

## Night Vision monitor for IR laser spot size Identification

M.T.Hussein

Department of Physics, College of Science, University of Baghdad

### Abstract

The aim of this research is to design and construct a semiconductor laser range finder operating in the near infrared range for ranging and designation. The main part of the range finder is the transmitter which is a semiconductor laser type GaAs of wavelength  $0.904 \mu\text{m}$  with a beam expander and the receiver; a silicon pin detector biased to approve the fast response time with it's collecting optics. The transmitters pulse width was 200ns at a threshold current of 10 Ampere and maximum operating current of 38 Ampere. The repetition rate was set at 660Hz and the maximum operating output power was around 1 watt. The divergence of the beam was  $0.268^\circ$  the efficiency of the laser was 0.03% at a duty cycle of  $1.32 \times 10^{-4}$ . Special software (ZEMAX EE 2000) was implemented for optimum optical design. The transmission and reflection of the laser pulse spot size were observed and detected by a Night Vision Monitor of second generation with fast digital camera. The Mat lab software used is capable of analyzing and displaying the profile in 4 different methods that is , color code intensity contouring , intensity threshold , intensity cross section along two dimensions x-y and three dimensional plot of the beam intensity given in the same display. The atmospheric attenuation for this semiconductor laser was also calculated using Low- Tran .6 code, which indicated that negligible attenuation is recorded below 2 Km range for  $\lambda=0.904 \mu\text{m}$

### Keywords

GaAs laser spot size  
Night vision

### Article info

Received: Mar. 2010

Accepted: Apr. 2010

Published: Nov. 2010

## تشخيص بقعة ليزر الأشعة تحت الحمراء باستخدام مراقب الرؤية الليلية

محمد تقي حسين

قسم الفيزياء - كلية العلوم جامعة بغداد العراق - بغداد

### الخلاصة

يهدف البحث الى تصميم وتصنيع مقدره مدى لليزر اشباه الموصلات والعامله بالاشعة تحت الحمراء القريبة لتحديد موقع وكشف الاهداف المختلفه. تم تصميم وتصنيع العناصر الرئيسيه لمقدره المدى الليزرية والتي تتضمن المرسله الليزرية حيث تم استخدام ليزر شبه الموصل نوع Ga As ذا الطول الموجي  $0.904 \mu\text{m}$  مايكرومتر مع الاجزاء البصرية الخاصة به (موسع الحزمة) والمستقبله المحتوية على الكاشف السليكوني السريع والجزء البصري الخاص بها. تم قياس مواصفات المرسله وكان عرض النبضة 200 نانو ثانية وتيار العتبة 10 امبير واعلى تيار للتشغيل 38 امبير عند تردد 660 هيرتز والقدرة الخارجة بحدود 1 واط. تم قياس انفراجية الليزر وكانت بحدود  $0.268^\circ$  درجة والكفاءة التحويلية بحدود 0.03% والدورة التشغيلية  $1.32 \times 10^{-4}$ . كما تم الاستعانة ببرنامج ZEMAX EE 2000 لاختيار التصميم البصري المناسب. تم تسجيل البقعة الليزرية لنبضة الليزر النافذة والمنعكسة من السطوح المختلفه وذلك بواسطة مراقب الرؤية الليلية مع كاميرا رقمية سريعة. لتحليل البقعة الخارجة والمنعكسة حيث تم استخدام برنامج Mat lab الذي يمتاز بقدرته التحليلية وعرض الأشكال بأربعة طرق مختلفة للشدة اللونية والكنترورية وبيدين وبثلاثة أبعاد لشدة الحزمة وعرضها في نفس المكان. كذلك تم حساب معامل التوهين الجوي لليزر شبه الموصل بأستخدام برنامج Low Tran 6. وكان التوهين اقل ما يمكن ضمن المدى 2 كيلومتر للطول الموجي  $0.904 \mu\text{m}$  مايكرومتر.

