Teledyne LeCroy: GMSL2 Physical Layer Validation

Introduction

As modern automotive and industrial systems evolve, the demand for high-speed, reliable video transmission continues to grow, specifically in applications such as Advanced Driver Assistance Systems (ADAS), autonomous driving, and high-resolution infotainment.

To meet these requirements, technologies like Gigabit Multimedia Serial Link 2 (GMSL2) have emerged. Developed by Analog Devices, GMSL2 is a high-performance serializer/deserializer (SerDes) interface capable of transmitting video, audio, and control data at rates up to 6 Gigabits per second (Gbps) over coaxial cables or shielded twisted pair cables.

In automotive environments, where electromagnetic interference, temperature fluctuations, and mechanical stress can degrade signal quality, maintaining the integrity and compliance of GMSL2 links is essential to ensure system reliability and optimal performance. To overcome these challenges, engineers depend on advanced signal analysis tools.

Teledyne LeCroy's SDA Expert (SDAX) software, offers a comprehensive solution for GMSL2 validation. It enables detailed signal integrity analysis through eye diagrams, jitter decomposition, and signal analysis, enabling engineers with the insights needed to optimize link performance and ensure compliance with GMSL2 specifications.

This document outlines the methodology and best practices for testing GMSL2 using SDA Expert, guiding users through the key steps of signal acquisition, analysis, and interpretation.

Test Setup and Equipment

To perform GMSL2 testing, the following equipment is typically required:

- Teledyne LeCroy Oscilloscope (WaveMaster HD or LabMaster series)
- SDA Expert Software Option
- GMSL2 compatible probes (e.g., high-bandwidth differential probes)
- GMSL2 DUT (Device Under Test) e.g. camera module.
- Test fixture for signal access

How to start testing GMSL2

GMSL can reach up to 3Gbps, while GMSL2 can reach speeds of 6Gbps, which requires, respectively, a minimum bandwidth of 6GHz and 12GHz oscilloscope to be able to test these signals. Additionally, the user must have the SDA Expert software option enabled on their oscilloscope.

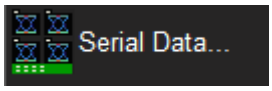

Figure 1: Toolbox icon in Analysis Menu

Once the software option is enabled, the user should have under the analysis tab in the oscilloscope user interface the serial data toolbox icon which will open the SDAX menu and allow the user to start using this toolbox to analyse GMSL signals. For more information over SDAX, you can follow this link: High-speed serial data page

Now with SDAX enabled, the user can utilize its full capability over their GMSL signal. SDAX also covers a wide variety of serial data communications protocols, such as FlexRay, DVI, Ethernet, HDMI and most recently, GMSL and GMSL2.

