دقة تحديد الموضع للثنائي الكاشف للضوء

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ملخص باللغة العربية

سعت هذه الورقة إلى قياس مدى اعتماد المستثمرون الليبيون الذين يتعاملون في سوق الأوراق المالي الليبي على القوائم المالية التي تنشرها الشركات والمصارف المسجلة بالسوق الليبي. كما سعت هذه الدراسة إلى قياس مدى رغبة المستثمرون الليبيون في المستقبل على مواصلة استخدام القوائم المالية التي تنشر عبر المواقع الالكترونية الخاصة بهذه الشركات والمصارف. ولغرض تحقيق أهداف هذه الورقة، قام الباحثان بتصميم صحيفة استبيان ، حيث تم توزيع (40) استبيان على هؤلاء المستثمرون وذلك لغرض استقصاء أراهم حول أثر جودة وفائدة المعلومات المستقاة من القوائم المالية المنشورة عبر المواقع الالكترونية. ولغرض اختبار فرضيات هذه الورقة ، تم استعمال الأسلوب الإحصائي المناسب (T. Test).

ولقد توصلت هذه الورقة إلى النتائج الآتية:

1 - أن المستثمرون لديهم الرغبة الأكيدة في استعمال القوائم المالية المنشورة عبر المواقع الالكترونية في المستقبل.

2 - أن الفائدة التي يتحصل عليها المستثمرون الليبيون من المعلومات المنشورة في هذه القوائم كان لها تأثير كبير في مدى الرغبة لمواصلة الاعتماد على البيانات المنشورة عبر المواقع الالكترونية لهذه الشركات والمصارف.

3 - إن جودة المعلومات المنشورة ضمن القوائم المالية كان أيضا لها تأثير مباشر وقوي على رغبة المستثمرون الليبيون في مواصلة استعمال المواقع الالكترونية لهذه الشركات.

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By using the value of total noise from the previous calculation, and by taken measurement of the responsivity R_{λ} at experiment wavelength (633nm).

The noise equivalent power (NEP) for R_{λ}=0.38A/W is 2.834W/$\sqrt{H}$.

The accuracy of the dynamic measurements of the PSD device ware started with higher level around 0.5mm. To decrease this Amount of fluctuation error the improvements has been made. The cause of the instability was the noise level comes from the environment to the system and the wire connectors were not perfectly covered and connecting. The improvement of these methods has been made, and the stability of the spot ends with 0.02mm by using 0.5mW and 1.03mm spot size.

By using lower incident power the random noise will be more and the fluctuation of the spot will be more than 0.5mm. The factors can affect the stability, are the noise level on the system and the instability of the laser beam itself. The fluctuation of the spot beam on the screen can affect the position measurement and to decrease the fluctuation level, total noise has to be taken into account. In addition, the designer of Labview program should implement any possible calculation that can be made to improve the display function of the spot on the computer screen. Moreover, to get a higher accuracy measurement the most effective way is to decrease all types of noise that can affect the output, even if it is in the digital measurement output or Analogue signals. Also, we can use the quadrant photodetectors QPD which are, the best approach in terms of resolution and noise, but requires complex and expensive x-y micropositioners to perform sensor alignment with the incoming laser spot [15]. Furthermore, there are different ways to improve energy calibration method of position sensitive silicon detectors [14].

V. Conclusion

The accuracy of system measurement has been investigated as 0.02mm within the PSD active area. The noise into the system was calculated and SNR was found 17.45dB and, the error of centroid measurement was measured as 3% on the active area and, it is increased around the PSD edges. .

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= 27.76 MHz >482.2877 KHz.

IV. Experimental result

Noise measurement:

As above equations on the noise calculation section, total noise current measured for the system from below equation:

$$I_{jn} = \sqrt{\frac{4k_B T\Delta f}{R_{SH}}} = 0.17\ nA$$

$$I_{sn} = \sqrt{2q(I_p + I_D)\Delta f} = 1.07699\mu A = 1.07699\mu A$$

$$I_{tn} = \sqrt{I_{sn}^2 + I_{jn}^2} = 1.077\mu A$$

Where I_{jn} is Johnson noise, I_{sn} is shot noise, q is the electron charge, I_p represents the photogenerated current, I_D represents the dark current of the photodetector, f is the noise measurement bandwidth (10KHZ)

The measurement of signal to noise ratio (SNR) for the system, as following:

$$SNR(dB) = 10\ \log\left(\frac{P_{signal}}{P_{noise}}\right)$$

Where P_{signal} is the total power from the light source and P_{noise} is the noise level (Background light level).

