White Paper

Preventing Automotive Backover Accidents

November 2019

Introduction

The importance of automobile safety has driven several key innovations over the last 50 years. It all started with the seat belt in 1966 when the U.S. Congress authorized the Federal Government to set safety standards for new cars. By 1968, seat belts, padded dashboards and other safety features became mandatory equipment. Since the early days of auto safety, many more innovations such as anti-lock brakes and airbags arrived on the scene as standard safety equipment.

German automakers have pioneered many of the most advanced technologies to improve driver safety. For example, over the last two decades alone, German vehicles were the first to offer lane-departure warning systems, which introduces a vibration to the steering wheel, and/or an audible alarm when the driver veers from his or her lane. Then came radar-based blind spot monitoring to help drivers safely change lanes. This was followed by the introduction of dynamic cruise control, which has evolved into stop-and-go and brake assist. That feature reduces the risk of rear-end collisions by quickly asserting the brakes before an impending crash. This white paper looks at the latest safety technology catching on worldwide as standard equipment: The rearview camera.

Rearview Camera Standard for New Car Models

Although rearview camera systems have been available as optional equipment for many years, U.S. automakers and others around the world are starting to make rearview camera systems (see Figure 1) standard equipment for all new car models. This global safety trend follows the U.S Federal Government's National Highway Traffic Safety Administration (NHTSA) mandate for rearview cameras. The new NHTSA regulation requires that automakers implement "rear visibility technology" as standard equipment for all vehicles under 10,000 pounds, as part of the Cameron Gulbransen Kids Transportation Safety Act of 2007.

Figure 1: The rearview camera system is now the baseline safety feature in all new car models

The legislation required NHTSA to revise the Federal Motor Vehicle Safety Standard 111 (FMVSS-111) to expand the required field of view behind the vehicle. It states that all new vehicles sold in the U.S. must have a rearview camera system, starting in May 2018. With this new standard, the rear camera system is no longer seen as a parking assistance feature, it is a safety feature. Honda and Acura were among the first automobile brands to offer backup cameras as standard equipment on all models. According to IHS Markit research, infotainment and safety critical displays will see double digit growth through 2022.

Design Challenge: Meeting FMVSS-111 Requirements

The major technical challenge faced by car OEMs is how to achieve compliance with the new U.S. law, including a key piece of the new NHTSA regulation, which states live rear camera video must be displayed in less than two seconds after the driver places the vehicle into reverse gear. The law aims to reduce the number of deaths and injuries caused by driver backup accidents, many involving young children. One key challenge to achieving FMVSS-111 compliance is the fact that the center head unit's main processor, or System-on-Chip (SoC), runs a complex operating system, which can take several seconds to boot up.

In addition, the operating system is prone to software freezes and glitches that can result in displaying a frozen image. As software complexity increases, freezes and hang-ups are becoming more prevalent, affecting system reliability and potentially leading to accidents or worse.

The Solution: Hardware Bypass

The TW8844 full high definition (HD) LCD video processor with built-in video decoder is optimized to ensure rearview camera reliability in automobile center console displays. It can turn on, synchronize to a video source and display that video in less than half a second, solving the fast boot reliability issue faced by carmakers today. Another major concern is the reliability of the camera displaying live video when the driver needs it. Because the system is running a very complicated operating system and software stack, it can freeze up and not show live video when the vehicle is placed into reverse gear.

The most significant reliability concern occurs when the driver shifts into reverse gear, and the rear camera video is displayed, but the image freezes. The result is live video is no longer displayed (see Figure 2A). The driver will think they are seeing a real-time video feed, and that the area behind the vehicle is clear, but in reality they are seeing an older, frozen video frame. By the time the vehicle starts to move, a child has run behind the vehicle, or someone walks by (see Figure 2B), introducing a major safety concern.

