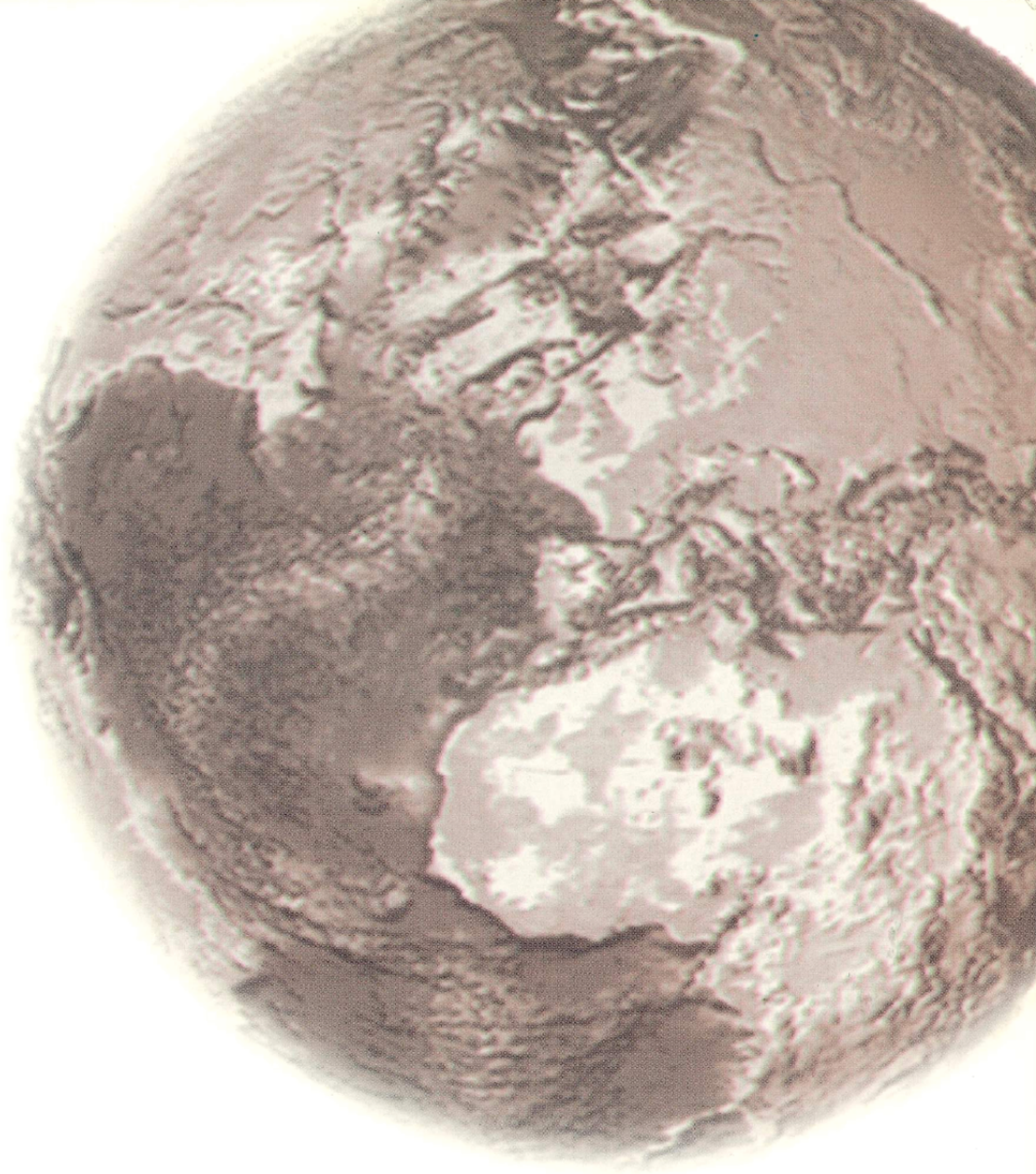




2002

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n. 10

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Abstract

Position Sensing Detectors provide an analog way to measure the position of a light spot. We show a simpler way if compared to the trivial classic solution to operate a PSD. This solution can be used when you have the control of the light source power.

