R+D Project: Universal Solution for Position Sensitive Detectors (PSD)

iC-Malaga has developed an Universal Position Sensing Amplifier IC, a versatile and miniaturized solution for a wide variety of Position Sensitive Detectors (PSD).

PSD's are purely analog optoelectronic devices. They can track the position of a light spot over a photosensitive area with extremely high accuracy. Due to their analog nature, position variations in the range of hundreds of nanometer can be resolved at very high-speed rates (up to tens of MHz).

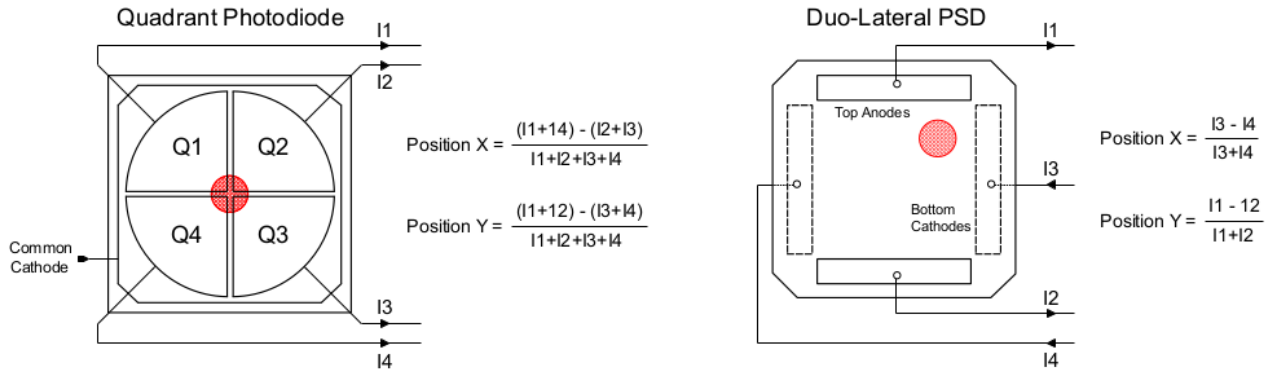

Figure1. Examples of PSD types: Quadrant Photodiode (left) and Duo-Lateral PSD (right)

Their unique characteristics in terms of bandwidth and resolution make them ideal candidates for a number of laser-based applications like laser alignment, biological analysis, medical equipment, defense, surface profiling or vibration analysis, among others.

Different types of PSD's are available: common-cathode or common-anode, one-dimensional or two-dimensional, segmented or lateral effect PSD (as summarized in table1), etc. They have different characteristics in terms of performance and signal conditioning requirements.

Segmented PSD	Lateral effect PSD
Quadrant Photodiode	Duo-Lateral
Bi-Cell	Tetra-Lateral
	Pin-cushion

Table1. Classification of PSD types existing in the market.

PSD vs CMOS cameras and CCD

In CMOS cameras and CCD's, resolution and SNR is limited by the pixel size. Also, the entire pixel array need to be read to determine the position of the light spot, which limits the maximum speed of detection. On the other hand, PSD's give instantaneous and continuous information and the resolution is mainly limited by the performance of the signal conditioning circuit.

Author: Bartomeu Servera Mas
Contact : tomeu.servera@icmalaga.com

iC-Malaga solution: Integrated and Flexible Analog Signal Conditioning for PSD's

Signal conditioning for PSD's is traditionally made of quite a large number of discrete components: opamps, precision resistors and even analog dividers mounted on a PCB. Evaluation and lab modules also exist, but their size, power consumption and bandwidth limit significantly their usability.

iC-Malaga has designed an integrated circuit (IC) that can replace all these hardware-intensive solutions in a single component QFN package of 4x4mm.

The integrated circuit is also available for being custom-assembled with PSD devices in conventional TO packages or any other space-saving solution, leading to a highly miniaturized smart sensor head.

