# Three-color Laser Marking Engine for KODAK Digital Lab System

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## Abstract

A three-color (RGB) Laser marking engine for Kodak digital laser printers will be described in this paper. These printers are intended for digital silver halide photofinishing products. The optical schematic of the laser marking engine along with the performance requirements and the capability of the marking engine will be presented.

## Introduction

Flying spot laser writers, using rotating polygons, have established a track record for producing high-quality hard copy images. A good example of the image quality capability of these writers can be seen in the monochrome film writers,[1,2] used in the Health science area. To write on silver halide color paper, the laser writer should be capable of generating RGB exposure on the medium. However, using RGB sources over a wide wavelength range makes the optical design and the beam combination complex. This is especially true when the marking engine has to maintain high-quality RGB spots, color registration, optical power stability etc. over the entire scan to produce high-quality color prints. The laser marking engine built for this application meets these stringent requirements, the proof of which can be seen in the quality of prints produced by this laser writer. Image quality requirements for this printer are covered in another paper titled "Image quality verification in the development of hardware and media for the KODAK Digital Lab System", in this conference.

## Performance Requirements of the Printer

| | |
|---|---|
| Max. Scan Length (print width) | 12 inches |
| Resolution (pixels/in) | 512 |
| Productivity (Pr/Hr - burst) | 1000 (4" x 6") |
| | Full color |
| Paper speed (inches/sec) | 3.354 |

## Description of the Printer

The Kodak laser printer to be described here is a stand-alone digital photo finishing system for consumer photography. It accepts electronic digital image input and generates color prints on silver halide media, and is capable of printing images up to 12 inch width, maximum.

In addition to power supplies and control electronics, the three-color laser printer consists of three major subsystems, namely, the laser marking engine, slow scan paper transport and data path electronics as shown in Fig. 1. The laser marking engine is comprised of input optics and scan optics. Functionally, the digital image data is appropriately formatted by data path electronics and sent to the Input optics of the laser marking engine. In the input optics, the electronic digital image data is converted to an RGB optical signal and sent to the scan optics. The spinning polygon in the scan optics generates RGB raster lines of optical image data, which are then exposed on to a silver halide medium mounted on a precision rotating drum transport. The successive precisely registered raster image lines written on the moving media generates the 2-D latent color image. The schematic of Laser marking engine, which consists of the Input optics and Scan optics is shown in Fig. 2. The Input optics consists of a red semiconductor laser diode (685 nm), a solid state SHG green laser (532 nm), a solid state SHG blue laser (473 nm), three acousto-optic modulators (one for each laser) and a single-mode fiber MUX beam combiner.[3] Beams from each laser are focused to a spot about 80 microns diameter in their respective acousto-optic modulators (AOM). Light from each laser is modulated by the AOM according to the electrical image data sent by the data path electronics. The first order diffracted beams exiting each AOM, which contain the image data, are coupled to the input of a single-mode fiber MUX. The fiber MUX combines the three beams into a single colinear beam and is carried to the scan optics through a single-mode fiber. The scan optics consists of prepolygon shaper optics, a multifaceted polygon mirror with a D.C. brushless motor, post-polygon shaper optics, and fold mirrors. The scan optics, shapes the combined beam from the fiber MUX, which is then reflected from the polygon to generate raster lines of specific waist size at the medium plane, while precisely maintaining the raster location for each of the successive raster lines.

## Laser Marking Engine Specifications

Based on the performance requirements of the printer, the marking engine was designed to the following specifications shown in the table.

