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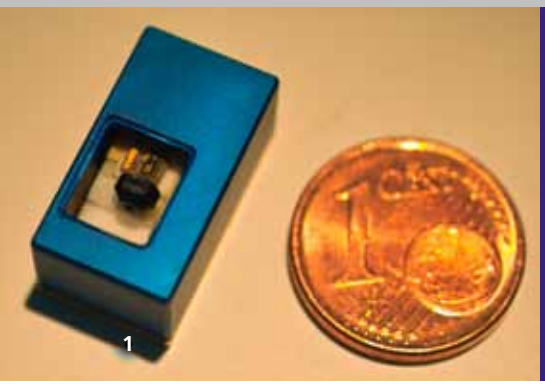
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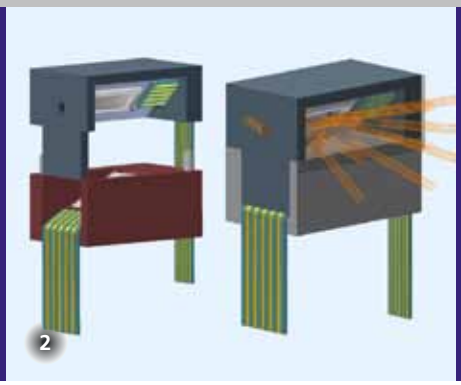
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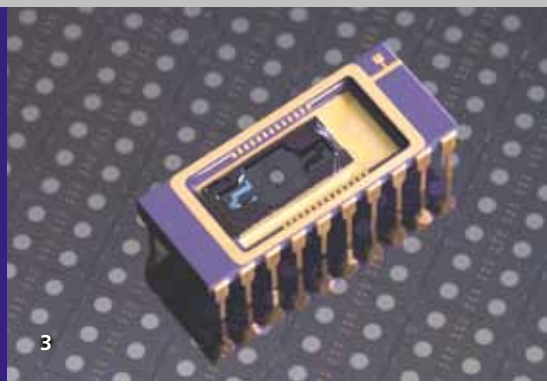
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1 *Ultra compact projection module.*
2 *Concept of projection head with two 1D scanners.*
3 *LinScan MEMS scanning mirror.*

LASER PROJECTION MODULE

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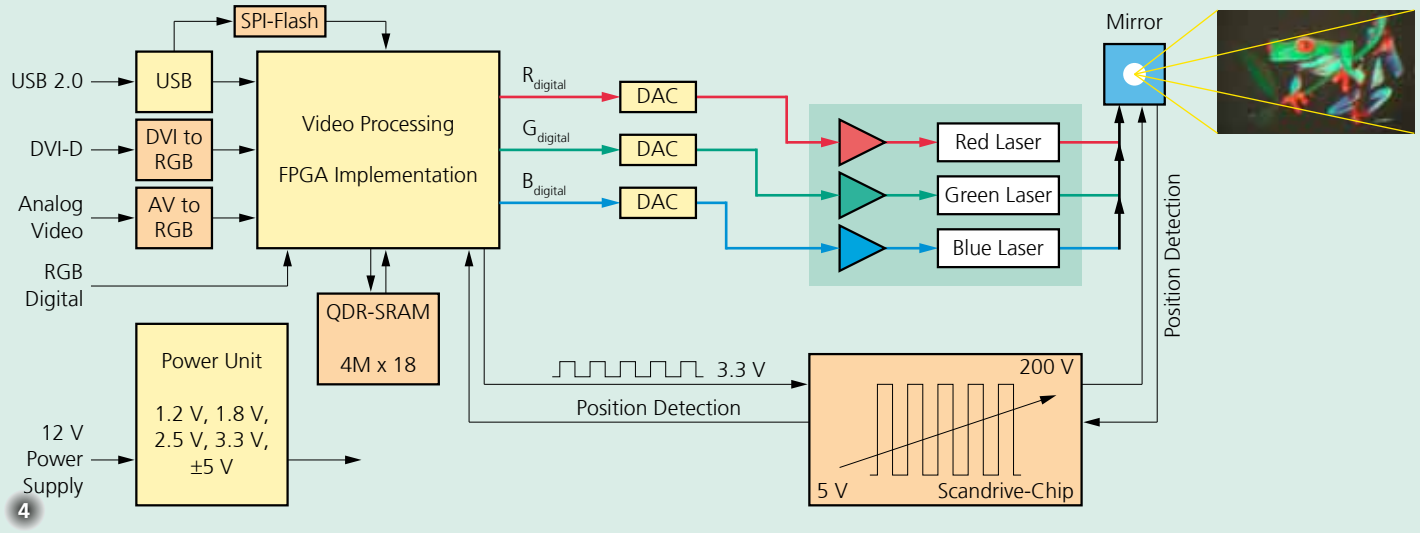
Introduction

Pico-projectors are considered the ultimate feature of future mobile telephones: Projectors so small that they can be integrated into the mobile device. At present a projection the size of a television screen seems possible from a short distance, and HD resolution is also in demand.