Introduction

Position Sensing Detectors "PSD" are silicon photodiodes that provide an analog output directly proportional to the position of a light spot on the detector active area. The PSD allows to simultaneously monitor position and light intensity. The PSD is a continuous analog position sensor and compared to discrete element devices (e.g. CCD) the PSD offer simpler ancillary electronics, good resolution, acceptable linearity and fast response time. A light spot within the spectral range of silicon will generate a photocurrent which flows from the incident point through the resistive layers to the electrodes. The resistivity of the ion implanted layer is extremely uniform so the photogenerated current at each electrode is inversely proportional to the distance between the incident spot of light and electrodes. The PSD outputs track the motion of the "centroid of power density" to an high resolution.

PSD scheme

A PSD (Position Sensing Detector) uses a simple principle to determinate the position of a light spot. The theory of operations is shown in fig 1:

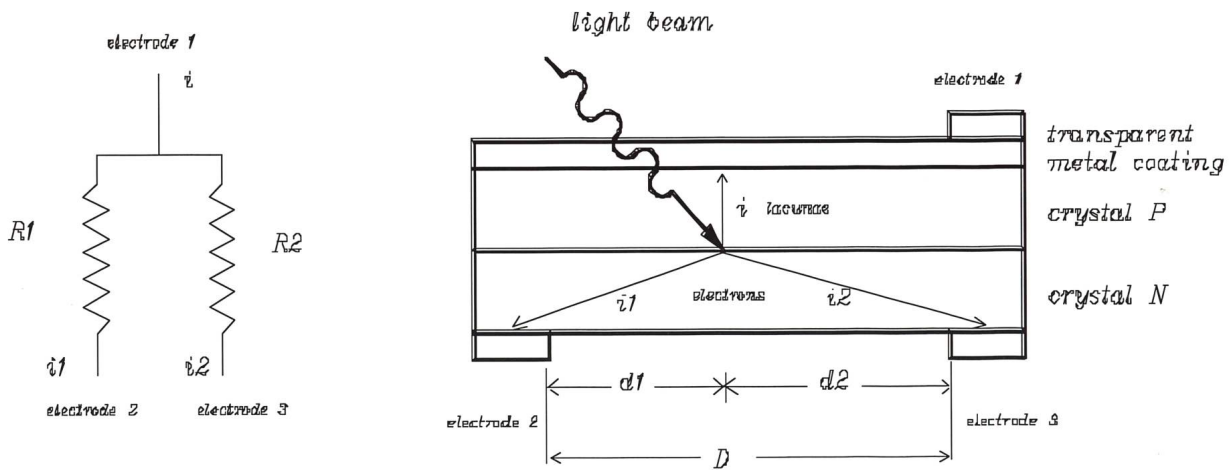


Fig. 1 Position Sensing Detector principle

When powering the system with a current i on the electrode 1 the current is split into two currents i_1 and i_2 ($i_1 + i_2 = i$) on the electrodes 2 and 3. The position of the light beam impact point against the sensor may be determined by the ratio

$$\frac{i_1 - i_2}{i_1 + i_2} = \frac{\frac{V}{R_1} - \frac{V}{R_2}}{\frac{V}{R_1} + \frac{V}{R_2}} = \frac{R_2 - R_1}{R_2 + R_1} = \frac{\rho \cdot d_2 - \rho \cdot d_1}{\rho \cdot D} = \frac{d_2 - d_1}{D} = \frac{2 \cdot d_2 - D}{D}$$

Where ρ is the N crystal resistivity and:

$$R_1 = \rho \cdot d_1$$

$$R_2 = \rho \cdot d_2$$

$$R_1 + R_2 = \rho \cdot D$$

The amount of the current (i_1+i_2) depends on the light beam intensity and on the position of the light beam impact on the sensor, and we have to consider this if we want to keep a good performance from the PSD. So the usually suggested scheme for using the PSD is shown in fig. 2:

