Therefore, a dedicated TFT-Bias power supply device is necessary to enable this high quality automotive display.

MARKET NEEDS

The heightened power requirements of display panels lead to the proliferation of TFT-Bias solutions. However, the variability of display panel options and expanded set of feature requirements introduces a new set of needs.

In the following sections, we will discuss six key needs that TFT-Bias designers face when designing TFT-LCD Display Systems:

1. **Source Driver**
2. **High Display Quality**
3. **Functional Safety**
4. **Fast Turn-On Time**
5. **EMI Mitigation**
6. **Low Total Solution Cost**

Figure 2. Multiple Display Sizes

NEED 1 – SOURCE DRIVER SUPPLIES

There are several TFT Technologies that can be used in display panel solutions, but they each come with their own set of benefits, requirements, and limitations. Two of the most common TFT Technologies are Amorphous Silicon (A-Si) and Low Temperature Polysilicon (LTPS) Panels. A-Si panels implement a unipolar source driver while LTPS panels typically implement a bipolar source driver.

Unipolar AVDD

Unipolar A-Si source drivers are bonded to the edges of the display panel. The source drivers contain multiple Digital to Analog Converters (DAC), one for each column in the display, which drive the sources of the TFTs. The DAC output voltage sets the transmissivity of the LC pixels according to the received video signal. The source driver voltage alternates between positive AVDD and zero while the common rail for the display backplane, VCOM, is set approximately at half the AVDD voltage. VCOM is set to this voltage to provide a net-zero average voltage across the pixel through polarity inversion. VCOM is adjusted for the best image quality during production by maintaining consistency despite the variation in TFT characteristics. Voltage applied to the pixel is controlled through the voltage supply at the gate of the transistor, V_{GON} and V_{GOFF}. The gate voltages are controlled through the source driver. Maxim Integrated provides a complete unipolar TFT-Bias solution for automotive applications in the **MAX20067** and **MAX20067B**.

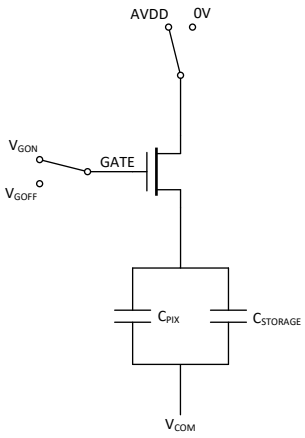

Figure 3 Unipolar TFT Solution

Bipolar AVDD

LTPS technology allows for all required circuitry to be implemented directly on the glass of the display panel, including the bipolar LTPS source drivers. This eliminates the need for an additional storage capacitor in parallel with the subpixels. Additionally, LTPS panels are typically higher performance, due to the higher carrier mobility in the transistors compared to A-Si and offer advanced features. In this case, the source driver voltage is between the positive AVDD and negative AVDD (NAVDD) supplies. Since the supply driver itself integrates voltage polarity inversion, the VCOM voltage is set approximately at zero. Maxim Integrated provides a complete bipolar TFT-Bias solution for automotive applications in the **MAX25220**, **MAX25221**, **MAX25221B**, and **MAX25222**. Additionally, Maxim Integrated offers a slimmed-down bipolar supply driver solution in **MAX25520**.

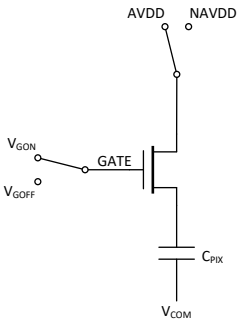

Figure 4. Bipolar TFT Solution

NEED 2 – HIGH DISPLAY QUALITY

High display quality is differentiated through optimal display panel performance and is supported by consistent pixel response. However, the physical manifestations of display solutions have deviations in parameter performance due to imperfections in materials and processes. These imperfections cause changes in the electrical characteristics of the materials. To stabilize the performance of the end product, the design must account for the changes and reestablish the electrical characteristics within pre-determined boundaries of the design. This is done through calibration methods such as selecting the optimal VCOM voltage.

VCOM

One way the inconsistencies between panels is resolved is through the calibration of the VCOM voltage. VCOM is the common reference voltage for the backplane in the TFT LCD panel. For consistent performance, panel manufacturers must tune the VCOM voltage in each panel according to the panel's characteristics. If tuned correctly, the VCOM voltage will reduce flicker. VCOM must also react during the pixel transition time to re-center the pixel voltage and avoid image retention through "ghosting." Maxim Integrated offers fully tunable VCOM buffers in MAX20067/MAX20067B, MAX25221/MAX25221B and MAX25222 TFT-Bias solutions with I^2C interfaces.

