Design of High-Speed Video Data Transmission Circuit Based on GMSL Technology

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Abstract. With the development of the complexity of the vehicle platform, the bandwidth required for video transmission on the vehicle platform is increasing. The traditional data bus transmission rate can no longer meet the needs in some application fields. The new generation of GMSL technology video format is equivalent to the serial interface video. Format, digital video and audio data are higher than the traditional bus data transmission rate, up to 3.12Gbps. In this context, this paper studies the design of GMSL technology high-speed video transmission circuit, completes the hardware development in ISE, uses FPGA platform to build a video video transmission control system, and completes the high-speed transmission of GMSL format video.

Keywords. Video transmission; GMSL technology; FPGA; serial data.

1. Introduction
On-board platforms including audio, video, audio and video entertainment, Ethernet control, body control, etc. have become more complex, and the substantial increase in data volume requires higher bandwidth. Regarding the underlying data transmission technology, the challenges faced by solving the problems of bandwidth, data integrity, interconnection complexity, and harsh working environment are increasing. In order to realize the long-distance and low-loss transmission of vehicle-mounted high-definition video, the framework and principle of vehicle-mounted camera transmission system based on gigabit multimedia serial link technology are studied [1]. Serial link technology must work well in this automotive environment to support high-speed, high-reliability, and low-latency requirements. Serial technology replaces parallel bus transmission and becomes the mainstream of high-speed data transmission with its advantages of fewer signal lines and higher transmission bandwidth. GMSL technology converts HDMI input to Gigabit Multimedia Serial Link (GMSL) through a serializer. Output, using the newly introduced GMSL technology can solve the problem of data transmission bandwidth [2, 3].

Based on the application of unmanned vehicles in the future, this paper proposes the use of the newly launched GMSL technology, namely Gigabit Multimedia Serial Link (GMSL) serializer and deserializer, which can transmit signal data at a rate of Gbps.

2. Advantages of GMSL Technology in Data Transmission
GMSL technology is similar to LVDS technology and is a low-amplitude differential signal technology. It uses point-to-point physical interface technology. The core of this technology is to use very low voltage swing to transmit data at high speed, which can realize point-to-point or point-to-multipoint transmission [4]. It has the characteristics of adapting to high-speed transmission and low power...
consumption. As a low-swing differential signal technology, it can enable signals to be transmitted on differential PCB pairs at speeds higher than 100 Gb/s. The GMSL serializer and deserializer has very low power consumption, and its signal swing is typically 350mV, which determines the extremely high efficiency in future video data transmission, which also makes GMSL a must for the future vehicle platform Develop and expand heroic technology. Compared with other level standards, the GMSL technical standard has many advantages in high-speed data transmission. GMSL technology has the advantage of high speed in data transmission. It works in a low-swing transmission mode, which means that GMSL technology can achieve high-speed data switching, especially in point-to-point connections. The transmission speed of GMSL It can reach 6Gbps; GMSL technology also has high noise immunity. The serializer and deserializer in the data transmission system can suppress the common mode noise on the differential signal, and it only responds to the differential signal of the digital information. GMSL technology can provide corresponding common-mode suppression capabilities; GMSL technology produces low noise, outputs a smaller current source and stable current, reduces the corresponding noise, and the tightly coupled signal line pair can make it emit the electromagnetic fields cancel each other out, and the resulting noise is also very small [5].

GMSL technology video data transmission is equivalent to traditional serial interface video data transmission, but GMSL technology has a higher video data transmission rate, up to Gbps, and audio data transmission is clearer, which has more advantages than traditional serial interface transmission.

3. Design and Analysis of High-speed Video Transmission Circuit based on GMSL Technology

3.1. System Design Plan
FPGA sends the video capture control signal to MAX9291 through the bus, completes the configuration of the camera’s various registers, starts the system initialization and captures the external video. The input video is converted into GMSL video format by serializer MAX9291 through parallel-serial conversion and encoding. Serial transmission via serial link. FPGA sends data stream read and write control signals to MAX9288 through the bus to complete the register configuration of the deserializer. The deserializer MAX9288 decodes and descrambles the video data serially transmitted by the serializer to complete the serial-to-parallel conversion. The decoded video data is converted into the HDMI video format that can be collected and processed by the DM8168 processor through FPGA and then output. The output original video is stored in the SD card using the ping-pong buffer mechanism. Ping-pong buffer is a common data access method in the field of video image processing [6]. The whole system is input by +5V DC voltage, which is converted into the voltage required by each device and chip through the power conversion circuit module.

3.2. Analysis of the Relevant Hardware of the Video Transmission System
According to figure 1, the system is mainly composed of modules such as a power supply circuit, a main processing circuit, a serial transmission circuit, and a storage circuit.