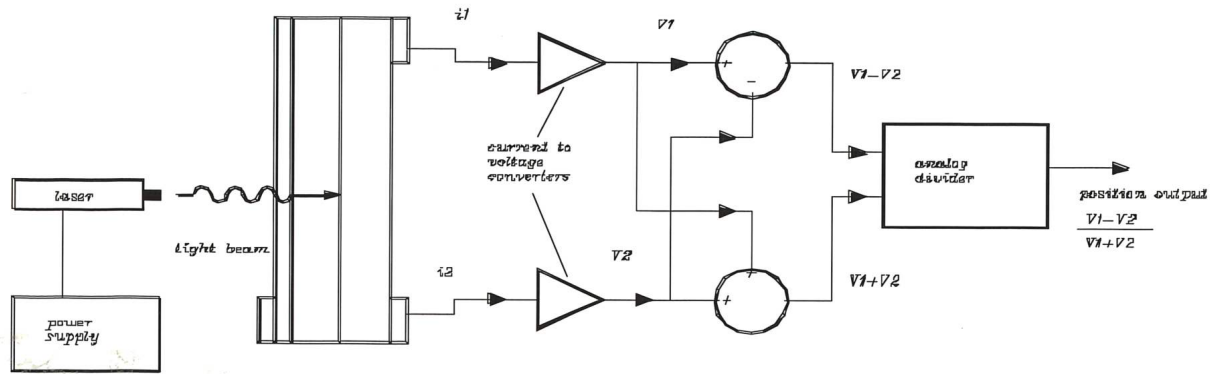


Fig 2: commonly suggested scheme for using PSD

This solution requires an analog divider, an expensive and sometimes critical component. We suggest a new scheme that uses the dependence of the current (i_1+i_2) of the light intensity to keep this current constant (obviously you can use this recipe only if you can control the light source). In this way the current i_1+i_2 stops playing an active role in the output determination but appears only as a scale factor (fig.3).

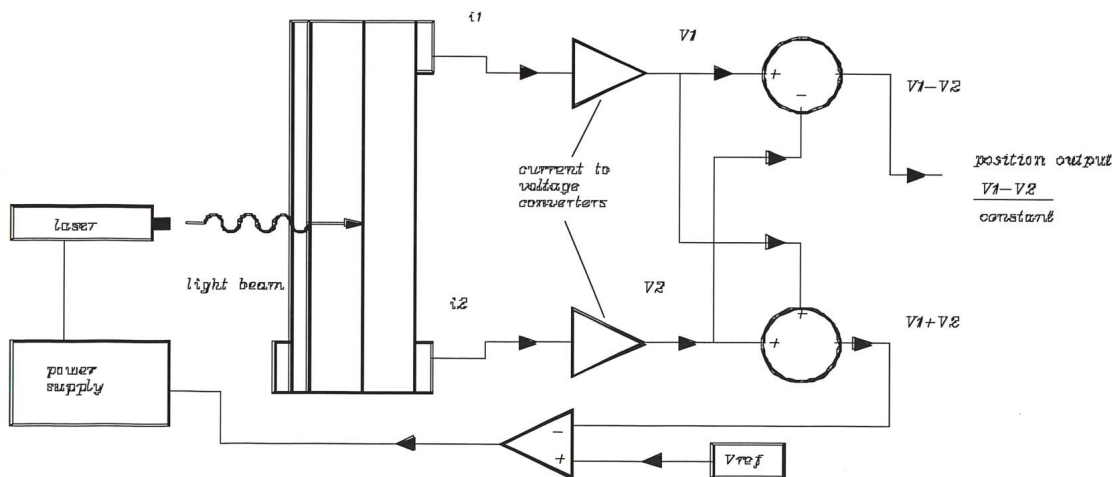


Fig.3: modified PSD scheme. The i_1+i_2 current is used to control the laser power supply in order to keep $i_1+i_2=\text{constant}$.

The schematic diagram of the modified PSD scheme is shown in fig 3. The use of better op amps will help to get better performance from the circuit.

Usually solid state lasers are sold in a mechanical assembly that contains a lens to collimate the beam and some electronics to keep the laser intensity constant. This electronics must be removed to use the modified PSD scheme. To protect the laser diode, R15 (100 ohm in the schematic) must be chosen to keep the laser current below the maximum allowed by the diode. R17 supplies the voltage reference, and must be tuned to obtain a constant output from U6, regardless the position the laser spot assumes on the sensor's surface.