Temperature Compensation

In the MAX25221/MAX25221B and MAX25222 TFT-Bias solutions, Maxim Integrated offers a method to adjust the VCOM output voltage over temperature by using a temperature-sensitive component. Since panel characteristics change over temperature, the VCOM voltage needs to be adjusted for consistent display panel functionality. The calibration of VCOM is controlled using I^2C to select the internal temperature sensor in the CONFIG register. The sensor is chosen depending on the resolution criteria at the given operating temperature. The VCOM value at 25°C is saved in the VCOM 25 register and serves as a reference for subsequent VCOM values. This feature allows for even more precise control of the VCOM value beyond just utilizing the VCOM DAC step size of 6.83mV. Self-compensating VCOM is just another way Maxim Integrated ensures consistent performance in its TFT Bias solutions

NEED 3 – FUNCTIONAL SAFETY

Automation and versatility are key descriptors in today's consumer market, and automotive displays are no exception. In the modern car, displays are used for a variety of purposes such as entertainment, digital instrument clusters, or advanced driver assistance systems (ADAS). Because of this safety application, it is essential that the displays showing safety-critical information comply with functional safety standards so that they can be relied upon to provide drivers with essential information. Functional safety standards aim to reduce the risk of failure of a system and minimize failure impact. These standards cover a wide range of protocols including reduced points of failure, redundancy, fault monitoring, and setting adjustment. Official compliance classification can be adjusted depending on the application of the product.

Integrated Diagnostics

Programming settings using I²C increases the number of applications where a customer can use a single IC, and also enables customers to read back diagnostic information. Integrated diagnostics allow for real-time debugging and direct feedback from the IC itself. This feature reduces the need for external comparators and flags which can significantly add to BOM cost. Additionally, integrated diagnostics include internal redundant references for analog-to-digital converters (ADCs) and comparators which are critical for monitoring important voltages for optimal performance. Maxim Integrated offers TFT-Bias solutions with diagnostic information in MAX20067/MAX20067B, MAX25220, MAX25221/MAX25221B MAX25222, and MAX25520. MAX25222 goes beyond the standard product by including extensive diagnostics that satisfy the ASIL-B safety level.

NEED 4 – FAST TURN-ON TIME

In a world revolving around the premise of instant gratification like backup camera application, reducing start-up time is a key to success. Before a panel is fully operational, the TFT-LCD Power Supply and VCOM voltages must be regulating. This includes selecting and starting up in the proper sequence, programming settings appropriately, waiting for supplies to settle, and reviewing diagnostic information. One way to speed-up this process is by tying the IC Enable to the TFT-LCD Power supply. However, another way to reduce start-up time is by pre-programming as many of the user settings as possible. This is possible using Multiple One Time Programmable (MOTP) nonvolatile memory banks.

MOTP

MOTP nonvolatile memory allows the output voltages and sequencing to be pre-programmed during production to enable faster display turn-on time. This is possible because the customer does not need to wait for the completion of start-up to write these settings using a communication protocol such as I²C. Maxim Integrated offers MOTP in the MAX25220, MAX25221, and MAX25222. These products offer both MOTP and communication through I²C. This is the best of both worlds since settings can be pre-programmed up to five times, but real-time diagnostic information can still be accessed through I²C. Pre-programming also offers another layer of safety since it reduces the failure rate that other solutions face when they require settings using external components. Using MOTP to store values integrates a reliable solution using internal component values to save settings.

Figure 5. Displays Used for Multiple Purposes

NEED 5 – EMI MITIGATION

With the quantity of infotainment electronics increasing and the placement of these electronics in easy to reach locations, there are now more risks for interfering with communication and broadcast electronics. Because of these risks, the automotive industry has several electromagnetic compatibility (EMC) requirements so that these electronics do not emit too much electromagnetic interference (EMI). Integrating EMI mitigation features within the IC solution itself saves customers from creeping BOM cost and integration issues. Mitigation techniques vary from switching frequency manipulation to integrating spread spectrum control blocks.

Switching Frequency

Higher switching frequencies above AM band helps reduce EMI problems to AM band if switching at 400kHz. MAX20067/MAX20067B, MAX25220, MAX25221/MAX25221B MAX25222, and MAX25520 all can switch at 2.1MHz.

Spread Spectrum

Spread Spectrum is a technique in which the information signal bandwidth is extended from narrowband to wideband. The purpose of this method is to distribute spectral power density across a wider range of frequencies so that the resulting power associated with the signal is lower and less likely to interfere with narrowband communication signals. Spread spectrum is implemented by injecting a higher frequency signal in the transmission chain according to the IC designer's proprietary spread spectrum control block. Maxim Integrated offers TFT-Bias solutions with spread spectrum in MAX20067/MAX20067B, MAX25220, MAX25221/MAX25221B MAX25222, and MAX25520.

