Detection and Analysis System of Low Frenquency Electronic Noise in High Power Semiconductor Laser Diodes

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Abstract

Detection and analysis of noise are meaningful to nondestructive examination and reliability representation of high power semiconductor laser diodes. In this thesis a test and anaylysis bench was designed ,which can both test real electronic noise of the laser diodes and analysis with software.Under a series small current injection, we get the low frenquency 1/f electronic noise,Realized the separation of 1/f noise and zero mean white noise, using wavelet analysis using the test and analysis platform.Obtain the value of γ from the relationship between the frequency exponent factor γ and Hurst index ,then,realize the feature extraction of 1/f noise.

Keywords

High power semiconductor laser diodes ; Wavelet analysis; 1/f noise； Fractal signal analysis.

1. Introduction

Electrical features as a characterization tool for semiconductor devices have been a long time. For example the electrical derivative data method with Jiawei Shi as its respective [1], and the low frequency electrical noise method with Yisong Dai as its respective[2], all produce a new field of the research field for semiconductor laser diodes.But Fengli Gao discovered disadvantage of electrical derivative data method, it has some universal problems, and the low frequency noise method has sensitivity, universality, avoiding destroying features, will become as an impotant approach to appraise the reliability of semiconductor laser diodes.In this paper,we design a set of platform including both hardwares and softwares to detect and analysis the low frequency electrical noise parameters of high power semiconduct laser diodes to evaluate the reliability of the semiconductor devices.1/f noise has fractal and self-similarity features, using FFT(Fast Fourier Transform) to solve the cross-correlation spectrum, analysis the 1/f noise under different small inject current.Solve the Hurst index and obtain the frequency index of 1/f noiseγ.

2. Meaturement of noise signal

In order to get more accuracy 1/f noise data of high power semiconductor laser diodes,we design the hardware meaturement platform by cross-correlation spectrum method,using Matlab and Labview hybrid programming establish the software analysis platform,shown in Fig1.

Across-correlation measurement method will effectively restrain the white noise in the measurement results. The two amplifers are not correlative, assume the signals of tunnel 1, 2 are:

$$X_1(t) = x_1(t) + w_1(t) \tag{1}$$

$$X_2(t) = x_2(t) + w_2(t) \tag{2}$$

$x_1(t)$, $x_2(t)$ are the low frequency voltage noise of the amplifers, $w_1(t)$ and $w_2(t)$ are the zero mean value addition noise of the two amplifiers.They are not correlative,then:

$$R_{X_1X_2}(\tau) = E[[x_1(t)+w_1(t)][x_2(t+\tau)+w_2(t+\tau)]] \\ = E[x_1(t)x_2(t+\tau)] + E[x_1(t)w_2(t+\tau)] + E[x_2(t+\tau)w_1(t)] + E[w_1(t)w_2(t+\tau)] \qquad (3)$$

Where, $E[w_1(t)] = 0$,and $E[w_2(t)] = 0$,then,from (3),we can get:

$R_{X_1X_2}(\tau) = E[x_1(t)x_2(t+\tau)] = R_{x_1x_2}(\tau)$,it will eliminate the zero mean value addition noise, and the cross-correlative spectrum simplified as (4) :

$$S_{X_1X_2}(\omega) = \int_{-\infty}^{+\infty} R_{X_1X_2}(\tau)e^{-j\omega\tau}d\tau = \int_{-\infty}^{+\infty} R_{x_1x_2}(\tau)e^{-j\omega\tau}d\tau \qquad (4)$$

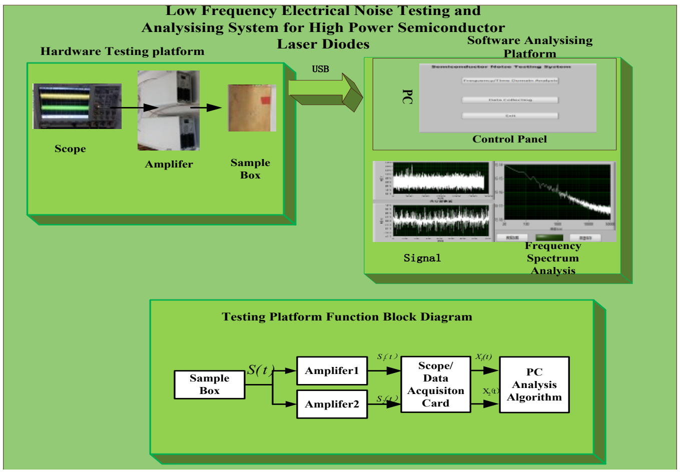
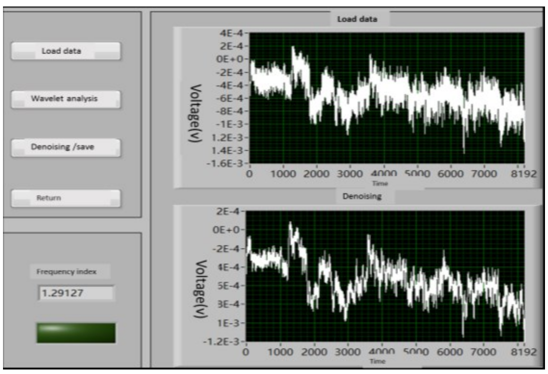


Fig1.The structure of low frequency electronic noise meaturement and analysis in high power semiconductor laser diodes

This will promote accuracy of the measured value.In Fig1.we use the Model5184 amplifer form Perkin Elmer,the range of frequency-response from 0.5Hz to 1MHz.The magnification is 10^3.