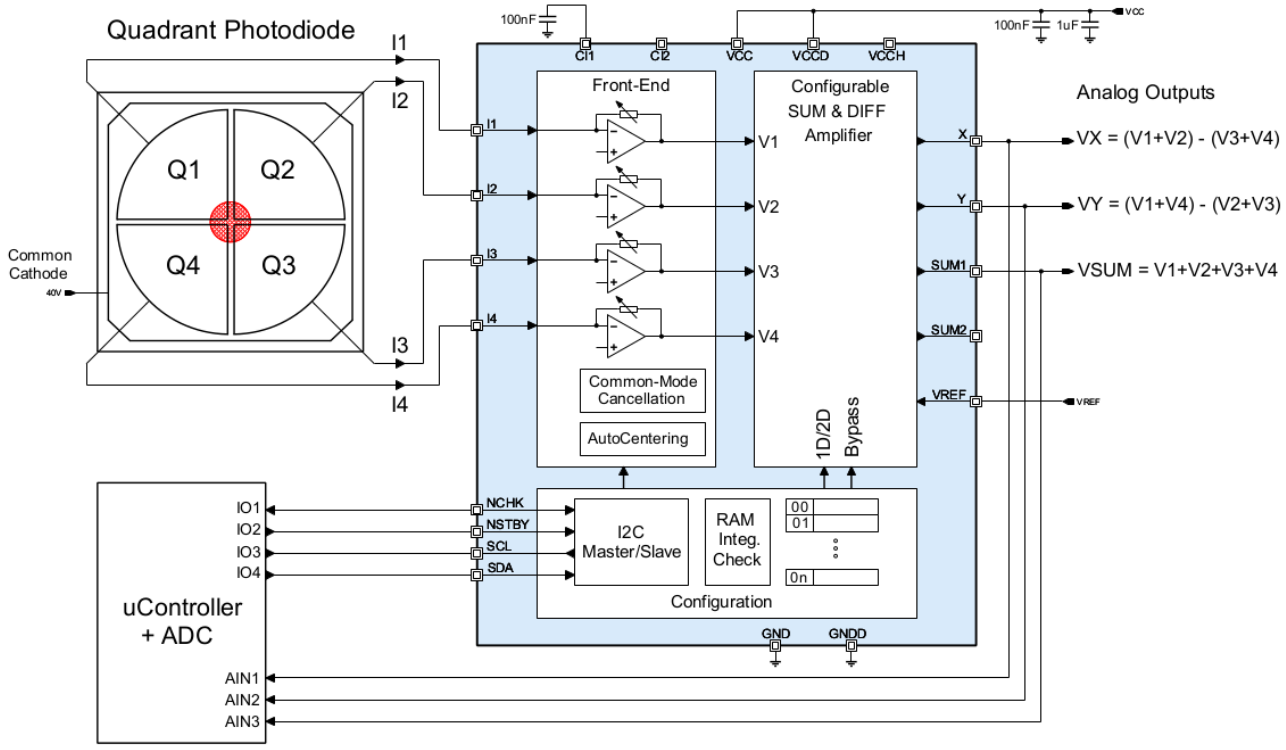

Figure2. Application example: Universal Position Sensing Amplifier IC with Quadrant Photodiode and micro controller

In addition to the miniaturization benefits, the Universal Position Sensing Amplifier IC offers unmatched flexibility due to their high level of configurability.

It provides four independent channels with 12-bit programmable transimpedance gain ranging from 1K to 1MEG. Configuration for common-anode and common-cathode devices, and even duolateral type PSD's (two anode and two cathode) are possible.

The Configurable SUM & DIFF Amplifier provides the analog calculation for position decoding of one-dimension and two-dimension devices, giving the X, Y and SUM analog output voltages.

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Phone: +34 971 518 527

Author: Bartomeu Servera Mas
Contact : tomeu.servera@icmalaga.com

The I2C interface with Master/Slave feature allows the IC to be configured via micro controller or just with an EEPROM for stand-alone applications.