## Introduction

A variety of techniques have been developed to achieve a laser range finder. Recently GaAs semiconductor laser of  $0.904\mu\text{m}$  was extensively used due to its compatibility in many applications for ranging measurement and designating of different target [1-3]. Laser applications are becoming more complicated therefore the quality of laser beam must be closer to 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 laser to much higher standards. To provide illuminating beam profile displays, these displays in 2D and 3D beam view, often provide sufficient intuition to enable the laser operator to make significant improvements to the laser beam is very short time. The other property of electronic beam profile analysis, system an added system for precision measurements could be used as a qualitative real-time visual display of laser beam intensity profile.

A pseudo color gray scale intensity pattern and TV monitor could display a colored image that presents the intensity distribution for the laser beam. The energy distribution of a laser beam is important in many applications. It is important to know the energy distribution of a laser beam applications such as free space communication radar and medical uses. 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 communication, and precision of laser radar tracking system [4].

## Experimental

The system we describe below is a laser range finder which consists of two parts.

- Firstly: The transmitter part shown in figure (1), contains charging and discharging circuits as well as a fast switching trigger circuit (Thyrestor). The main job of the trigger circuit is to operate the laser diode with a suitable pulse frequency limited by the value  $f=1/R_1C_4$ . The charging circuit provides a suitable pulse width and the output laser beam of the transmitter device passes through a beam expander of focal length (6.8 cm) with a lens diameter (3.2 cm). The beam trace was obtained by ZEMAX –EE 2000 Code as shown in figure (2) to achieve a small spot size and parallel beam with minimum divergence.

- Secondly: The receiver part, shown in figure (3), receives the collimated reflected beam by a Dome lens as (a fish eye) with a focal length of 1.5 cm and a lens diameter of (4.14 cm). The lens was made of BK-7 type glass to achieve good for optical transmission. The receiver circuit is triggered by the beam transmitted and reflected automatically records time duration. The output laser pulse duration and repetition rate were measured using a 100MHz storage Tektronix oscilloscope.

## Result and discussion

Figures (4, 5) represent the time behavior of the laser pulse at FWHM of 200 ns and a repetition rate of 660Hz. The duty cycle ( $\delta=f.\tau$ ) at different frequencies was too low as shown in fig.(6).

The transmission and reflection of the laser pulse were observed and detected by a night vision monitor of second generation as an image intensifier with fast video digital camera. The laser spot size was systematically analyzed by Mat-Lab computer code and the analysis showed uniformity of the intensity distribution different color regions as shown in figures 7& 8 respectively. The laser spot size showed a broadening of over 10 times of that photographed as indicated in figures 9

& 10 which compare transmitted and reflected laser pulses. The benefit of pseudo contour is to enable on intuitive visualization of laser beam intensity distribution. In these contours the background signal level corresponds to white colors and colors from blue (lowest) to red (highest) display the intensities of laser beam. It can be clearly noted the cross section of laser diode is an elliptical. This is because of divergence in x-direction is different from that in y-direction. This because the cavity of laser diode is rectangular. This result show the

capability of our system in analyzing the laser source.

The severe broadening of the reflected beam weakens the detected signal .Which imperatively reflects the improvement of the sensitivity of the detected circuitry.

The results obtained of low tran-6 code indicates further expected attenuation of the transmitted laser pulse which further limits the range finder identification [5, 6].The results of low tran-6 code is shown in Table-1 as average absorbing particles in atmosphere. Figure (11) shows the transmittance of the laser pulse as a function of range.