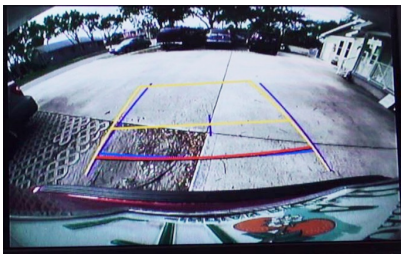

Figure 2A: Frozen rearview camera image

Figure 2B: Actual rearview camera image

Figure 2 shows a frozen rearview camera image on left, and the actual rearview camera image with a pedestrian walking behind the vehicle on right

The TW8844 full HD LCD video processor works in conjunction with the system's main SoC, and is capable of monitoring both the camera output and the video data coming out of the SoC. If it determines the SoC's output video is frozen, the TW8844 will reroute the camera video and bypass the SoC, sending the camera video directly to the center stack LCD panel. This happens nearly instantaneously. And when the SoC recovers, the TW8844 can switch back to it.

Rearview Camera System Signal Flow

Under normal operating conditions, the rearview camera video is fed into the TW8844 LCD video processor as shown in Figure 3. The TW8844 can receive either traditional analog composite video or HD digital video. It processes the video then routes it to the SoC via a MIPI-CSI2 interface. The SoC mixes the camera video with graphical overlay content such as text, icons and colored parking guidelines. Then the combined image is sent back to the TW8844, which in turn drives that video directly to the LCD panel. Throughout this process, the TW8844 is constantly performing frozen detection measurements, using multiple techniques to measure image aspects such as luminance, color values, individual pixels, and more to determine if the video is frozen or corrupted. The system designer can program thresholds for the various measurement techniques to create a unique and robust frozen/corrupt image detection capability that meets a particular OEM's requirements.

If the TW8844 determines that the SoC is sending frozen or corrupted video, it automatically issues an interrupt signal to the microcontroller (MCU), which instructs the TW8844 to go into bypass mode, directly driving the rear camera video to the LCD panel. At that point, the MCU can also instruct the SoC to go into soft reset so that the driver does not have to re-start the vehicle in order for the head unit software to recover. Once the software stack starts working properly again, the MCU instructs the TW8844 to change from bypass mode and go back to feeding video into the SoC again.

The same signal flow occurs during fast boot mode. When the vehicle ignition starts up and the driver places the car into reverse gear, a reverse signal is triggered, telling the system MCU the car is in reverse. If the SoC software has not completed boot up by the time the vehicle is shifted into reverse, the MCU instructs the TW8844 to send the camera video straight to the LCD while the SoC completes the boot up cycle. Once the operating system is booted, the TW8844 instantly changes modes and routes the signal to the SoC to mix the video with graphics before the signal comes back to the TW8844 to route to the LCD.