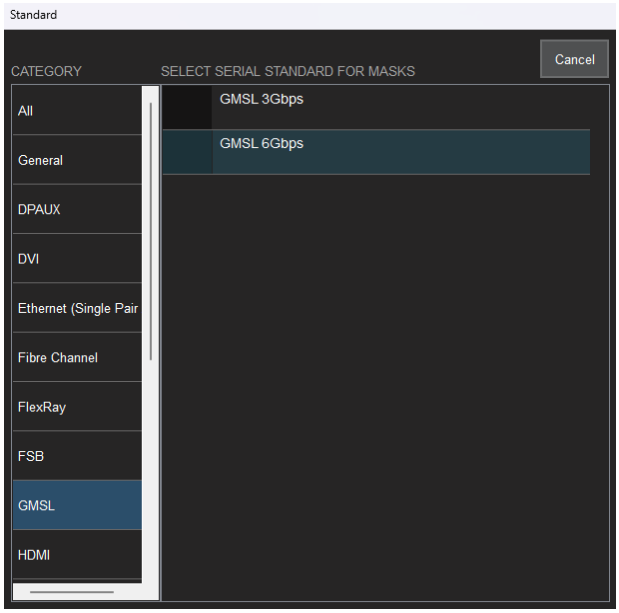

Figure 2: GMSL option in signals standard list

Setting up a GMSL Oscilloscope test

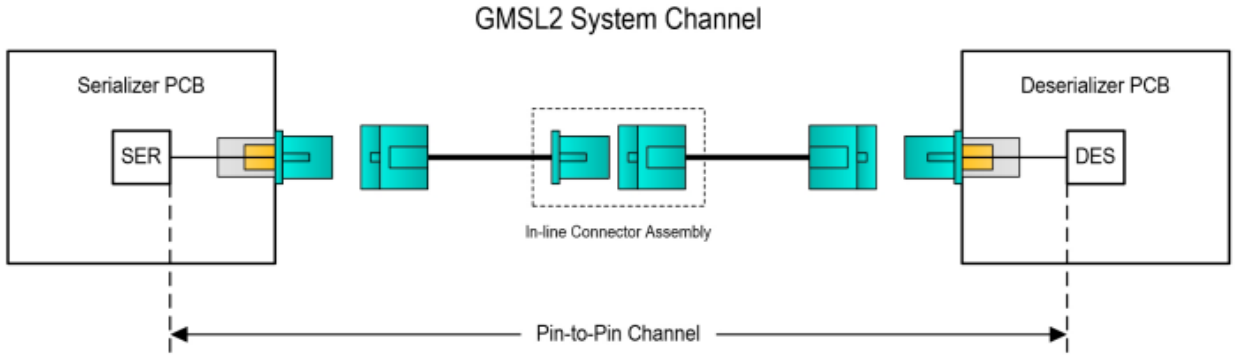

Figure 3: GMSL signal path REF: *GMSL2 Channel Specification User Guide*

As figure 3 shows, in a GMSL2 system, the serializer (SER) module, often integrated within camera modules inside an automotive environment, converts parallel video and control data into a high-speed serial stream, which is transmitted over a single coaxial or Shielded Twisted Pair (STP) cable to the deserializer (DES) module, often an ECU inside an automotive environment, where the data is reconstructed back into its original format.
The cable between these modules is critical, as it must maintain signal integrity across long distances and harsh environments.

To validate the electrical performance of this link, Teledyne LeCroy oscilloscopes are integrated into the test setup. The oscilloscope connects to test points on the cable, typically near the SER and DES ends, allowing engineers to probe the transmitted signals directly and provide a holistic idea of the overall performance of the GMSL system.

Teledyne LeCroy's SDAX capabilities are particularly valuable here. SDAX enables advanced eye diagram analysis, jitter decomposition, and noise characterization, which are essential for assessing compliance with GMSL2 physical layer standards.

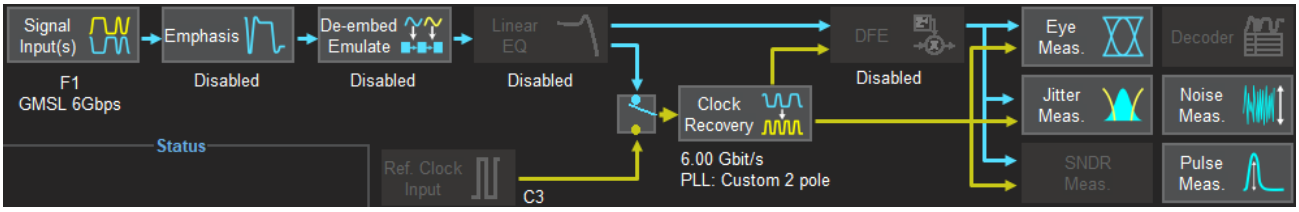

Figure 4: SDA signal path in Oscilloscope

Figure 4 shows the SDAX workpath, which offers a powerful set of tools for deep signal integrity. Within the SDAX interface of Teledyne LeCroy oscilloscopes, users are presented with a comprehensive overview of the signal path, offering direct access to each analytical block. Upon selecting either the Signal tab or the Signal Input box, the user can configure critical parameters such as the tested lane, protocol standard (ex. GMSL), nominal data rate, and the nature of the input, namely single-ended or differential. An optional input filter may also be enabled to further refine and optimize the signal prior to analysis.

Secondly, the Emphasis Block is typically employed in high-speed signals to mitigate high-frequency transmission losses.

A particularly powerful feature of SDAX is its De-Embed/Emulation functionality, which allows users to mathematically remove or simulate the effects of specific cables, fixtures, or interconnects. This is necessary for isolating the true behavior of the device under test.

Clock recovery is another strong feature in SDAX. Users may define a symbol rate, use a symbol rate tracker, supply an external reference clock, or activate a phase-locked loop (PLL).