This PSD was used the first time in an educational experiment at the INGV to close an S'13 system loop showing the effects of feedback, but can be useful in any system where a light beam provided feedback could take place, like electronic or electro-mechanical systems.

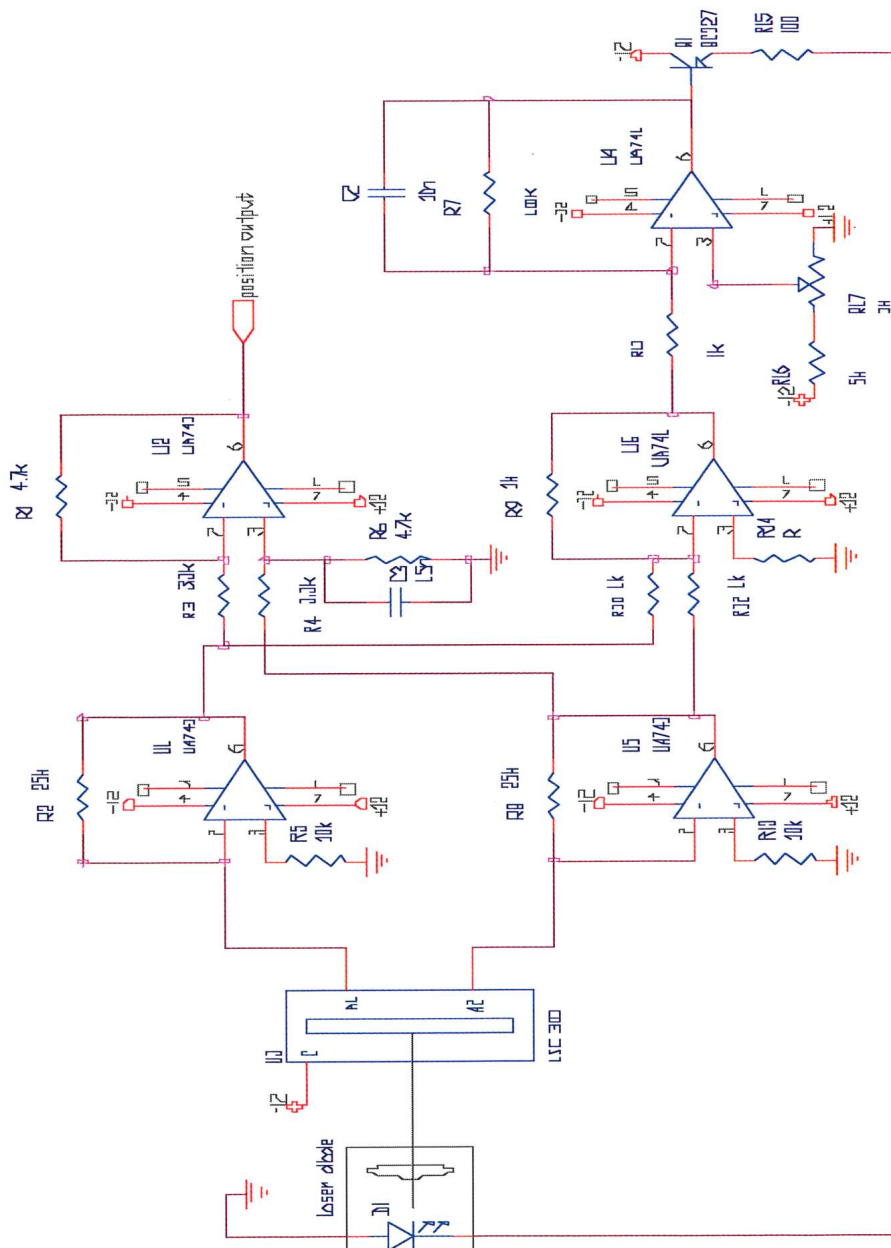


Fig. 4: modified PSD scheme designed to work.