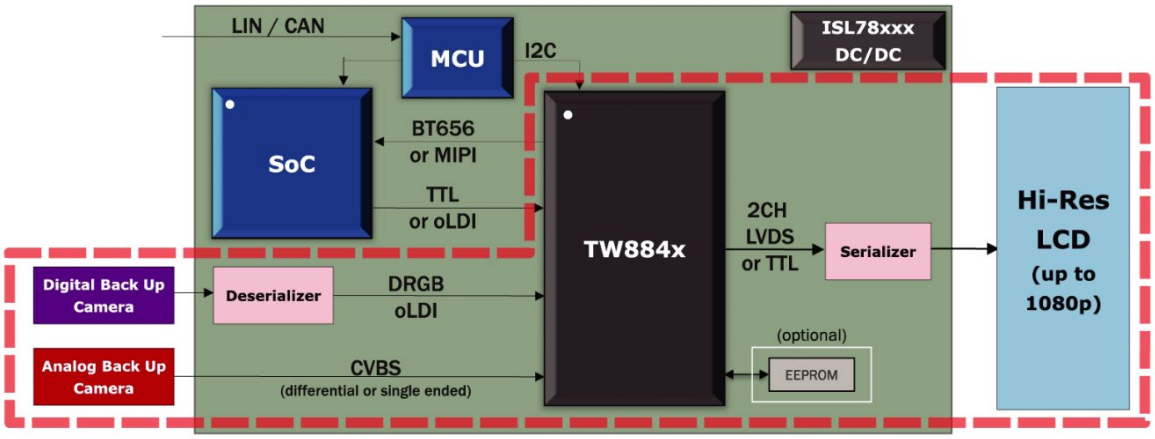

Figure 3: Frozen detection decouples the camera-display path from the SoC

Inside the Full HD LCD Video Processor

The highly integrated TW8844 is the first full high-definition (HD) 1080p LCD video processor with analog video decoder, two scalers and MIPI-CSI2 SoC interface designed specifically to address infotainment and rear camera display systems. The TW8844 provides the reliability automakers require to ensure their rearview camera is compliant with the FMVSS-111 standard for preventing injury or death caused by backover accidents. The TW8844 enables the migration from analog to digital camera systems, and supports a variety of video interfaces and LCD panel resolutions up to full HD 1920 x 1080. The TW8844 LCD video processor is ideal for center stack/head units, full display rearview mirrors, instrument cluster displays, and rear seat entertainment systems.

The TW8844 video processor with MIPI-CSI2 output and its sister device, the TW8845 video processor with traditional BT.656 output, exceed the requirements of the FMVSS-111 law. Both devices display live video with graphics overlay in less than 0.5 seconds after vehicle ignition, overcoming the fast boot reliability issues inherent with today's more complex center-stack systems. Through its frozen/corrupt image detection capability, the TW8844/45 provides a robust rear camera architecture that adds a level of system reliability that goes beyond the specific wording of the FMVSS-111 regulation, but is in keeping with the intent of the new law. That is to consistently and reliably display rear camera video to expand the driver's field of view and reduce the number of backover accidents that occur every year.