The PLL itself is highly configurable, with selectable loop types including Open-Loop Jitter Transfer Function (OJTF), Jitter Transfer Function (JTF), and Natural Frequency. It is important to mention that Teledyne LeCroy has integrated a PLL setup dedicated for GMSL2 clock recovery.

Once the signal path is fully defined, SDAX unlocks a set of advanced analysis tools. These include jitter filtering, pattern analysis, jitter tracking, histograms and parameters. Similar analysis results are available for noise analysis.

The final element of this process is the generation of a detailed eye diagram, offering a visual representation of signal integrity at the selected measurement point.

This modular and flexible architecture enables users to accurately diagnose signal degradation, jitter accumulation, or noise intrusion. As a result, SDAX facilitates rapid and accurate troubleshooting, ensuring robust system performance and compliance with stringent physical layer standards.

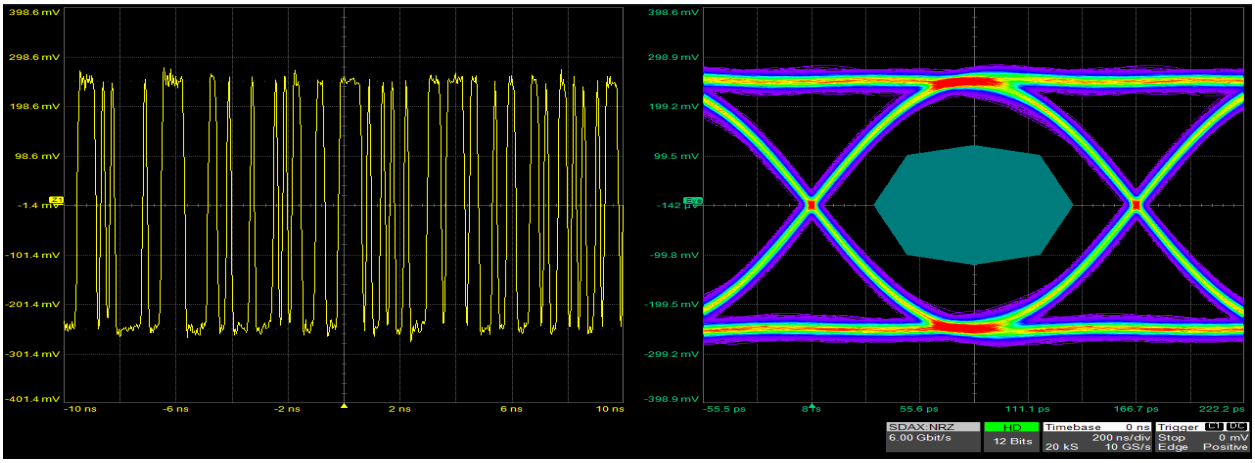

Figure 5: GMSL2 6 Gbps Eye Diagram

Figure 5 illustrates the result of Teledyne LeCroy's SDAX in the context of GMSL2 signal validation. On the left, we observe a time-domain waveform, capturing voltage transitions of a GMSL2 6Gbps NRZ serial signal. On the right, the eye diagram provides a visual demonstration of signal integrity, revealing overall link quality. For GMSL2, SDAX contains the specific compliance eye diagram mask, which determines boundaries that define acceptable signals in accordance to the GMSL communication protocol, allowing engineers to immediately identify deviations from standard performance.

The user may apply this SDAX test setup at different test points such as the serializer output, along the transmission cable, and at the deserializer input to evaluate key parameters such as signal degradation, interference, jitter, and noise—ensuring comprehensive insight into the integrity of the GMSL2 physical layer across the entire link.

Conclusion

As the automotive environment increases in complexity, serial data diagnostics and analysis require more precision. GMSL2, designed for high-speed multimedia transmission over a single cable, presents specific challenges in signal integrity that demand targeted evaluation across the physical layer.

Teledyne LeCroy supports this need through its SDAX platform, offering structured access to signal path blocks, protocol-specific masks, and configurable measurement parameters. This reflects a continued commitment to providing engineers with reliable instrumentation for GMSL2 and similar standards, enabling efficient validation and diagnostics across serializer, cable, and deserializer stages.

For more information, please head to our In-Vehicle Network page and our High-speed Serial Data page