Electronic diagnostics system for the analysis of laser beam profile

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Abstract
In this work the analysis of laser beam profile system ,using a two dimensional CCD (Charge Coupled Device) arrays, is established. The system is capable of producing video graphics that give a two dimensional image of laser beam. The video graphics system creates color distribution that represent the intensity distribution of the laser beam or the energy profile of the beam. The software used is capable of analyzing and displaying the profile in four different methods that is , color code intensity contouring , intensity shareholding, intensity cross section along two dimension x-y, and three dimensional plot of the beam intensity given in the same display.

Key words
Beam profile, Diagnostics System, Gaussain Beam

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المنظومة الالكترونية لتحليل الحزمة الليزرية

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الخلاصة
في هذا البحث تم بناء منظومة تحليل الحزمة الليزرية باستخدام جهاز الشحنة المزدوجة ثنائي الإبعاد. المنظومة لها القابلية رسوم فديوية بصورة ثنائية الأبعاد لحزمة الليزر. المنظومة تولد توزيع لوني للدلالة عن توزيع الشدة لحزمة الليزر أو شكل توزيع الطاقة.البرمجيات استخدمت لتمكننا من تحليل وإظهار الشكل بأربع طرق ،كصورة ملونة، وتوزيع الشدة ببعدين، وثلاثة أبعاد، ومسقط لتوزيع الشدة والكل يظهر بشاشة واحدة .

1-Introduction

By increasing sophisticated uses of lasers, laser applications are becoming more complicated, therefore the quality of laser beam must be closer to the ideal profile to achieve success. Traditional methods of measuring the laser beam intensity profile, such as burn spot, mode burns, and viewing the reflected beam, do not provide sufficient information to enable a scientist to achieve optimum laser performance. On the other hand, the availability of electronic laser beam profiling instrumentation has enabled scientists and engineers to tune lasers to much higher standers. Two provide illuminating beam profile displays. These displays in 2D and 3D beam views, often provide sufficient intuition to enable the laser operator to make significant improvements to the laser beam in very short time. The other property of electronic beam profile analysis, added system for precision measurements could be used as a qualitative real-time visual display of the laser beam intensity profile.

A pesudocolor gray scale intensity pattern and TV monitor could display a colored image that represents the intensity distribution for the laser beam. The energy distribution of a laser beam is important in many applications. Such applications are free space communications radar and medical; these require data on a pulse by pulse basis, so that pulse to pulse variations in the beam quality can be measured. These data are useful in predicting error rates for a laser communications system, and precision of laser radar tracking system [1].

Precise measurements of the laser beam width are major keys in enabling a laser designer or user to maintain optimum performance. From accurate measurements of the laser beam with are derived much accurate measurement of laser beam width. In addition, electronic laser beam diagnostics provides other measurements of the laser properties, such as fanssian fit of near Gaussian beams, Top hat measurement of flat top beams, and statiscal measurements to determine the stability of many beam properties.

Video-Graphics system coupled to a minicomputer forms a comprehensive tool for analyzing a laser beam. In addition to precision measurements of beam profiles, a number of other measurements can be made. These include measuring the scanning properties of abeam a cross a large field of view. Pulse to pulse variations in the total energy of the beam over a large number of pulses, precision measurements in the timing of the laser-beam pulse and demodulation of the output from a laser transmitter[2].

There is a number of other standard beam profiling methods utilizing detector arrays, scanning aperture, scanning knife-edges, burn patterns and photographic technique [3]. All of these methods have disadvantages in certain situations, for example, detector arrays becomes difficult to use when beam size exceeds that detector array, scanning apertures require a very large number of shots to cover a beam in two dimensions with reasonable resolution. Using scanning knife-edges reduces the number of shots required, but assumes circularly symmetric profiles. Burn patterns are unsuitable for precise work, being only a rough guide, and required a certain threshold energy density. There are several disadvantages associated with photographic technique e.g. chemical pressing, non linearity of film response, wavelength sensitivity and the need to use a microdensitometer to reach a quantitative results [4], while video graphics creates a pesudocolor representation of the intensity distribution for the full beam.

Two dimensional optoelectronic imaging and digital processing circumvents limitations inherent in earlier measurements techniques. All the requirements for measuring laser beam profile have been include in our video graphics system. This system can be used for pulsed and CW laser. The beam size measured range from few millimeters to few centimeters. The computer of this unite generates histograms of 200 pixels across the beam that enable computing two-dimensional parameters for the beam profile [3, 4].

Experimental work

The image of a video graphics system is shown in Fig.(1).The intensity beam profile measurements used a video camera with high resolution, low geometric distortion, wide dynamic range and uniform sensitivity across the image plane. A standard video camera (CCD 50) is incorporated into the system. This camera is sensitive in visible and near inferad regions (e.g. Nd:YAG, He-Ne, diode, lasers ….etc) [3,4]. Only the diode laser has been studied in this work.