Figure 6. Displays Integrated in Dashboard

NEED 6 – LOW TOTAL SOLUTION COST

While adding the latest features to the modern vehicle increases its appeal, there is a limit to how much the consumer will spend in each market segment. Therefore, it is critical for the Original Equipment Manufacturer (OEM) to appropriately allocate their costs. This responsibility is passed down from the OEMs to their Tier 1 suppliers who continue to pass it to their providers. Therefore, the solution cost for a given feature set is tightly monitored and this starts with the Bill of Materials (BOM).

Low BOM Cost

The BOM consists of all the essential and supplementary components needed to perform a certain function. The design company can minimize cost by reducing the number of essential components needed to make a solution work. Techniques that reduce the number of required components include having a stable output to reduce the need for additional filtering, appropriately compensating internally for input fluctuations to reduce the need for additional filtering, using synchronous rectification to remove the external boost diode, implementing functional safety diagnostics at IC level, and integrating necessary components internally. These techniques are all implemented in Maxim Integrated's MAX20067/MAX20067B, MAX25220, and MAX25520. Additionally, Maxim Integrated has increased the level of solution integration in MAX25221/MAX25221B and MAX25222 with the introduction of the world's first TFT-Bias ICs which have +/-AVDD, I^2C, VCOM, ASIL B and MOTP, eliminating the need for an external EEPROM.

SUMMARY

The surge of display integration in the modern car requires modern solutions. Maxim Integrated offers a strong portfolio of TFT-Bias solutions that allow for increased flexibility and performance. Each product is designed to work with a wide range of display panels and can be configured for multi-solution platforms.

In this design guide, we discussed the three key needs of the modern automotive display: source driver supplies, stability of electrical characteristics, EMI mitigation, faster turn-on and ASIL B. In each case, we provided the best products that Maxim Integrated has to

