Advances in Sampled Analog Video Transport

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Abstract

For current high-end displays, conventional data transports require parallel data-pairs plus equalization circuits to deliver the required video data to the edge of the display panel. These accommodations increase cost, power, and complexity.

HYPHY's revolutionary 'Sampled Analog' video transport is the solution to this impasse, demonstrably delivering 10X more video payload per "wire-Hertz" than conventional methods, meaning more image data can be transferred to the panel while decreasing the cost and power of display driving hardware.

Author Keywords

Sampled Analog; Video Transport; Display Driving

1. Introduction

The current generation of LCD source driver ICs (SDICs) relies on digital video transport from the device video subsystem to the edge of the glass, where the DDIC translates digital representations of video samples into the analog voltages required by the TFT array. With the continuous increase in display resolution, frame frequency, and sample color depth, the limits of digital video transport are reached and, for some applications, exceeded. For example, an 8K television with 240 Hz refresh rate, 10 bits per sub-pixel moves 230 Gbps through the wiring harness in aggregate. Even if we distribute this payload across 24 SDICs, this requires almost 10 Gbps per source driver IC. Since compression for these data streams is not an option, the only way to achieve the required throughput would be with multiple data pathways per source driver IC, thereby increasing system cost.

2. First Light and Optimization

First Silicon

In 2024, the first generation of SDICs using Sampled Analog Video Transport (SAVT) was developed [1], resulting in a prototype IC intended for evaluation of the performance.

The DDICs were assembled on a 65" 8K LCD panel, and the video performance was evaluated, referring to the earlier modeled potential error sources (Table 1).

Table 1: Error parameters

Error sources (model calculations)			
	Noise	*Gain Error*	Offset
Transfer / wiring	0.05 mV	0	0
Pre-amp	0.18 mV	<1%	0.15 mV
Distribution	0.14 mV	<0.5%	2.5 mV
Driver amp	0.29 mV	<0.1%	5 mV

From these evaluations, it was clear the display could reach the performance predicted by signal loopback and modeling [2] (Figure 1):

- Noise contribution was as low as expected and didn't play a role in the image quality evaluation.
- Timing and synchronization were managed correctly, and despite some small errors in the first silicon, reliable locking of the video signal was achieved.
- Re-distribution artifacts and settling time errors were not observed.
- Amplifier gain errors were minor and easy to correct when necessary.
- Offset errors were present to a higher degree than expected due to an on-chip wiring error (400 mV total). However, even this could be handled at the expense of some dynamic range.

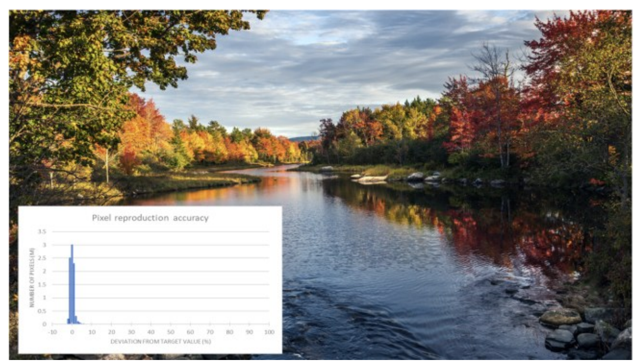

Figure 1: Loopback evaluation and accuracy histogram

Silicon Re-spin

A second spin of the DDIC removed several of the errors found and is currently (February 2025) under final evaluation.

3. Electromagnetic Radiation

The Electromagnetic Radiation (EMR) profile of the SAVT display was compared with the corresponding profile of a digital TV-panel. As expected, the digital signal generates significant EMR, since the video transport signal consists of 4 GHZ signals of full-swing "1" 's and "0" 's. Even the most basic image (e.g. mid gray at binary "10101010") will produce an emission comparable to half the clock frequency of the signal, i.e. a 2 GHz base signal (harmonics not considered). This frequency will easily radiate from any conductor with a comparable half-wave length (in this example: ~ 8 cm). If we consider even the first harmonic, even 4 cm conductors will radiate strongly unless significant (expensive) countermeasures are taken.

The SAVT signal has a much lower base frequency (~400 MHz) and in addition only varies with the direct image variation. The same mid gray image as above will have no level variations at all, and will therefore only have the base frequency of the line blanking. Worst case (vertical grid), the base frequency is 200 MHz, meaning the base frequency only has a tendency to radiate from conductors of 80 cm, but since most video images will have a much lower apparent frequency, radiation is unlikely and can be mitigated by simple means. Because of the non-periodic nature of the image signals, harmonics are much less significant than in the case of binary transmission (Figure 2).

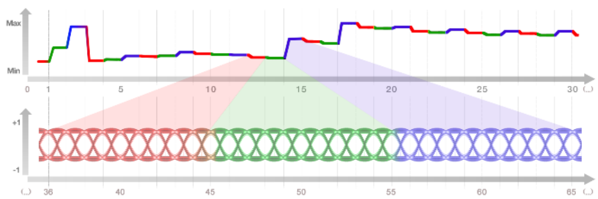

Figure 2: SAVT signal (top) and digital signal (bottom) clearly showing difference in base frequency

4. Evaluation

The results pave the way for a commercial device, and allows the design to be more fine-tuned than the conservative approach of the first prototype. The earlier predictions were confirmed:

- The cost of the SDIC is predicted to be lower than that of current, digital SDICs (since SDICs are pad-limited, the benefit of running slower data-rates provides the possibility of using older, less expensive semiconductor nodes and therefore lower prices per unit area).
- Due to the lower frequency, the power consumption of the SDIC is (much) lower than that of the corresponding digital SDIC.
- Also, due to the nature of the analog driving voltages and the lower transmission frequency, electromagnetic radiation is orders of magnitude lower than that of digital communication paths.

The introduction of Sampled Analog Video Transport will have a significant impact on serial data transport from video source (SOC or TCON) to display driver. Reduction of overall system cost, based on lower DDIC cost and greatly improved EM radiation and lower sensitivity to EMI makes SAVT the natural replacement of SerDes P2P communication.

5. Conclusion

Building of this prototype has proven it is possible to design an analog transmission system that produces no visible errors. Using SAVT, the image bit-depth can be increased arbitrarily while reducing transmission power and DDIC cost. Improved prototypes are planned to be demonstrated in the first quarter of 2025, and first commercial products are also planned.

Commercial application of HYPHY's video transmission technology will significantly reduce the manufacturing costs of larger, faster, and more vivid television sets and gaming monitors, while maintaining excellent signal robustness, low EMI emissions, superior video quality, and reduced power consumption.

6. References

[1] Henzen, A; Rockoff, T; Modulated Analog driving of high framerate UHD displays", Proceedings of the SID/DSCC 2023

[2] Henzen, A; Rockoff, T; Caulkins, W: Modulated Analog Driving and Evaluation of Image Quality; Proceedings of the SID 2024