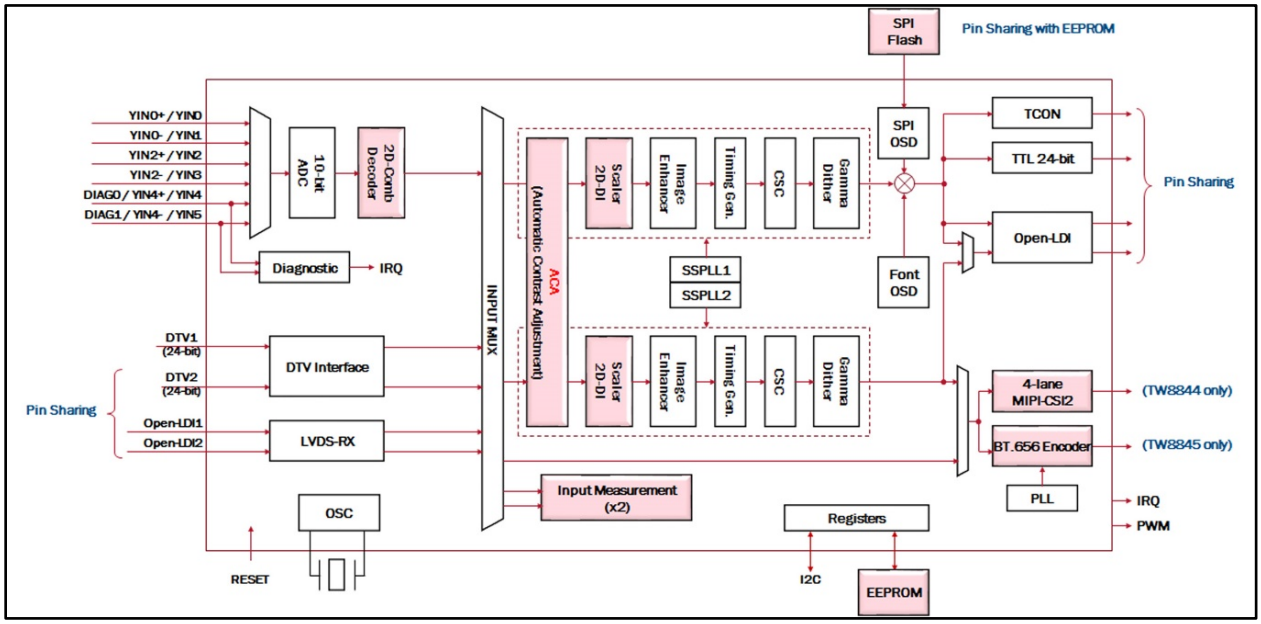

Figure 4: The TW8844/45 circuit diagram highlights key function blocks within the HD LCD video processor

Automatic Contrast Adjustment Enables Clear Images

Another innovative feature of the TW8844 and TW8845 is the automatic contrast adjustment, or ACA (see Figure 5). With this feature, the video processor utilizes proprietary algorithms to optimize the brightness and contrast levels of the camera image, dynamically and in real-time, on a pixel-by-pixel basis. It brightens up dark areas or brings down the levels of bright areas. Therefore, if you have a dark area next to a bright area, the TW8844 and TW8845 can boost up that area without over saturating the

bright area. The thresholds of what is considered too bright or too dark are programmable, giving true flexibility to the system designer.

Figure 5: The TW8844/45's automatic contrast adjustment (ACA) feature dynamically optimizes the image brightness and contrast levels in real time

Solution for All Types of Automotive Displays

The TW8844/45 full HD LCD video processors address any display system in the car including rear seat entertainment as shown in Figure 6, instrument cluster displays, and LCD based mirror replacement display systems. Two separate H/V scalers are able to output up to 1080p (1920 x 1080) resolution and allow processing of two different sources simultaneously, while outputting different data to the SoC and display. In addition, these LCD video processors can simultaneously drive two separate displays with different content, making it an ideal solution for dual headrest rear seat entertainment systems.

Figure 6: The TW8844/45 can simultaneously drive two rear seat video displays with different content

LCD Rearview Mirrors

We are also beginning to see LCD panels replace the front windshield rearview mirror, as shown in Figure 7. Replacing these mirrors significantly improves the rear field of view in comparison to standard reflective glass mirrors. In addition, carmakers can minimize the rear windshield's size and shape to strengthen the vehicle's structural integrity and aerodynamics. A problem faced by high occupancy, large size vehicles such as minivans and SUVs, is that with flip-down rear seat entertainment displays and the rear passenger head rests, the field of view through the rear windshield is often heavily obstructed. Replacing the old rearview mirror with a camera-based rearview display mirror can eliminate this problem. Further down the road, carmakers are looking at side mirror LCD replacements, as this would improve vehicle aerodynamics considerably (and therefore improve fuel efficiency) as the drag created by the side mirrors is eliminated.

Figure 7: LCD rearview mirrors are beginning to replace reflective glass mirrors

Conclusion

Safety is a significant differentiator and has become a real factor in the consumer's choice of vehicle. There is more on the horizon as the cost of implementing safety features continues to decline, making it possible to deliver them in more mainstream models. Moving forward, more video will be used to deliver capabilities like night vision and object recognition (video analytics) to improve vehicle safety.

We will also see the windshield become a heads-up display for presenting key information such as driving speed, warning signals, directions, and indicator arrows projected directly in front of the driver's line of sight. The ability to deliver reliable, easy to integrate and cost effective video solutions will be a key enabler of the next generation of advanced driver assistance systems (ADAS), to improve driver safety and increase consumer demand for new vehicles. Keep watching this space as more innovations are on the way, placing us squarely on the road to self-driving cars.

Learn More

- Learn more about the TW8844 LCD video processor ›
- Download the datasheet ›
- Watch a quick video on how Renesas solves the rear-camera reliability problems faced by OEMs ›

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