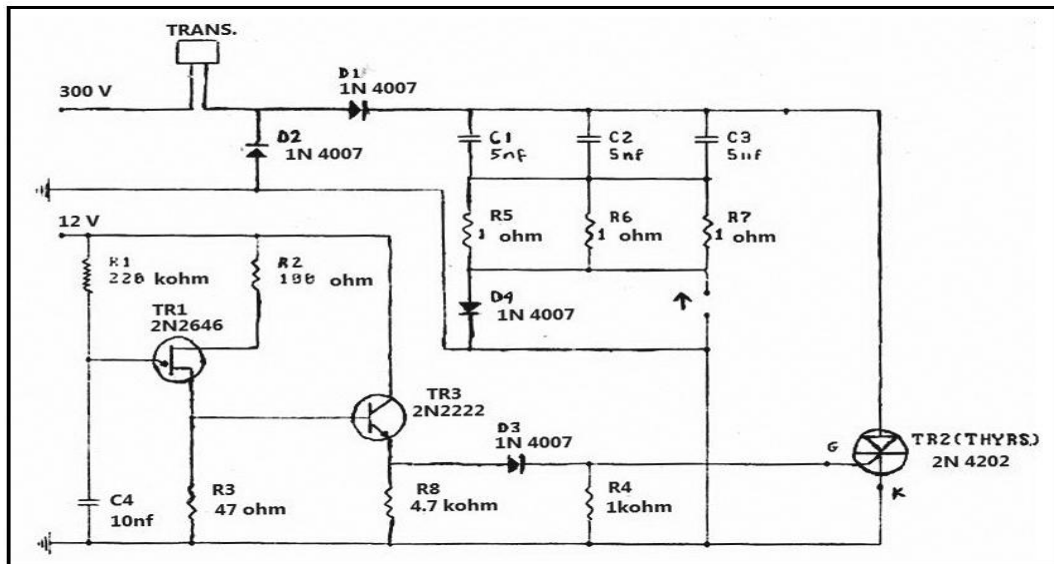


Fig.(1) Transmitter circuit block diagram of laser range finder

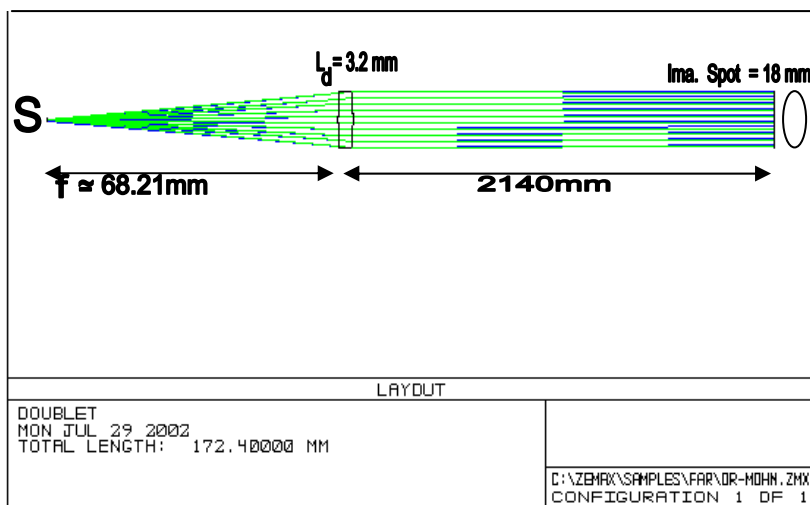


Fig.(2) Beam trace of output semiconductor laser range finder