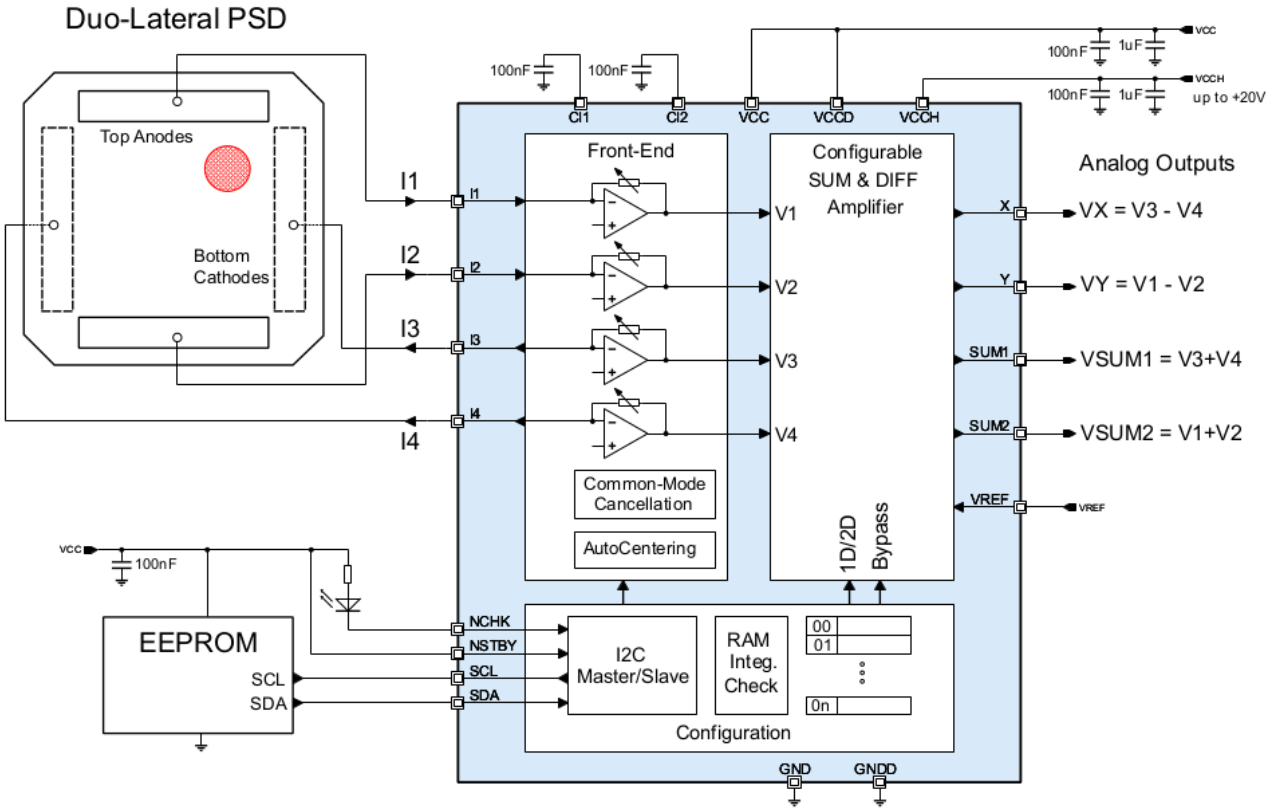

Figure3. Application example: Universal Position Sensing Amplifier IC with Duo-Lateral PSD and EEPROM.

New key features: AutoCentering and Common-Mode Cancellation

New additional features have been designed to improve some of the remaining drawbacks associated with PSD's. As en example, AutoCentering and Common-Mode Cancellation helps to reduce the constrains associated when using Quadrant Photodiodes.

Quadrant Photodiodes are segmented-type PSD's. They offer best performance in terms of sensitivity and speed. However, the achievable resolution and measuring range is highly depended on the light spot size and shape.

The detection range is limited by the spot size, since it must cover the four quadrants for proper position calculation. Then , the larger the spot size, the larger measuring range is achieved. Unfortunately, position resolution decreases with spot size, because a given movement in a small spot will create a relative much bigger differential signal than the same movement in a larger spot.

Then, there is a tradeoff in terms of measuring range and resolution that it is constrained by the size of the light spot. This is traditionally solved by using a proper optical setup with collimation lenses, etc.