To capture the beam profile with video system necessitates synchronizing the laser pulse to video scan. The CCD array camera simplifies this process because the odd and even video fields are alternatively transferred out at the 30 Hz frame rate. Thus the exposure time of each filed is 33.3 ms. The extreme intensity of the laser beam exceeds by many by many orders of magnitude the ambient background from the room lighting. Therefore, the laser pulse can occur at any time wthin the filed except at the time of transfer from the photo sensor to the vertical clocking register in the CCD array [5]. An A/D converter signal (flash converter) was applied to convert the video signal to digital signal. Also, a sequential parallel technique was applied by the A/D converter to obtain a high-speed operation. A static rams where used to store the digital data immediately as it is available by the A/D convert. The memory addressing lines for the static rams are achieved by using counters.

Laser beam has been divided in two using beam splitter as shown in Fig.(2).One out part, was directed to the power meter to measure laser beams power, it is multiplied by two to be displayed on the computer monitor. The second part, of the laser beam was passed through the beam optics controller. The attenuator reduces beam intensity to operate within the linear region of the CCD camera [6,7]. Consequently the beam is directly "imaged" with a CCD camera linked to computer.

The image of semiconductor laser spots at different intensities and distances are displayed. Using the image transfer card, these images are transferred to the computer to be shown on the monitor. The image process is done with the help of the image processing software.

The image passes through a number of software stages of image processing to be dealt with later by connecting it to MATLAB program this enables drawing laser beam intensity; as an image in 2-dimansions or 3-dimensions. Also, it enables drawing the intensity in a counter fashion.

3-Results and Conclusions

The CCD camera output images of the laser spots are recorded at different applied voltage using semiconductor laser. These recorded images are shown in Fig.(3).

The computer analysis of the above mentioned images are shown in Figs. (4 and 5). These figures show the laser beam profile with applied voltage (2.5V and 3.5V).

Studying the above results one could analyze the intensity distribution of the laser beam, the laser energy, number of modes, and transverse mode intensity distribution.

Consequently a computerized laser beam profile analyzer system has two privileges. The first is the ability to provide instantaneous beam profile displays. this these displays, in both 2D and3D beam views often provide sufficient intuition to enable the laser operator to make significant improvement to the laser beam in very short time. The second property is the higher accuracy with which laser beam properties are measured that would be useful for many medical and military applications.

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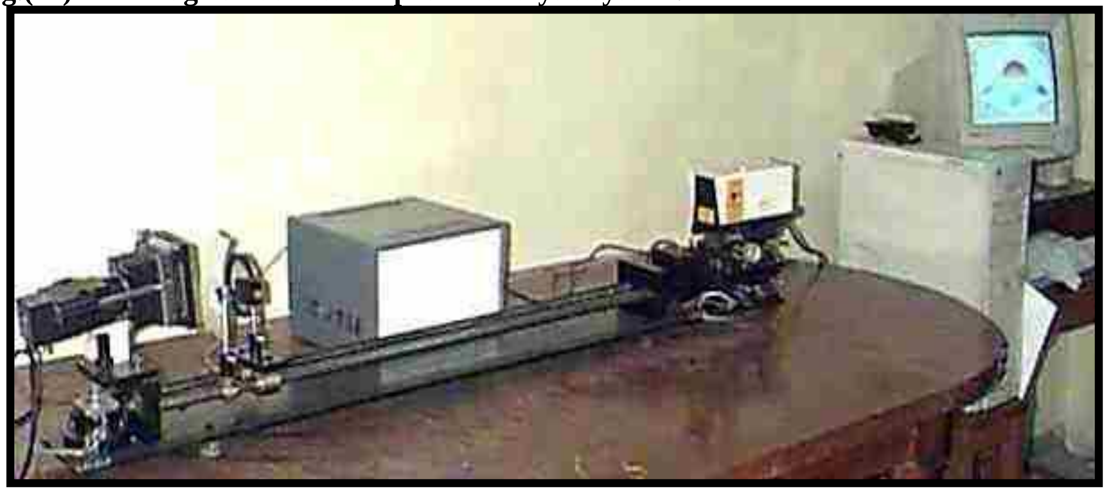
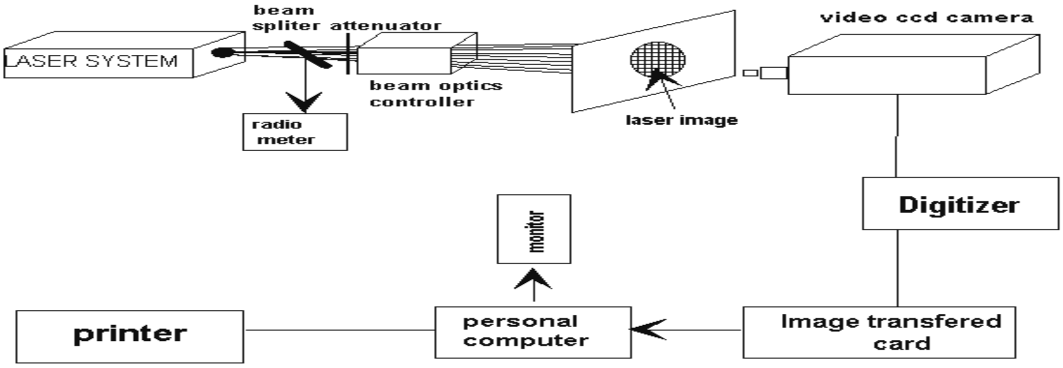
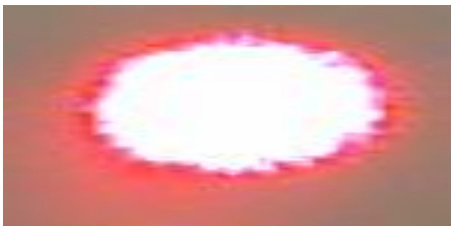
Fig.(1) The image of laser beam profile analysis system.