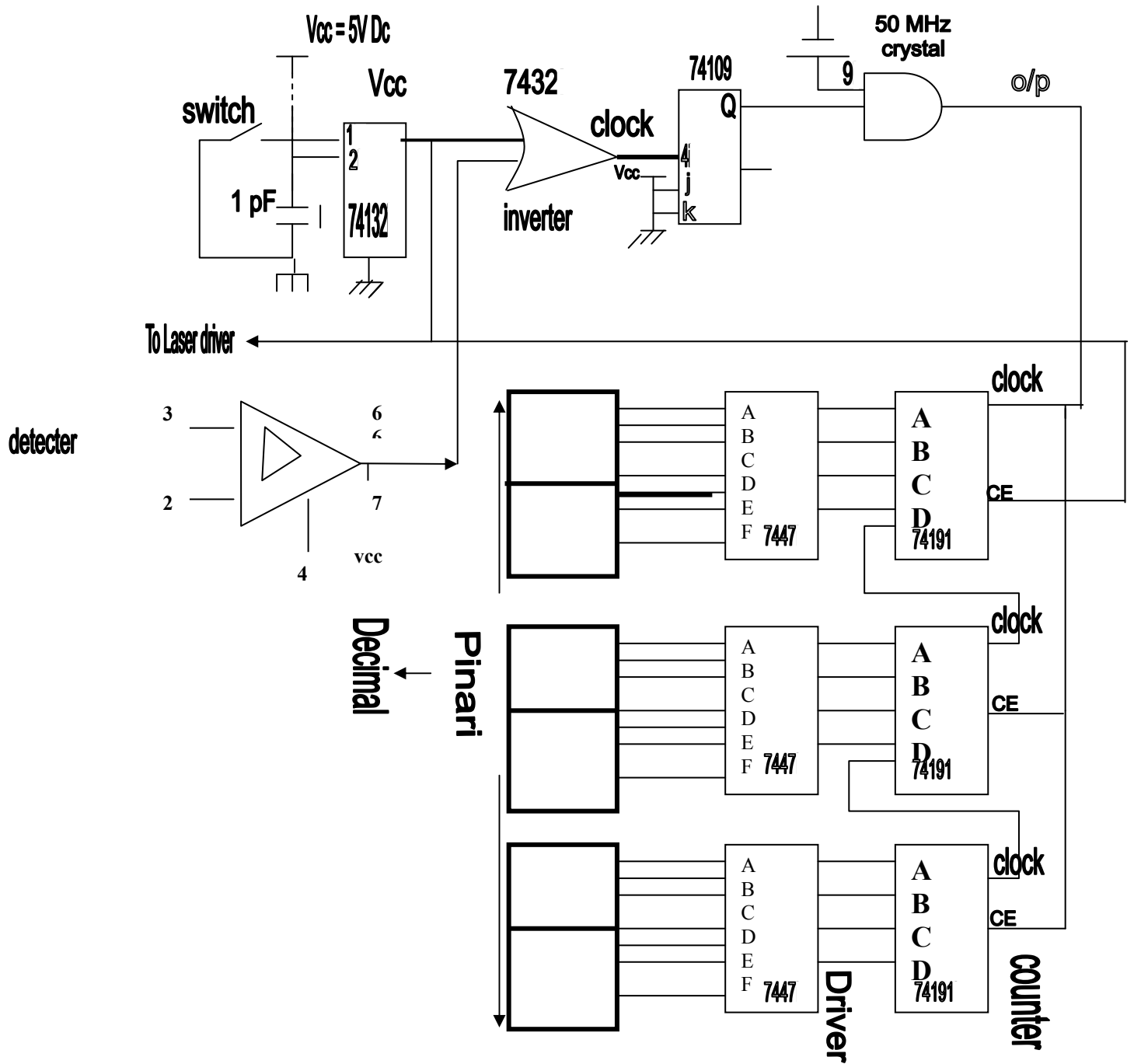


Fig. (3) Receiver circuit block diagram of laser range finder



Fig. (4) Represents laser semiconductor pulse duration show by storage Tektronix oscilloscope where x-axis =0.5 usec/div, y-axis=0.2 V/div.

