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The Measurement Method of Wavelength and Direction of Tunable Laser Single Pulse Under Sun Light

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Abstract: This article presents a measurement method of real-time wavelength and arriving direction of wide band tunable pulsed-laser under harsh circumstance using grating diffraction principle. The experimental opto-electronic system is been designed, through which wavelength and incoming direction data of tunable pulsed laser are obtained. These information are processed and analyzed with DSP chip TMS320VC5509 The experimental results prove that the laser wavelength resolution with 10nm and direction resolution in 1° can obtained in real time. Wavelength range is from 400nm to 1100nm, Filed of View with 22. 5° this measurement technology can be used in the novel a generation tunable laser warning receiver.

Key words: diffraction optical grating; wavelength measurement; tunable pulsed-laser; direction measurement; real-time

太阳光下可调谐激光脉冲的波长和入射方向的实时测试和系统研究

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摘 要：提出了在恶劣环境条件下，应用衍射光栅测量宽波长范围可调谐脉冲激光波长和入射方向的实时测试方法，并设计了实验系统，在该实验系统中，光电传感器采用了ATMEL公司的50 MHz线阵探测器，由高速度数字信号处理器TMS320VC5509处理该传感器获得的信号，获得入射激光的波长和入射方向，实验结果表明，该系统能达到10 ns的波长分辩率和1(°)的角度分辩率；该测试方法可用在相干探测激光告警接收机中.

关键词：衍射光栅；波长测量；入射方向测量；可调谐激光脉冲；实时检测

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1 Measurement principle of wavelength and incoming direction of laser

Measurement of the wavelength and arriving direction of tunable laser is a harsh task now. The

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difficulty lies in the interference of background light, the sensitivity of pulse laser and S/N ratio. measurement system of wavelength and direction of tunable laser pulse using coherent technology is Presented. The measurement system is depicted in Fig. 1.

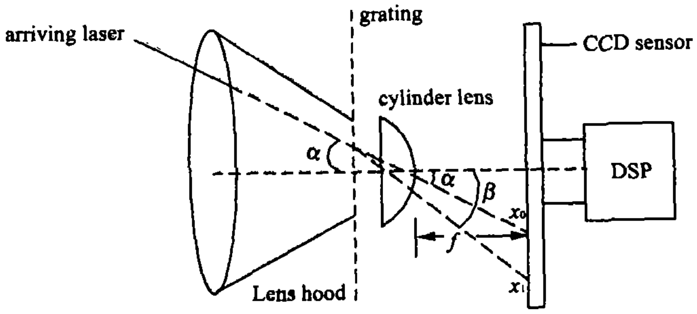


Fig. 1 Measurement system of Laser wavelength and arriving direction

图1 激光波长和入射方向测试系统

A linear matrix CCD sensor, which possess response from 500 to 1100nm, a cylinder plane convex-lens, which is used to focus incident laser signal on linear matrix CCD sensor, A special transmission grating and DSP will be used; the groove density of the grating is 300 l/mm, this grating has no diffraction orders above 1st; that is, the diffractions of zero and the first orders of the grating are reserved, the rest diffraction orders are wiped off. From Fig. 1, we can see, after being diffracted by grating, laser is focused by the Cylinder lens (includes laser) on CCD as a line, CCD sensor transfers these diffraction stripes into electric signal at the end, electric signal is processed by high speed DSP, if incident angle on paper plane is α(in longitude), and diffraction angle is β grating equation can be wrote as

$$d(\sin\alpha + \sin\beta) = k\lambda. \tag{1}$$

the coordinates of zero-order and 1st-order diffraction spectrum lines are respectively

$$x_0 = f\tan\alpha, \tag{2}$$

$$x_1 = f\tan\beta, \tag{3}$$

where f is the focus length of cylinder lens; d is groove density of transmission grating; and k is diffraction order. x_0, x_1 can be direct measured, from Eq. (2),(3), we can get arriving angle α and 1st-order diffraction angle β, substitute α, β into Eq. (1), the laser wavelength is expressed

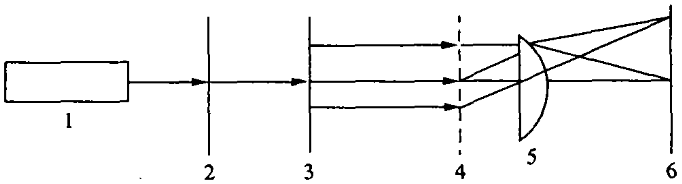
$$\lambda = d\left[\sin\left(\arctan\left(\frac{x_0}{f}\right)\right) + \sin\left(\arctan\left(\frac{x_1}{f}\right)\right)\right]. \tag{4}$$

Theory analysis indicates that when $d=1/450$ mm, area is 50×40 mm^2, width $w=40$ mm, height $h=40$ mm of grating, focus length f is 53 mm of cylinder lens; read rate of CCD is 10 MHz, SNR=4.39. Rotating this system 90° around the optic axis, can measure arriving angle in latitude.

Up to now, optical system of this measuring system has been designed, but the problems of how to forward reject the interference of sun light and reaction speed of this system have not been solved yet. laser signal features extraction method and DSP(IC) technique may be taken to solve these problems.

The following technical demands should be satisfied: wavelength from 500 to 1100 nm, wavelength discrimination is 10 nm, duration of laser pulse is from 7 to 20 ns; range of arriving angle is from −22.5 to 22.5 degree in both longitude and latitude, the angular discrimination is no more than one degree; response time of measuring system is no more than one second. Besides, measuring system can reject the interference from Sun light.

2 Experimental setup and results



1—laser; 2—attenuator plate; 3—expender of laser; 4—Blazing grating; 5—Cylinder lens; 6—line array CCD

Fig. 2 Experimental setup

图 2 实验装置

In order to increase the response speed, TMS320VC5509 DSP is used, the total response time is less than 30us, Experimental datum are given In table 1.

Tab. 1 Experimental data and processing

表 1 实验数据及过程

Incoming angle	position of Zero-order diffracted light (no. of pixel)	position 1th order diffraction light(no. of pixel)	Measuring wavelength (nm)	Measuring incoming angle
10. 0°	552	377	644. 6	9. 9°
9. 0°	535	360	647. 1Δ	8. 8°
7. 0°	508	335	642. 1	7. 1°
4. 5°	466	294	638. 9	4. 5°
2. 5°	435	263	636. 5	2. 5°
0. 0°	396	221	641. 1	0. 0°
−2. 0°	365	187	644. 2	−2. 0°
−3. 5°	344	167	634. 2	−3. 3°
−5. 7°	310	129	635. 7	−5. 5°
−7. 5°	281	92	643. 1	−7. 3°
−10. 5°	240	50	636. 8	−9. 9°Δ

From this data table, we obtain the average wavelength is $\bar{\lambda}=640.9$ nm, Derivation of wavelength is $\sigma=4.8$ nm, maxmum of derivation $\Delta\lambda_{max}=6.2$ nm;error of incoming angle $\Delta\alpha_{max}=0.6°$.

This results indicate that the proposed method and experimental setup can meet the need of 10nm resolution in wavelength, and direction resolution of 1(°).

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