The value of SNR was taken by using the voltage, which is proportional to the power, and the measurement of SNR for the PSD circuit is 17.45dB.

The measuring noise equivalent power (NEP) for the PSD can explained as the amount of incident light power on the PSD that can generate a photocurrent equal to noise current.

$NEP = I_{tn}/R_{\lambda}$

From the above equation, R_{λ} is the responsivity of the PSD in A/W and I_{tn} the total noise current of the photodetector.

As above diagram the circuit demonstrate one output of the PSD electrodes connected to the Amplifier circuit. By the following, the additional electronic circuit has been made to reduce the bandwidth and to increase the speed of the device.

Before we start changing the feedback resistance and the external capacitor, the first measurement of the system was taken with decreasing the background light level by using low-pass filter.

The next step in this work is, changing the feedback resistor to R_F=100 KΩ and C_F=471pf, so the operating bandwidth was from the later equation:

$$f(Hz) = \frac{1}{2\pi R_F C_F} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

f = 3.379 KHz

Where R_F is feedback resister, C_F is external capacitor.

For stable system, the Gain Bandwidth product (GBP) of the amplifier should be bigger than the operating Bandwidth.

$$f_{3dBMax}[Hz] = \sqrt{\frac{GBP}{2\pi R_F (C_J + C_F + C_A)}} = 7.63\ MHz \ldots\ldots\ldots\ldots (6)$$

$$= 7.63\ MHz > 3.379 KHz$$

Where C_J Junction capacitor of the PSD and C_A is the amplifier input capacitance.

The next step is changing the feedback resistor value to (10kΩ) and external capacitor to (33pf). That can change the bandwidth signal and the noise level on the scope.

$$f(Hz) = \frac{1}{2\pi R_F C_F} = 482.2877\ KHz$$

$$f_{3dBMax}[Hz] = \sqrt{\frac{GBP}{2\pi R_F (C_J + C_F + C_A)}} = 27.6\ MHz$$

The estimated beam centroid position on the X-Y PSD plane is displayed in 9x9mm over a limited area around the centre of the pin-cushion PSD (which is the active area of the PSD that is covered on the Theory section on this paper) on the PC screen with a whit cross. Moreover, the output value of the power when the lights emit the PSD surface can be clearly presented and the average power of light on the active area can be almost the same. Although, spot size is dependant on the focal length of the lenses used within the system, that can affect the positioning measurements. By converting the digital signals to analogue signal, the computer can control the driver circuit, the direction of scanning and the speed of scanning.

To simplify the centring process a persistence effect on the whit cross visualization has been introduced. Non-linear effects on the centroid estimation depend on the characteristic of the incident laser beam [11].

The pre-amplifier used is a high-speed input op-amp, followed by one or more amplification stages, for the direct detection of high-energy particles. The incident radiation power and the counting efficiency are proportional to each other. In order to achieve a low noise ration, it is recommended that all components be kept in a metal box. It is recommended, moreover, that the power supply used be a very low ripple (±12Volts) DC supply. The circuit diagram below describes the amplifier, which is specifically used in this work.

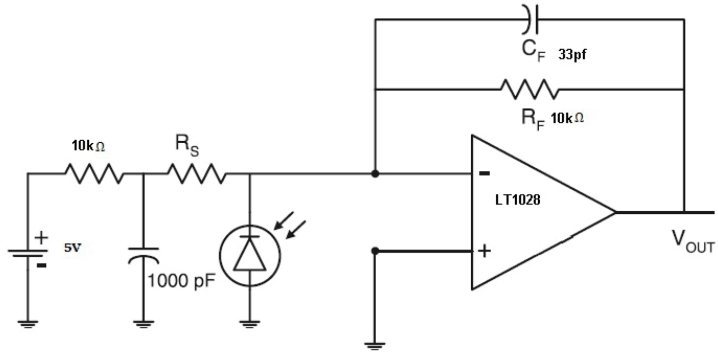

Figure 6: Electronic circuit layout

"the default configuration of the USB-6008/6009 DIO ports is open-drain, allowing 5 V operation with an onboard 4.7 kΩ pull-up resistor" [1]. In this work, we follow Ruttiger by using the USB in differential mode with a range of +/- 1V and an input resolution of 12bits [5].