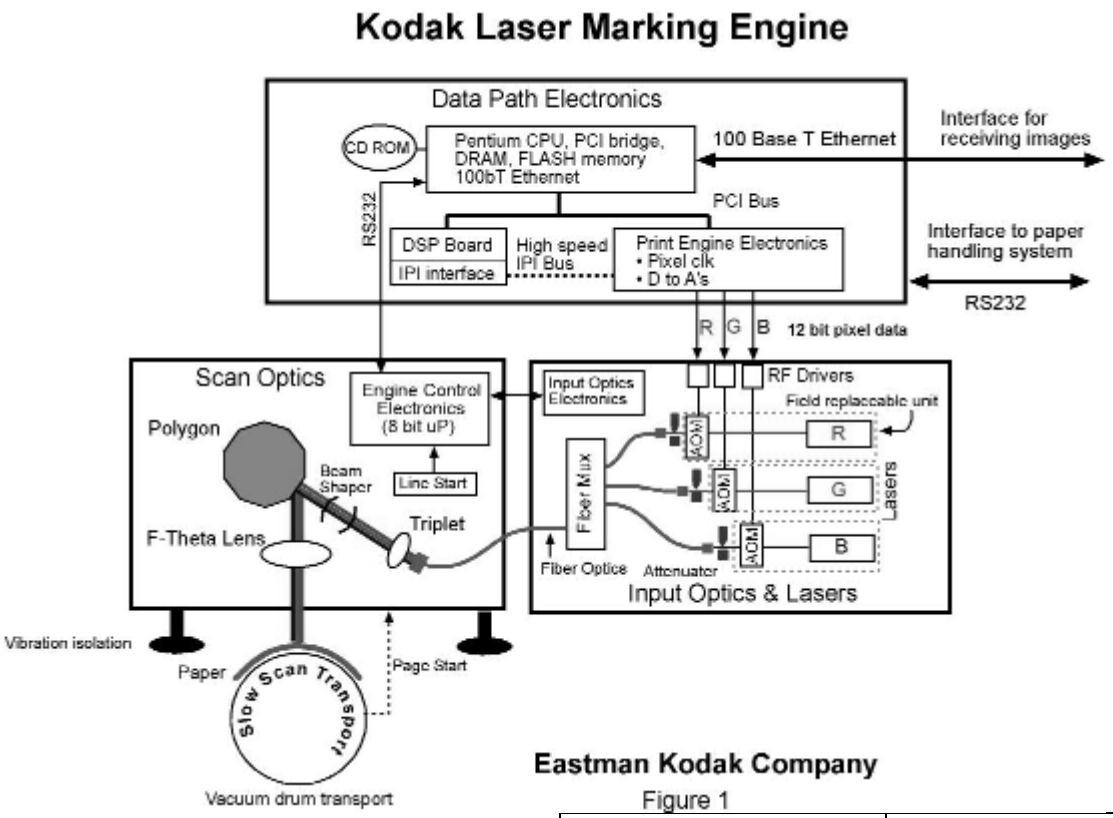


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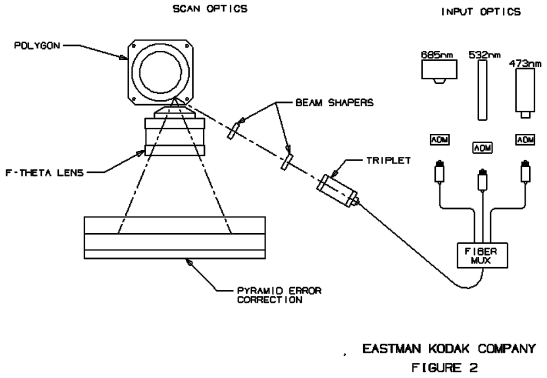
Figure 1




| | |
|---|---|
| Polygon speed | 10304 rpm |
| Number of facets | 10 |
| Dynamic pyramid angle error | ±10 sec |
| Active scanning time/facet | 582 microsec |
| Life | 10000 hr run time |
| Spot size at image surface: 70 micron @1/e2 dia (nominal) | |
| Beam combiner | Fiber MUX |
| Pitch irregularity | < =/- 0.1% of line pitch |
| Modulation | Acousto-optic modulators |
| Light sources: | Red - Laser diode (685 nm)<br>Green - Solid state laser (532 nm)<br>Blue - Solid state laser (473 nm) |
| Time/pixel | 71 nsec (14 Mpix /sec) |

## Summary

This printer, as designed is capable of much higher productivity and with the same design, a productivity of 18000- 4R prints/hr at a lower resolution has been demonstrated by changing the polygon and the shaper optics. Very high quality color pictorial images with text and graphics are being made with this printer.

## References

1. U.S. patent # 4,921,320 issued on May, 1990.
2. U.S. patent # 5,151,810 issued on Sep., 1992.
3. U.S. patent # 5,666,447 issued on Sep., 1997.