In this paper,we ues 4,9v batteries to reduce the noise.The functions of the measurement and analysis platform,including signal collecting, signal denoising, freqency analysis.The sofrwarecan be expanded for further research.



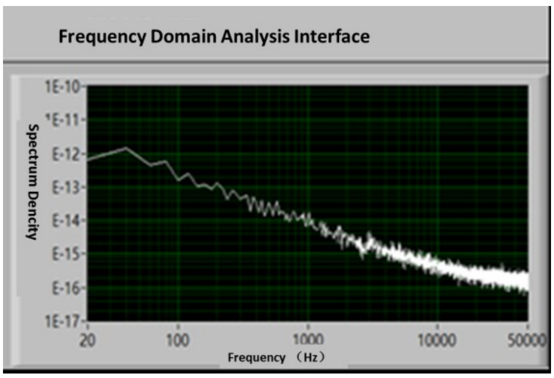


Fig2. Wavelet denosing of #18 device Fig.3 The Power spectrum analysis of #18 device

3. Analysis of the noise signal

To number #018 high power semiconductor laser diode, under the small inject current of 0.15ma-3.9ma, obtain a series noise, the main component part is 1/f noise.Using the software analysis platform,by wavelet denoising we get the signal in fig2.below.And its power spectrum is shown in fig3.

1/f is a kind of fractal signal, is an unstable stochastic signal, it is fractal in space, and self-similar in time domain. The power spectrum of 1/f fractal is the reciprocal of its frequency.

$$S_x(\omega) \sim \frac{\sigma_x^2}{|\omega|^\gamma} \tag{5}$$

Where, $S_x(\omega)$, σ_x^2, γ are the power spectrum density, the variance, spectrum index of noise signal, respectivel. When the 1/f fractal signal get through the filter expressed as formula(5),

$$H(j\omega) = \begin{cases} 1, \omega_0 < |\omega| \le \omega_1 \\ 0, else \end{cases} \tag{6}$$

where, $0 < \omega_0 < \omega_1 < \infty$

its power spectrum density is:

$$S(\omega) = \begin{cases} \dfrac{\sigma_X^2}{|\omega|^\gamma}, & \omega_0 < |\omega| \le \omega_1 \\ 0, & else \end{cases} \tag{7}$$

where, $\sigma_X^2 > 0$, the relationship between fractal index γ and the similar parameter H is: $\gamma = 2H + 1$.We can get the frequency index γ from Hurst index.The power spectrum desity curves under different small inject current are shown in fig4.

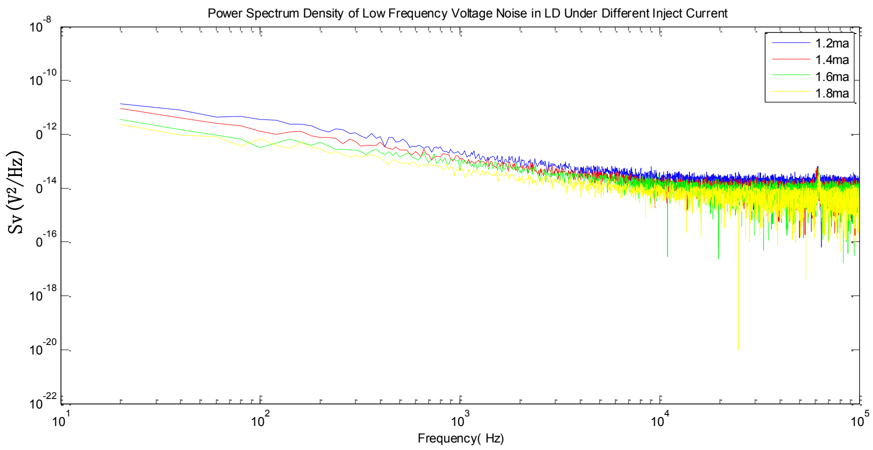


Fig4.Power Spectrum Density of Low Frequency Voltage Noise in LD Under Different Inject Current

Using the software platform, we can obtain the Hurst index of every curve, then calculate frequency index γ ,as shown in table 1.

Table 1. Frequency index under different current

Inject current	Frequency index
1.2ma	0.142556
1.4ma	0.181504
1.6ma	0.694771
1.8ma	0.291443

4. Conclutions

In this thesis, we design a platform to measurement and analysis low frequency voltgage noise in high power semiconductor laser diodes. Test the voltage *1/f* noise under small inject current variance continuously. In range of 1.2ma-1.8ma ,the low frequency voltage noise value in devices will reduce when the small inject current increase. Apply the platform we also calculate the frequency index using wavelet analysis method.

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