B. ***System Design Hardware:***

From figure 5, we can see the experimental set up which is including laser source (HeNe laser), two lenses to control the spot size of laser beam and to avoid the affect of the aberration. Moreover, an aperture was used to clean the beam and to remove any reflected beam back to the system. Furthermore, low-pass filters are included to the first step of the measurement, to decrease the incidence light intensity and to remove the background light effect.

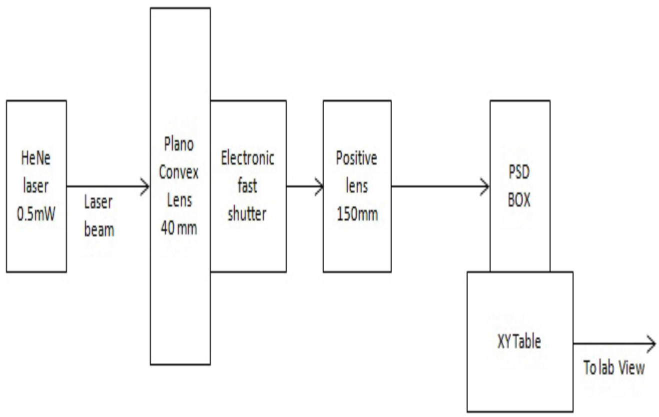

Figure 5: Experimental setup

Below is a list of the demonstration features used:

- The software for position measurement, data processing and driver controller runs on LabView for Windows XP and uses an ND6008 USB device as the A/D converter.
- The resolution of the X-Y movement is 10 mm to scan the incident light area of the PSD front surface by using two motor driver circuits to make the PSD move in both the x and y directions. The motors can be controlled by manual movement in steps or by using computer program (LabView). *Due to high position resolution and fast speed, the position sensitive detector PSD is widely applied in micro displacement measurement* [16].

$$I_{sn} = \sqrt{2q(I_p + I_D)\Delta f} \quad \text{.................................... (2)}$$

In the above equation, q is the electron charge, I_p represents the photogenerated current, I_D represents the dark current of the photodetector, f is the noise measurement bandwidth [10]. The equation for calculating Johnson noise is also shown below.

$$I_{jn} = \sqrt{\frac{4k_B T\Delta f}{R_{SH}}} \quad \text{.. (3)}$$

In the above equation k_B is the Boltzmann Constant, T is temperature (Kelvin), f is the noise measurement bandwidth and R_{SH} is the photodiode shunt resistance [10].

Finally, the total noise is worked out by inserting the results from the Johnson noise and the shut noise calculation on the following equation:

$$I_{tn} = \sqrt{I_{sn}^2 + I_{jn}^2} \quad \text{.. (4)}$$

When considering the above theory it should be noted that every resistor has a Johnson noise value relating to it that is inclusive of the load resistor. The load resistor can often add to greatly to the Johnson noise, and this caused by the shunt resistance [10].

III. System Design

A. ***Labview:***

This work requires that an XY Table be produced on which the laser beam will be projected on various spots. In order to control the use of the XY table it is necessary to utilise the Labview program, which is an automated program that can control the table and, in turn, can read the voltages that the system generates. So Labview can read the output digital signal which is converted from analogue signal by NI6008 USB. According to the USB handbook

- The effect caused by the Temperature from the optical system and electronic circuit.
- The incident Errors from the PSD itself for position detection.
- Anomalies in the optical system (Aberration effect).

Moreover, the measured global energy resolution is defined by the energy spectra summed over all strips of the detector, and thus it includes electronic noise of the front-end electronics, charge sharing effects, and other system noise sources [13].

D. ***Noise:***

It is important to consider the noise produced by a PSD of which there are two main types [5] as noise “can be a major problem” [2] when attempting to gain accurate measurements from a chip. The first type is Johnson noise and this is present due to the internal resistive layer, which is silicon, at a certain temperature and is typically a flat frequency reading that does not depend on any external current. The second type of noise is, shot noise and these results from a quantized flow of single electrons. It should be noted also, that any noise reading should consider external interference perhaps caused by radio or television stations. A crucial area of design is in determining the implantation level of the pin-cushion PSD. The implantation level depends upon two key factors, namely the noise characteristics and the dynamic behavior [4].

Another crucial type of noise that it is necessary to measure and understand is the dark current produced by the pin-cushion PSD. The dark current is simply the charge produced when no light is present on the sensor and it is sensitive to both temperature and reverse voltage. It is sensible to ensure that the level of the charge is restricted to being under 20nA in value [6]. If the dark current is not negligible then the following methods of adjustment are possible. The first method, as described by Song [8], is to utilize a modulation detection method. The other method of reducing the dark current is called the sample-hold detection method. Both these methods, according to Song [8], seem to work to reduce or eliminate the dark current reading.