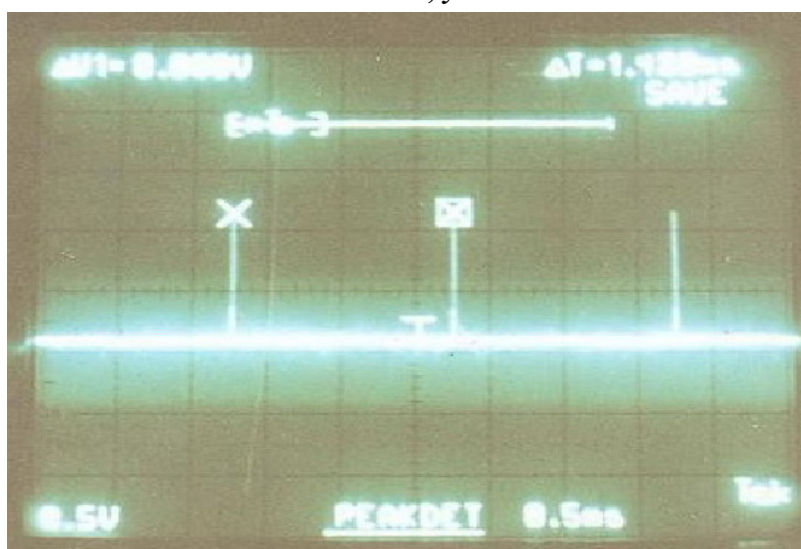


Fig. (5) Represents laser semiconductor repetition rate show by storage Tektronix oscilloscope where x-axis =0.5 msec/div, y-axis=0.5 V/div.