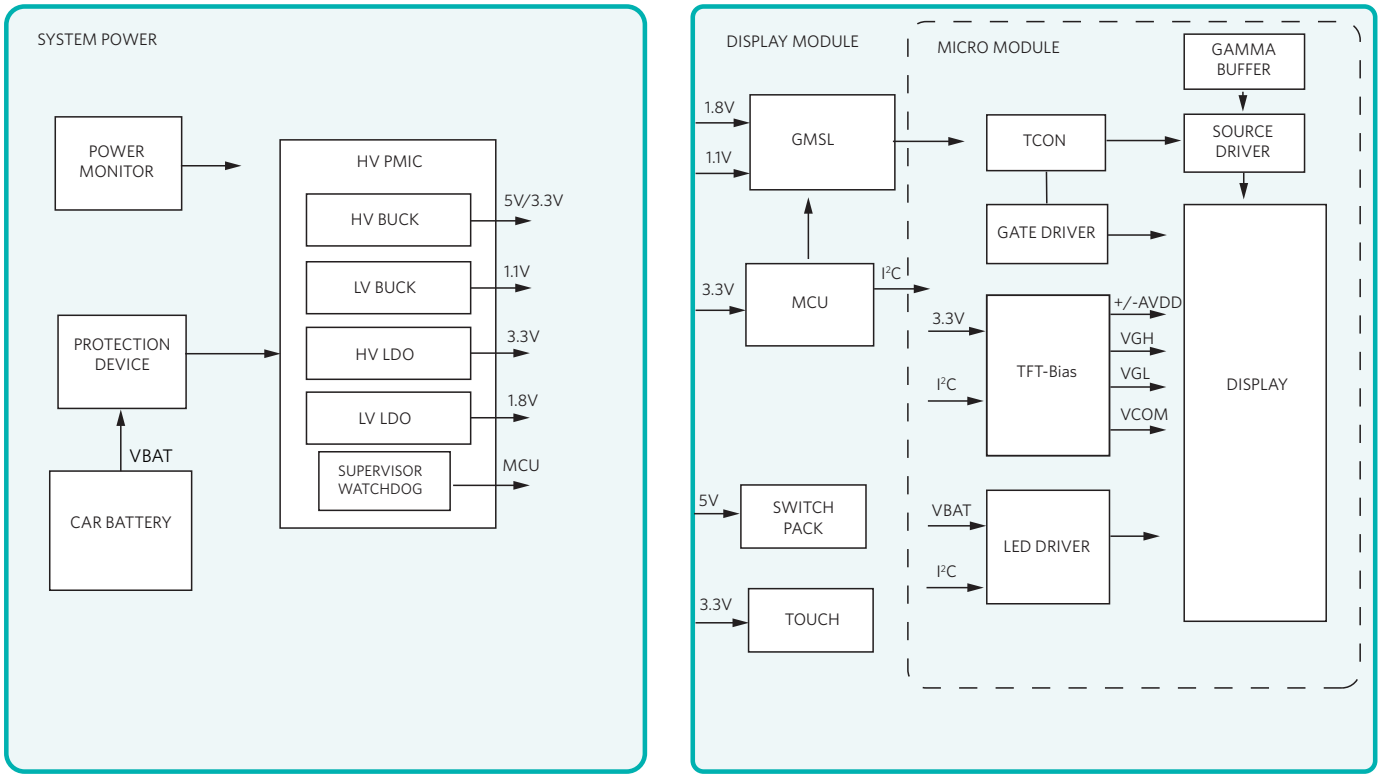

Figure 7. TFT-LCD Display Simple Block Diagram

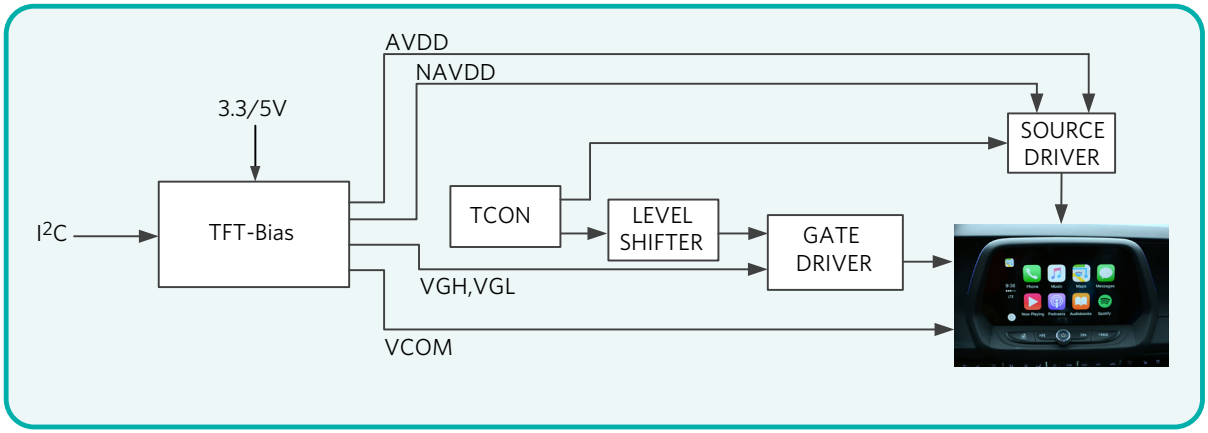

Figure 8. TFT-Bias Block Diagram

Below is a summary of Maxim's Automotive TFT-Bias Product Solutions. See the Product Selector Table to compare product specifications.

Product Solutions

Applications	Product	Function
Amorphous Silicon Panel	MAX20067	Automotive 3-Channel Display Bias IC with VCOM Buffer, Level Shifter, and I²C Interface (High Power: 2.5A)
	MAX20067B	Automotive 3-Channel Display Bias IC with VCOM Buffer, Level Shifter, and I²C Interface (Low Power: 1A)
LTPS Panel	MAX25220	Automotive 4-Channel TFT-LCD Power Supply
	MAX25221	Automotive 4-Channel TFT-LCD Power Supply with VCOM Buffer
	MAX25221B	Automotive 4-Channel TFT-LCD Power Supply with VCOM Buffer (EN Controlled Output)
	MAX25222	Automotive 4-Channel TFT-LCD Power Supply with VCOM Buffer and ASIL B Features
LTPS or OLED Panel	MAX25520	Automotive 2-Channel TFT-LCD Power Supply

Product Selector Table

TFT LCD Power Supply

Part Number	AVDD (max)	NAVDD (min)	VGON (max)	VGOFF (min)	VCOM Range	Operating Frequency	Package-Pins	Special Features
MAX20067	18V	-	32V	-24V	5V – 18V	440kHz, 2.2MHz	TQFN-32	Higher Power and Synchronous Boost
MAX20067B	18V	-	32V	-24V	5V – 18V	440kHz, 2.2MHz	TQFN-32	Synchronous Boost
MAX25220	10.5V	-10.5V	20.2V	-18.2V	-	420kHz, 2.1MHz	TQFN-32	MOTP Non-Volatile Memory
MAX25221	10.5V	-10.5V	20.2V	-18.2V	-2.49 – 1V	420kHz, 2.1MHz	TQFN-32	MOTP Non-Volatile Memory
MAX25221B	10.5V	-10.5V	20.2V	-18.2V	-2.49 – 1V	420kHz, 2.1MHz	TQFN-32	MOTP Non-Volatile Memory EN Controlled Output
MAX25222	10.5V	-10.5V	20.2V	-18.2V	-2.49 – 1V	420kHz, 2.1MHz	TQFN-32	MOTP Non-Volatile Memory ASIL B
MAX25520	12V	-12V	-	-	-	420kHz, 2.1MHz	TQFN-16	Spread Spectrum

Related Resources

Products

MAX20067

MAX20067B

MAX25220

MAX25221

MAX25221B

MAX25222

MAX25220

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