To calculate the noise, the equations for the calculations are outlined below. The magnitude of short noise is expressed in terms of the root mean square (rms) noise current [10].

noise, low-stored energy pre-amplifier for high-voltage radiation detectors" it is concluded that the pre-amp that they are scrutinising can withstand an input voltage of 3.5kv, such a high-voltage is not necessary for this work. In fact, the pre-amp displays a physical input capacitance of 200pF and an effective small signal capacitance of 30μF.

C. Position Sensitive Photodetectors:

Position sensitive photodetectors are semiconductor devices, which rely upon a lateral photo-effect that, when a light spot hits the detector, produces four electrical signals. These signals pass through resistors in the circuit and the current of each signal, in the case of the pin-cushion PSD, is measured at four points. This in turn allows the X and Y positions of the spot of light to be calculated after amplification and ratio metric amplitude processing systems [3].

PSDs contain wiring surrounded by silicon that produces resistance and it is this, in turn, which gives the current different distance to travel and therefore it encounters varying amounts of resistance. From figure 4, the resistance designed as internally resistance into the top layer (p-side) of the PSD. That design to reduce the time travelling current into active area.

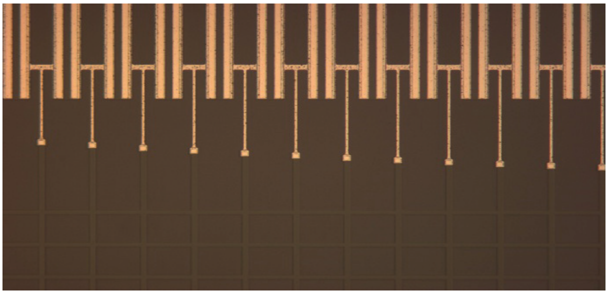

Figure 4: Focused image on the resistors in the PSD chip (magnification x10)

There are several factors that can affect the accuracy of measurement, which is given by the PSD itself or by the outside environment. The factors caused by the PSD include:

- Spot size of the light
- Noise from the circuit connected to the PSD.
- Background light level

interference between the signals generated for the x and y co-ordinates can be minimized. When discussing responsivity of the pin-cushion PSD it is necessary to give some information about Quantum Efficiency. This can defined as the "fraction of the incident photons that contribute to photocurrent [10]." For the calculation of Q.E (Quantum Efficiency) from the wavelength graph above, the equation below is necessary.

$$Q.E = R_{\lambda}\frac{hc}{\lambda q} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

In the above equation, h is the Planck constant, c is the speed of light (m/s), q is the electron charge, R_{λ} is the responsivity (A/W) and λ is the wavelength (nanometers) [10].

A key concern is the linearity. In recent studies, a Finite Element Method (FEM) has been used to assess the voltage distribution and the linearity performance in PSDs with complex structures [8]. Changing the light spot and using the key formula for position derivation with pin-cushion PSDs can derive the linearity and position errors. Moving on to further possible causes of error it may well be necessary to investigate how the cross-talk and responsivity measurements effect the working of the pin-cushion PSD [12].

B. ***Amplifier circuit:***

The current produced by the pin-cushion PSD is amplified and, in turn, a voltage is the output of the designed system. When a PSD is used for centroid detection, it is solely the induced charge caused by the charge carriers, which produce the information relating to the position of the centroid. If a proper amplifier is not used then it is likely that a voltage signal will develop on the electrode. This could be caused, as Harder explains, by "float" [7] or by connecting it to a greater impedance than necessary and, in either case, an error will caused in the position detection as the voltage will be coupled capacitively. It is much more complicated to perform a position calculation when the electrodes are floating and therefore it makes sense to use fixed electrodes to increase capacity. In the study carried out by Harder [7] into "low-of 2.33g/cm3 [9].

These attributes allow the silicon strips to be highly effective in the measuring of laser beams.

II. Theory

A. Linearity, wavelength and impedance:

Figure 2 shows the relationship that the PSD used in this work should give. Due to the fact that only one wavelength is used, it is not possible to plot responsivity at various wavelengths, as this work specifically concerns with the 633nm wavelength.