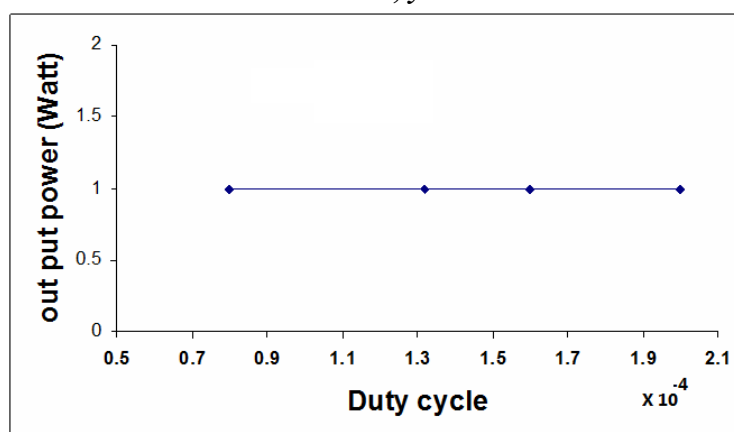
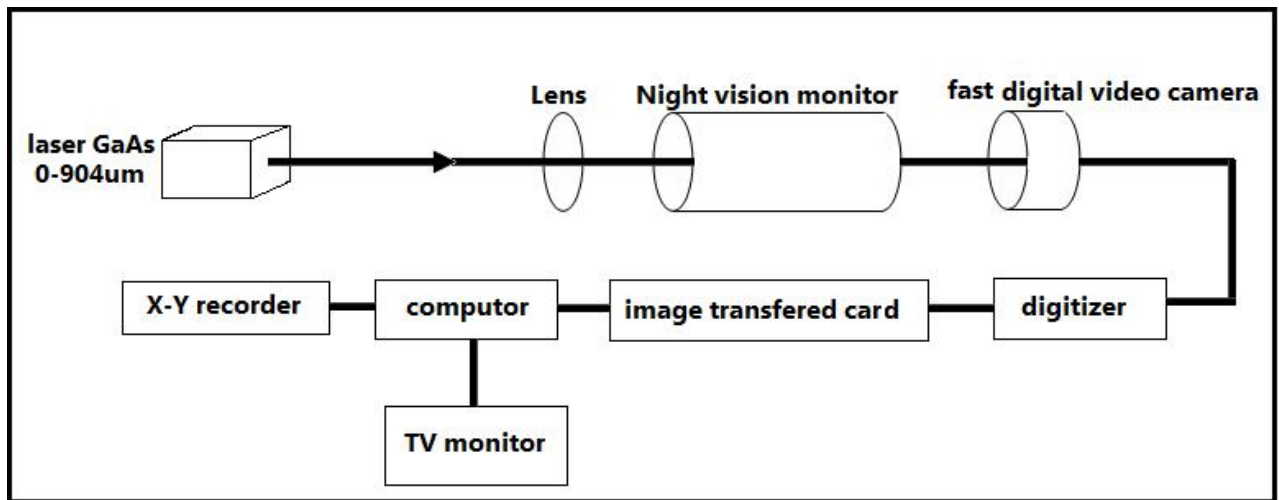
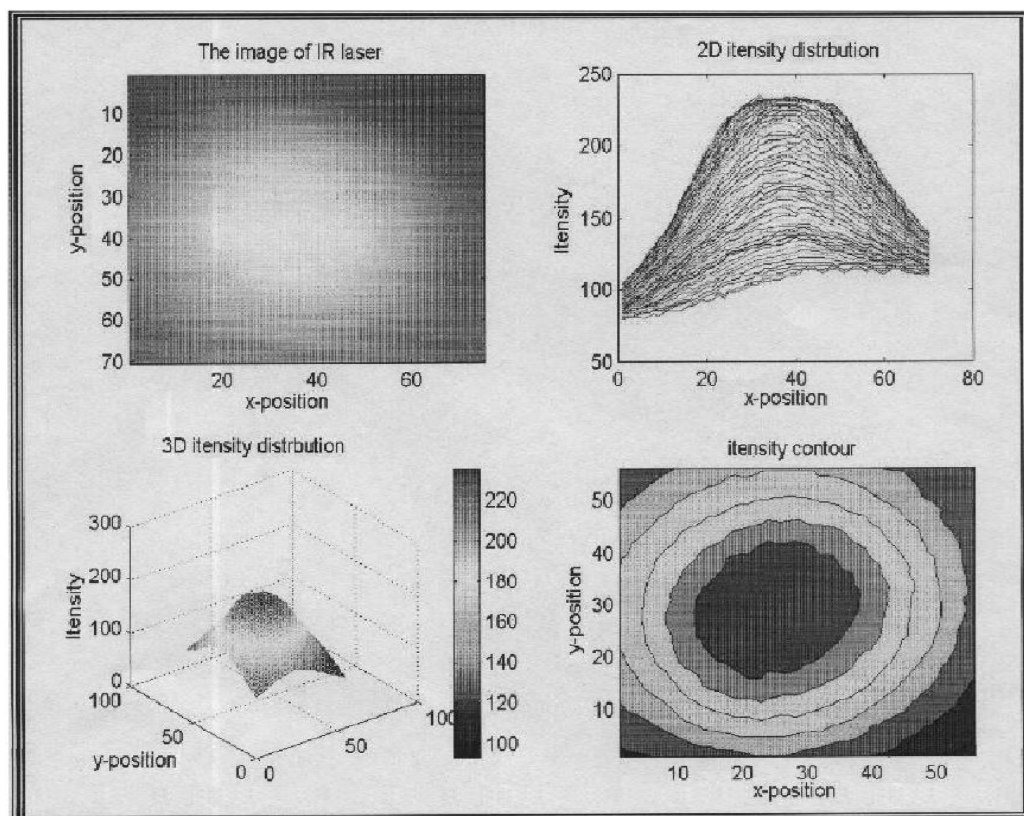