![Figure 1. How the system works.](image-url)
The power circuit is composed of three HCE4620 DC-DC power modules. The power circuit converts +5V DC input into +3.3V, +1.8V, and 1.2V voltages. Among them, the 3.3V voltage is mainly used to supply power to the IO interfaces of various interface chips and processor chips, the 1.8V voltage is mainly used to power the FPGA core, and the 1.2V voltage is used to power the high-speed processing module inside the FPGA [7]. The power supply topology is shown in figure 2.

![Power supply topology](image)

**Figure 2. Power supply topology.**

The main processing circuit is composed of XILINX-XC6SLX75 FPGA chip and its peripheral circuits, and the serial transmission circuit is composed of MAX9291 sequencer and MAX9288 deserializer. The FPGA chip has rich internal logic resources, with a maximum operating frequency of 104MHz, and an integrated high-speed serial transceiver module GTX with a transmission rate of up to 6.6Gbps. The FPGA of this system is used to receive the strobe signal sent by the video sequencer and deserializer through the bus and send the strobe command to the serializer and deserializer chip to realize the data stream parallel-serial conversion and high-speed transmission of the input video.

The serializer MAX9291 uses differential CML signals to drive twisted-pair wires, and single-ended CML drives coaxial cables with programmable preamplifier/buck and AC coupling [8, 9]. The MAX9288 deserializer uses an AC coupler and programmable channel equalization. Shuffle the input data, and then encode 8b/10b (9b/10b in high-bandwidth mode). The polarity input of each encoding unit of the multi-channel encoder comes from the polarity output of the upstream encoding unit [10]. The deserializer recovers the embedded serial clock, then samples, decodes, and decompresses the data. In 32-bit mode, the first 29 bits contain 24 bits of video data, 3 bits of control data (HS/VS/DE) and 2 bits of control data (CNTL1/CNTL2). In high bandwidth mode, the first 24 bits contain video data or special control signal packets. In all modes, the last 3 bits contain the embedded audio channel, the embedded forward control channel and the parity bit of the serial word. The GMSL deserializer recovers the clock from the serial input signal and extracts video, audio and controls. The video data is grouped according to the MIPI CSI-2 packet format and sent out through the MIPI DPHY serial channel. As shown in figure 3.

![Transmitting a Frame from GMSL to MIPI CSI-2](image)

**Figure 3. Transmitting a Frame from GMSL to MIPI CSI-2.**
3.3. Video Data Format Conversion
The video data is decoded by the deserializer and output, and the video decoded by the MAX9288 deserializer is output through the MIPI CSI-2 interface. The unmanned vehicle platform we developed uses the DM8168 processor, which collects video data. Through HDMI interface collection, then the processor encodes HDMI. Before HDMI encoding, each TMDS channel contains 8-bit video data, 4-bit audio data packets, and 2-bit control data. These data are expanded to 10-bit according to different encoding methods during HDMI encoding [11]. This system realizes the interface conversion of video data format through FPGA.

4. Test Results and Analysis
When using dual μC in the test, the serializer and deserializer host are disabled, and RX/SDA and TX/SDL are configured as UART interfaces by their corresponding μC. The link will conflict with dual μC, so it is changed to single μC, and the serializer side of the link is a camera module configured as a remote end. The INT output of the MAX9291 controls the shutdown input and single/dual μC switching of the board, thereby solving the problem of conflicting commands in practice, as shown in figure 4. In this application, INT is used as a GPO, and the output is controlled by setting SETINT (0x0D D7 of MAX9291) or the INT input of the deserializer. Once powered on, the INT output is low, keeping the remote device off. The inverter output is connected to the CDS to configure the serializer as a remote device. Since the active low AUTOS is set to high, the MAX9291 powers up in sleep mode.

To open the remote panel, the deserializer wakes up the MAX9291 through the GMSL UART command. Then, the deserializer sets the INT output of the MAX9291 to a high level to power up all remote devices. The inverter output sets the MAX9291 as a local device and can receive UART commands through the local μC.

To turn off the remote panel, the deserializer sets the INT output of the MAX9291 to low level, turns off the remote device and sets the MAX9291 as a remote device. Then, the deserializer sets SLEEP = 1 in the MAX9291 to make the device enter the sleep state.

![Figure 4. Single μC remote control.](image)

Through the simulation software Medelsim simulation combined with physical debugging results, as shown in figures 5 and 6, it is shown that there is no interference in the video transmission process, the video data is clear and stable, and the transmission rate reaches the design expectations.
5. Conclusion
This paper designs and develops a high-speed video transmission system based on GMSL technology, describes the principle of the system, analyzes the hardware modules according to the system design, and finally builds a hardware test system for verification and testing. The test results indicate the system transmission rate. In line with the design, it can achieve 1920×1080@60Hz resolution, 3.12Gbit/s link rate video transmission, the output video signal is clear and stable, the effect is good, and the expected goal is achieved. The modified design can be adapted to future unmanned vehicle platforms and has broad application prospects.

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