Fraunhofer IPMS has already been active for a few years in making customer solutions for pico-projectors available. The Institute has been focusing on the principle of laser beam steering for image generation. Just like a CRT in which an electron ray is deflected so that it stimulated one image point after the other to light up, one brightness-controlled laser beam (or three in red, green and blue for full-color display) is directed so quickly over the projection surface by a single miniaturized scanner mirror that an image cohesive to the human eye appears. The scanner mirrors typically have a diameter of about one millimeter and are manufactured from micro-crystalline silicon wafers with established processes in cost-effective lots in the Microsystems technology clean room at Fraunhofer IPMS.

System architecture

The laser projection system consists of the laser sources plus optics, the micro scanning mirror and system electronics (see block diagram in fig. 3). The laser beam is collimated and directed onto the scanning mirror. Three different mirror types are possible which have an influence on the way the image generated in detail. First type are bi-resonant mirrors with sinusoidal oscillations of the mirror around two perpendicular axes, a Lissajous figure is projected onto a screen. By carefully



choosing the frequency ratio for the two axes it can be ensured that the laser beam hits every virtual pixel of the image grid overlay of the Lissajous pattern within the time available for a given frame rate. By synchronous modulation of the laser source and driving of the mirror, arbitrary images can be projected.

The demonstrators allow a direct connection with any standard analog or digital video source, no special software to control the projector is required. Necessary adjustments can be made directly.

Technical Parameters

The bi-resonant micro mirrors used in full featured laser projection demonstrators achieve oscillation amplitudes of about 10° (fast axis) and 12° (slow axis) at driving voltage of 70 V and at normal pressure with open-loop control. In order to cope with long-term environmental changes, a closed-loop operation with position detection is required. Analog signal processing is handled by the special Scandrive chip that also features generation of voltage pulses for driving the mirror. The oscillation frequencies of the available micro mirrors of about 1.2 kHz (slow axis) and 28 kHz (fast axis) allow a resolution of up to 640 x 480 pixels (VGA resolution) and refresh rates of up to 50 Hz. Recent developments at Fraunhofer IPMS make advanced system parameters (SVGA, i. e. 800 x 600 pixels and 60 fps) possible. The control circuit also provides SVGA resolution. Support of grey scales with 8 bit resolution per pixel and elementary color as well as the correction of inhomogeneous illumination caused by the varying beam speed in different parts of the projection area are integrated in the control unit.

The electronics accepts video data in digital form via DVI-D as well as analog signals. For backward compatibility with previous systems also sending data via USB 2.0 from a PC running a special control application is possible.

Figure 1 shows a module for monochrome red image projection that comprises the laser, the micro optics and the micro scanning mirror. It has a volume of only 17 mm x 7 mm x 5 mm. Full color capable systems still have larger dimensions.

Alternative Approaches

The second type of micro mirrors for laser projection also uses the Lissajous pattern approach. However, instead of using a single two-dimensional MEMS scanning mirror, the projection head comprises two 1D mirrors. Figure 2 shows a drawing of the projection head.

Path to higher resolutions is set by the new quasi-static scanner concept from Fraunhofer IPMS called LinScan. The basic technology doesn't have to be changed, so that our customers continue to profit from the seasoned manufacturing process. It is sufficient to tilt the actuator combs toward each other permanently with a final micro-assembly step, along with a small modification of the mechanical design. The Institute was able to show that a combination of resonant actuator on the quick horizontal axis and LinScan on the slower vertical axis is possible for a two-dimensional scanner like those necessary for pico-projectors. The laser beam can now make targeted jumps from line to line according to an externally configured frequency. Pico-projectors with a SVGA resolution (800 × 600) and higher will be easily practicable.

Applications

- Image projection
- Rear projection
- Laser labeling
- Various exposure purposes

4 *Block diagram of system electronics for laser projection module.*