Fig. (6) The relation between out put power versus duty cycle

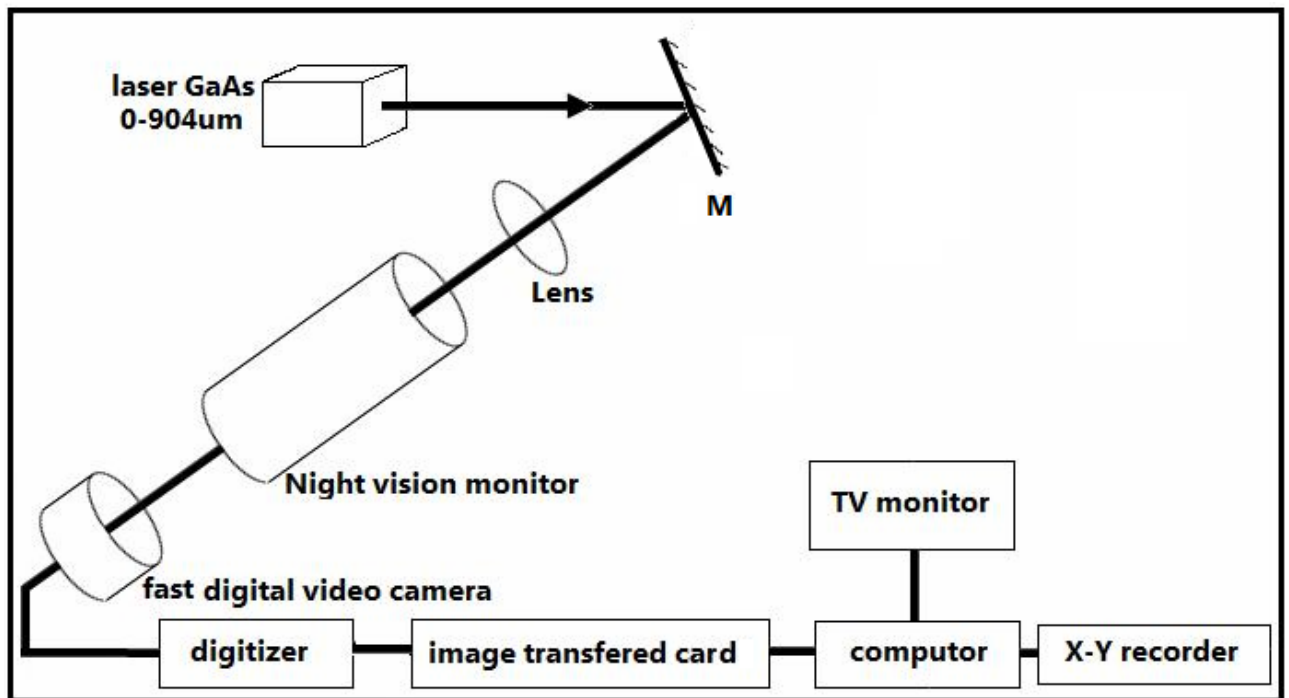


*Fig. (7) The schematic diagram of transmitted IR laser spot Size analysis system*

