High-Speed Time-Domain Measurement of Laser Beam Signals from Raster-Scanning RGB Laser Projector

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ABSTRACT

Scanning laser beam signals from raster-scanning RGB projectors were measured in time domain using high-speed photodiodes and a real-time oscilloscope. Temporal signal variations around 1 ns were obtained in each flame at 60 fps. These are useful for characterizing smart laser projectors from both technical and standardization point of views.

1 Introduction

Recently, laser displays based on semiconductor lasers have been attracting a lot of interest owing to the excellent color reproducibility, simple and compact optical circuit, low power consumption, and long lifetime, which have been demonstrated with laser cinemas and laser lighting systems in this decade [1]. These advantages of laser displays are essentially due to the unique features of a semiconductor laser as a light source compared with conventional ones: a narrow optical spectrum width (typically < 1 nm), and large spatial and temporal coherence obtained by the light amplification by stimulated emission of radiation.

With the success of commercial laser-based systems such as the laser cinema, laser spotlight and laser lighting, more advanced laser display/projection systems with high resolution and low-power consumption (sometimes, called as 'smart laser display' with the combination for tracking functions of a laser beam projection area) are attracting much more interest [1], [2]. A key technology for this advanced laser display is to control multiple visible-colored laser beams with a high-speed in temporal domain (< ns) and special domain (> 4K resolution).

We have been trying to study and discuss laser beam measurement techniques from raster-scanning RGB laser displays for detailed analysis and characterization of the projected images and the international standardization projects [3]-[5]. In this paper, some experimental results about the detection of raster-scanning RGB laser beams with a high temporal resolution around 1 ns are reported. By use of a multiple beam detection using two or more high-speed photodiodes (PDs) and bias-Tee circuits with an appropriate time trigger for a high-speed real-time oscilloscope, useful information about laser beam scanning/driving operations for safety controls are obtainable.

2 Experiment

The experimental set-up for the measurement of laser beam signals from raster-scanning projectors is shown in Fig. 1. Several laser projectors (1K or 2K resolution) with raster-scanning RGB laser beams were used in the experiment. The projectors were fixed on an optical bench by use of a standard optical stage and connected to a laptop computer with a HDMI cable for projecting several test patterns on the screen apart from the project with ~1 m.

In the just front of the screen, two or three high-speed Si PIN PDs were installed with a bias-tee circuit. The measured signals from the photodiodes were monitored and analyzed by use of a real-time digital oscilloscope with a frequency bandwidth of 4 GHz.

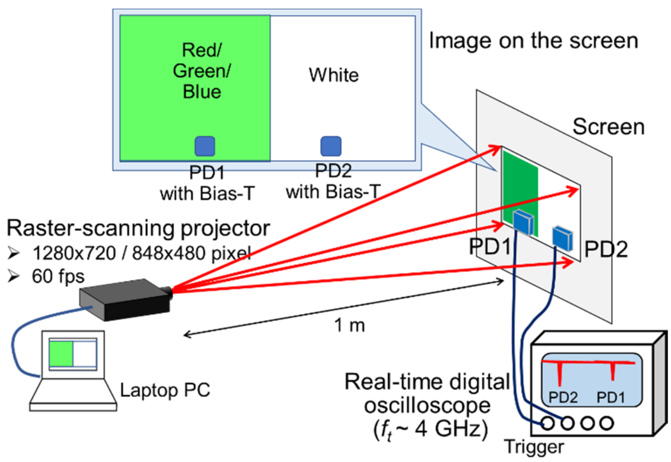

Fig. 1 Experimental set-up.

3 Results and Discussions

Fig. 2 show a typical example of the measured signals from PDs when a simple static test pattern is projected on the screen. The signals from the PDs have a negative polarity; when a laser beam is irradiated on it, its output voltage is reduced according to the laser beam power. We can see that the time resolution of the measurement system we used was below 1 ns and that high-speed signals from the scanning laser beam can be detected up-to several 100ps

Another example of the scanning beam measurement results is shown in Fig. 3, where white-/red-/green-/blue-colored simple title patterns were projected on the screen from a commercially available raster-scanning RGB projector. We can see that there was the temporal delay of ~50 ns between R/G/B signals. This temporal delay between RGB signals seems not so a big problem in 2K resolution. However, for the higher resolution in 4K and 8K, precise time domain control becomes necessary, we believe.