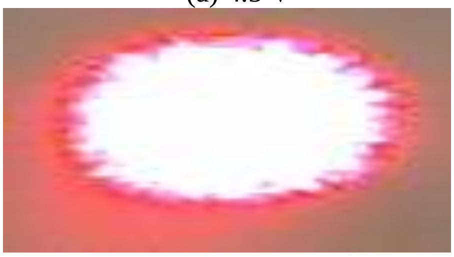


Fig(2) Diagram of laser beam profile analysis system



(a) 4.5 V

(b) 4 V

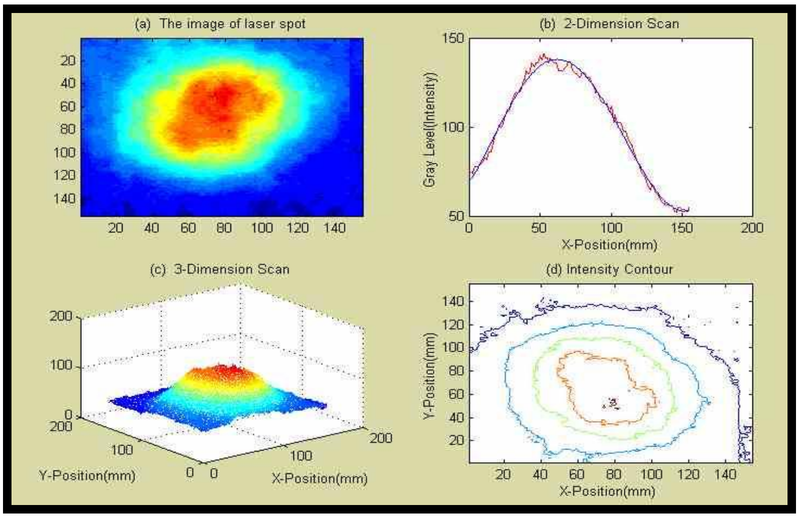


(c) 3.5 V

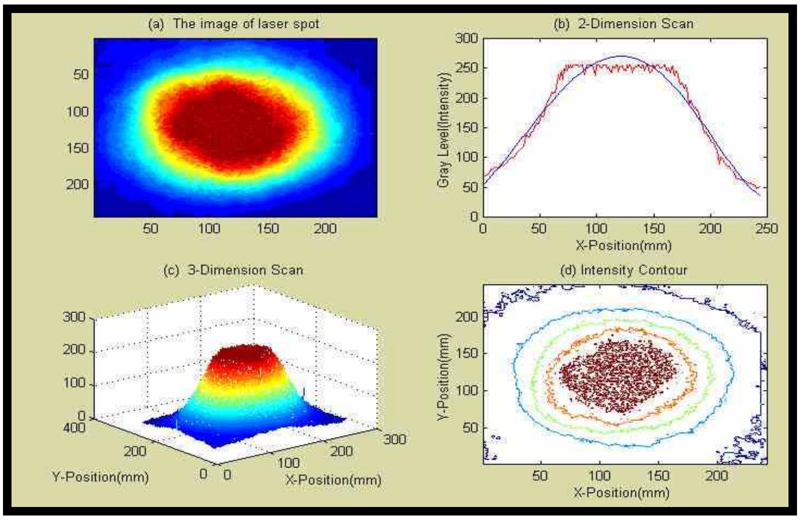
(d) 3 V

(e) 2.5 V

Fig. (3) Semiconductor laser at different applied voltages. (a)4.5V, (b)4V, (c)3.5V, (d)3V, (e)2.5V.



Fig(4)Semiconductor Laser beam profile at(2.5 V) applied voltage (a)Image spot, (b)2-Dimension Scan profile fitting ,(c)3-Dimension Scan ,(d)Intensity Contour



Fig(5)Semiconductor Laser beam profile at(3.5 V) applied voltage (a)Image spot ,(b)2-Dimension Scan and profile fitting ,(c)Dimension Scan ,(d)Intensity Contour