DESIGN AND SIMULATION OF A POSITION SENSITIVE DEVICE WITH GAUSSIAN RESPONSE

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ABSTRACT

This thesis describes a new approach for designing position sensitive devices (PSD). Rather than trying to obtain a linear response to a light source this design takes advantage of the nonlinearities present in existing devices. Specifically it uses a p-n junction to obtain a Gaussian-shaped response curve to light. Using such response curves, two-dimensional position detection of an object can be accomplished with three detectors. The sensitivity of this PSD may be independent of the size of the light source and the device may not need calibration.

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INTRODUCTION

1.1 Position Sensitive Devices

A position sensitive device (PSD) is an optical sensor which is capable of estimating the centroid, or "center of mass", of a light spot hitting its surface. PSDs produce a current flow proportional to the intensity and position of light incident on the surface of the device. This information may then used to determine the actual position of the light spot.

There are currently two general types of PSDs which are capable of measuring lateral displacement in two dimensions. The first group, and most commonly used PSD, is referred to as lateral effect photodiodes [MAKY2003]. These devices consist of a single large-area photodiode with four contacts positioned at opposite edges of the device. The photon-generated current is divided between the contacts in proportion to the resistance of the current paths between the illuminated region and the contacts. Therefore the current flow through the contacts is directly related to the distance between the contact and light spot.

The second group of PSDs is referred to as quad detectors. These devices consist of four photodiodes symmetrically positioned around the center of the device. Position information is determined by the strength of the signal received by each of the quadrants. The electrical contribution of each signal is then used to determine

the relative position of light with respect to the center of the device. The structure as well as the detailed operation of these devices is described in Chapter 2.

1.2 Applications

Position sensitive devices are used for a variety of commercial applications, for instance, in consumer products PSDs are used for tasks such as precision position sensing and auto-focusing in photographic and video cameras [FRAD2004]. PSDs are typically favored over other imaging devices such as charge-coupled devices (CCDs) in high volume applications where signal processing, high speed, robustness, and low cost are of importance.

These devices also have industrial applications, including the for measurement of small displacements. As such, they are sometimes used for machine tool alignment [KOMA1996] and optical lateral, rotational or angular position sensing [CHOW1998]. Further, PSDs may take precise measurements of device height in applications like printed-circuit board inspection, liquid and solids-level control, laser torch height control, etc. They may also be used for thickness and precision displacement measurements. These latter types of measurements can be useful in detecting the presence or absence of an object such as a medicine bottle cap.