These measurement results are also useful for the standardization of the measurement techniques for laser display devices and systems, The measurements for moving target case are also underway.

(a)
(b)
(c)

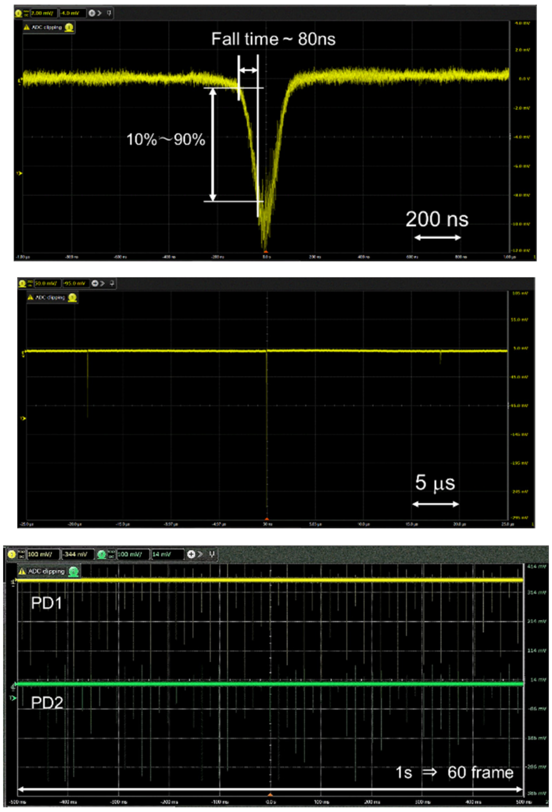

Fig. 2 Typical example of measured signal.
(a) Single scanning signal.
(b) Triple scanning signal.
(c) All scanning signal in 1 s (60flame).

(a)
(b)
(c)
(d)

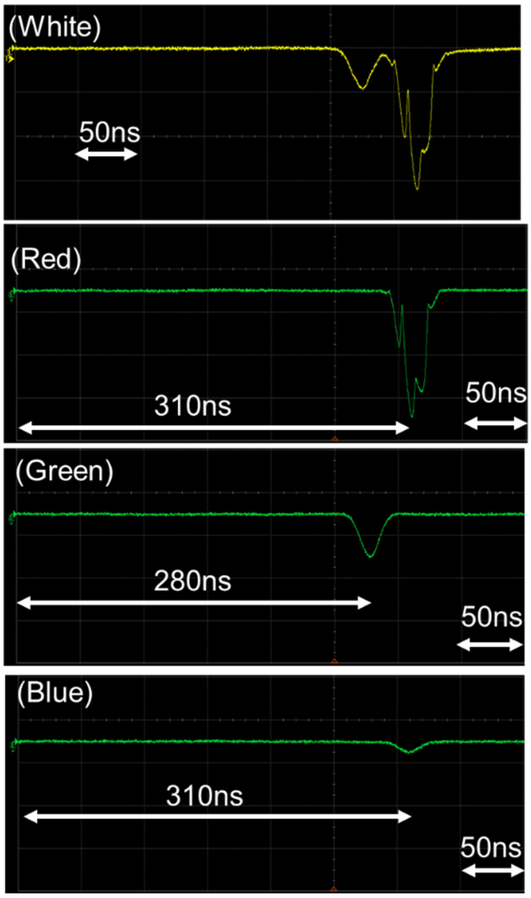

Fig. 3 Measured results corresponding to a single scanning signal from a 2K scanning display used in the experiment.
(a) White-colored tile pattern projection.
(b) Red-colored tile pattern projection.
(c) Green-colored tile pattern projection.
(d) Blue-colored tile pattern projection.

4 Conclusions

Temporal signal measurements from raster-scanning RGB laser projectors are reported. Clear pulse-like signals were identified around 1 ns time resolution using high-speed PDs and real-time oscilloscope, which is useful to characterize advanced high-resolution smart laser displays and to analyze color speckles in detail [6]. It should be noted that a key point in time domain measurements for self-operating scanning displays is to prepare an appropriate trigger signal for a real time oscilloscope from the projected signal. Further experimental results including moving images/targets for smart laser displays and precise spatial resolution measurements will be presented in the conference.

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