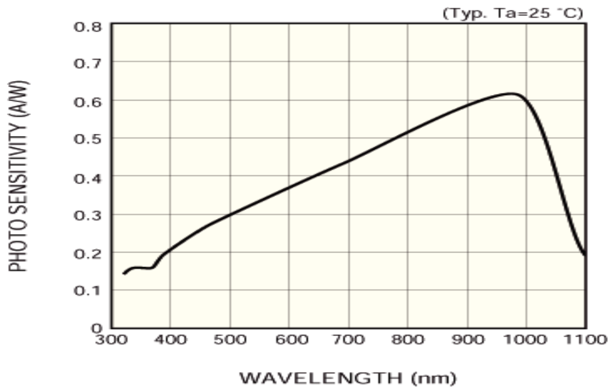

Figure 2: Wavelength vs photo sensitivity [3]

The active area of Pin-cushion PSD as shown in Figure 3 is the area in which accurate measurements can be made (in this case 9x9mm²), as the beam moves towards the edges of a PSD the error increases.

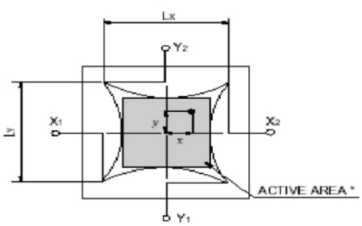

Figure 3: active area of Pin-cushion PSD

The pin-cushion PSD has four additional low-resistance circular arcs at the junction of the responsive region and there are four contacts placed adjacent to the areas where the circular arcs intersect. Due to this unique design, the four electrodes on the upper-surface that run perpendicular to each of the four edges [3]. This difference in electrode positioning, compared to the duo-lateral type, means that electrodes usually interact closer to the corners of the active areas, causing the positional distortion to be larger [4]. The pin-cushion model is an improvement upon the tetra-lateral model allowing for a more sensitive active area and reduced interference between electrodes. The pin-cushion PSD not only has the high-speed attributes of the tetra-lateral model but the circumference distortion also significantly lessened and the design allows for easy use of the reverse bias mode.

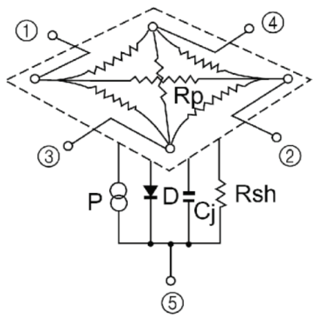

Figure 1: PSD circuit. Source Hamamatsu PSD data sheet**[3]**

The above diagram shows the pin-cushion PSD, where P is current generator, D is ideal diode, C_j is junction capacitance, R_{sh} is shunt resistance and R_p is positioning resistance.

The pin-cushion PSD used in this work is a silicon detector and there are many factors that have to be considered when using this type of detector. They have several characteristic properties, which make them useful when researchers wish to measure ionizing radiation. The most notable characteristics of using detectors made by silicon compared with other semiconductors:

- Small band gap energy of 1.12eV at room temperature means that there is substantial amount of charge carriers per unit energy loss.
- Speedy charge collection time facilitated by the mobility of electrons at 1450cm2/Vs.

There is a significant amount of energy dispersal due to the high density

Effect of Noise on the Accuracy of Position Sensitive Silicon Detector

***Abdelkhader.A.Abobaker** ****Tark. M. Fayez**

Abstract

PSD is an optical sensor that contains an analogue output that is proportional to the positioning of where a light beam's centroid hits its surface. This paper will investigate the effectiveness of pincushion PSD by using the Amplifier circuit to reduce noise levels. The noise into the system was calculated and Signal to Noise Ratio (SNR) was found 17.45dB. The error of centroid measurement was measured as 3% on the active area and, it is increased around the PSD edges.

Index Terms— Pincushion PSD, Laser beam, Silicon Detector.

I. INTRODUCTION

PSD is a quite simple device, and is therefore reliable and lasting. They are available in one or two dimensions (a thin strip or a wider surface). PSDs are manufactured in strips around 19mm long, with active area in this case 9x9mm^2, and will return a result in a matter of nanoseconds. The output is highly accurate to a matter of nanometers. Detecting the centroid of light 'gravity' on its surface is the only useful function the PSD can perform. The output of the PSD is one continuous voltage waveform.

This work concentrates on the pin-cushion model and its application to a beam centroid tracking system.

To give a brief overview of each type, the duo-lateral model consists of a resistive layer, processed from an N-layer, and two pairs of X and Y electrodes are positioned at right angles. On the other hand, the tetra-lateral model has

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