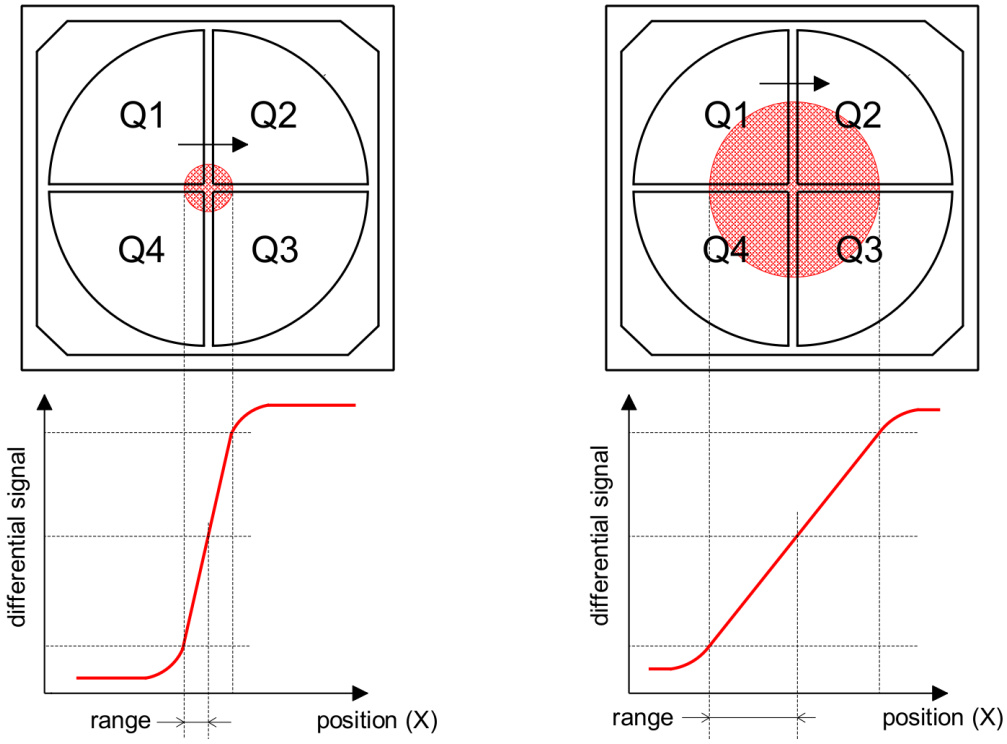

Figure 4. Dependency of resolution and range with the spot size in quadrant photodiodes.

The new Universal Position Sensing Amplifier IC offers an alternative solution to this issue: by using the Common-Mode Cancellation, much higher resolution can be achieved even with larger spot sizes. This is because all the current that is "common" between the four quadrants is removed before being amplified. Then, only the differential signal is processed by the transimpedance stage, and very high amplification factors can be used without saturating the system.

The next figure shows the working principle of the Common-Mode Cancellation (just for two photodiodes). It consists on a feedback loop that regulates the output of the transimpedance stage in a manner their common-mode is canceled. This is achieved by injecting a DC current (Icomp) that is equal to the common-mode current generated by the photodiodes. Only the difference between the two photodiodes is then amplified. Equivalently, in a quadrant photodiode, only the differential currents caused by small variations of the light spot position are amplified, independently of the size of the light spot.

It must be noted that Common-Mode Cancellation also serves as ambient-light rejection, avoiding solar radiation to blind the amplifiers.

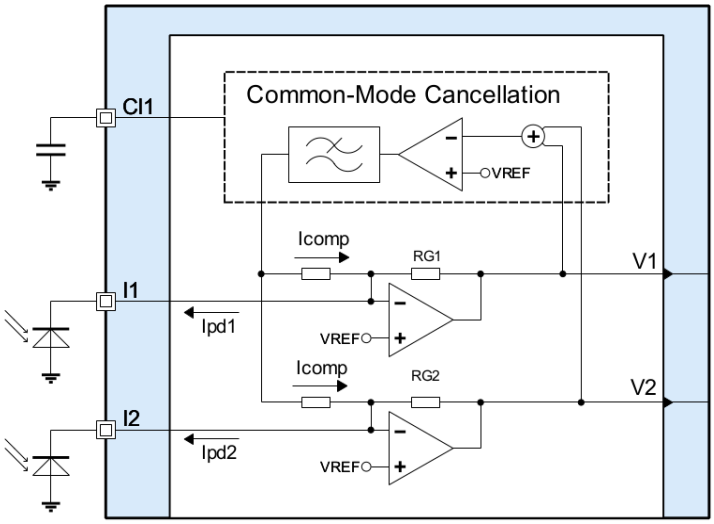

Figure 5. Principle of the Common-Mode Cancelling function (only shown for two channels)

Another drawback that should be considered when using quadrant photodiodes is the need for alignment between the device center and the light spot. Traditionally, any misalignment in the light spot is corrected using x-y micropositioners. This m,ay increase system complexity, size and cost.

The AutoCentering consists on doing a fine gain adjustment of each amplification channel, so the light-spot is “virtually“ center. Intuitively, the gain of the quadrant that is receiving more light is reduced, while the other channels gain must be increased.

High-resolution, 12-bit programmable gain is provided for each channel for realizing such a function. Then, just re-programming the IC is enough to “center“ the light spot.

Summary

The new Universal Position Sensing Amplifier IC designed by iC-Malaga is a flexible device that will serve as signal conditioning for a wide variety of Position Sensitive detectors (PSD) existing in the market.

Compared with existing solutions , it contains all necessary functions integrated into a single component in a QFN package of 4x4mm. This allows much higher levels of miniaturization of the sensor head and significant reduction in power consumption.

This project has been founded in part by the Spanish Ministry of Energy and Tourism and Digital Agenda, under contract TSI-100103-2016-11 “Diseño y desarrollo de un nuevo sensor de posicionamiento univiersal”.

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Author: Bartomeu Servera Mas
Contact : tomeu.servera@icmalaga.com