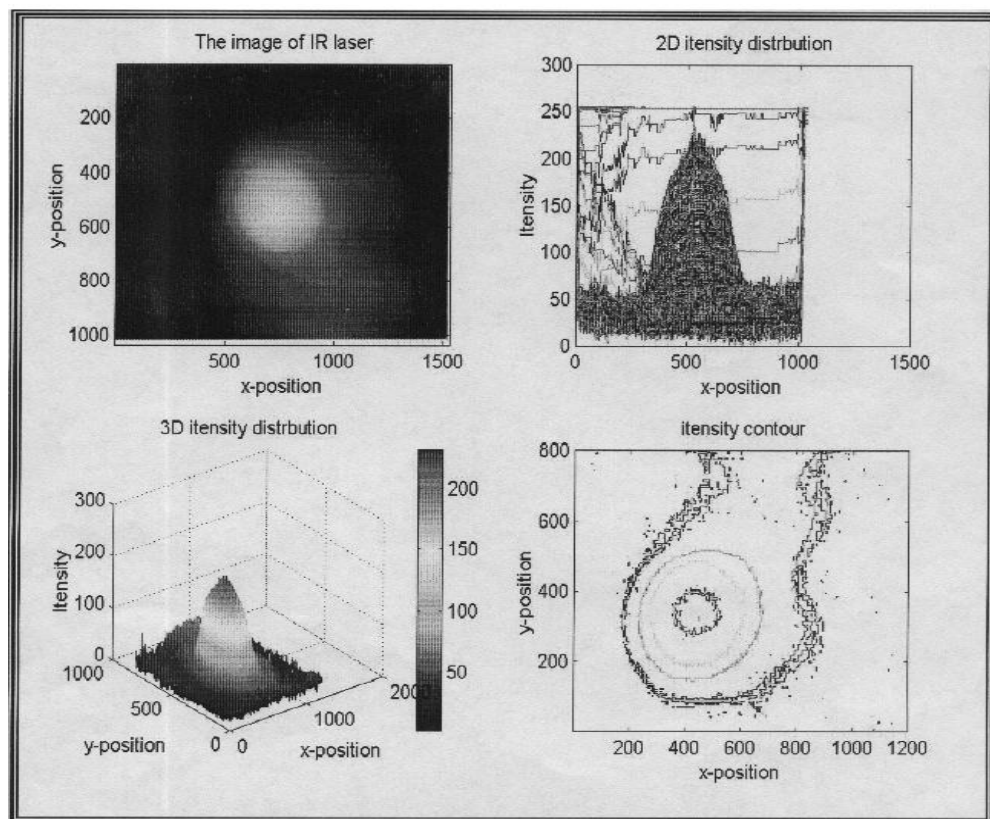


*Fig. (8) Analysis of the transmitted laser pulse*





*Fig. (9) The schematic diagram of reflected IR laser spot Size analysis system*



*Fig.(10) Analysis of the reflected laser pulse*

Table -1 Results obtain from low tran-6 code

Range(Km)	Transmission of atmospheric suspended particles	Absorption of atmospheric suspended particles
2	0.4173	0.651
3	0.2696	0.0961
4	0.1739	0.126
10	0.126	0.2858
20	0.0002	0.4900

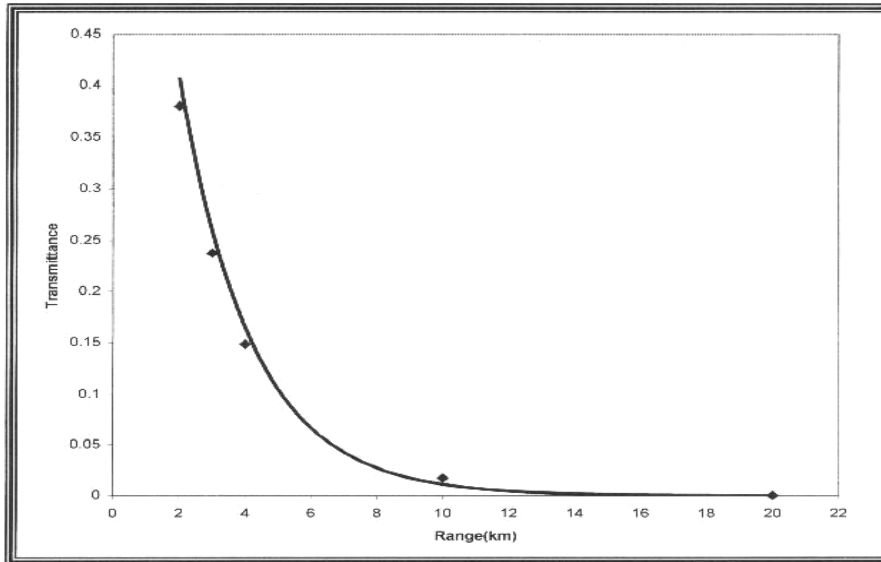


Fig. (11) Transmittance vs. laser ranging

### Conclusion

The divergence of the diode laser limits its target selective identification which correspondingly affects the useful recorded distance as a range finder

This high divergence limits the collimated effective spot for range finder as compared with minimum divergence type solid state laser which ranges to several kilometers.

The codes used proved its reliability in assessing the relevant optical geometry for minimum beam divergence which relatively confirms the beam attenuation in the order of 0.1 mW/meter which was verified experimentally. The cost of building the proposed system for ranging and analyzing the laser source is very cheap. The image processing to the laser beam profile and its energy distribution can be computerized in a very short time. The image processing of the laser is

related to the power source, can be used in determination the distance of the object.

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