



PHOTOARRAY: FUNCTIONAL & CHARACTERISITICS DESCRIPTION

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Document Revision History

Table 2: Document Revision History

Version	Issue Date	Brief description of Change
V1.0	29-03-2019	First version of the document

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1 Introduction

This document describes the board called PhotoArray its functions and characteristics.

PhotoArray is an array of photodiodes placed at a fixed pitch to measure the incident light.

Following picture shows a graphical view of the incident light to the different photodiodes (or pixels) on the board:



Figure 1: Graphical representation on incident light

In addition to the array of photodiodes, it also contains the electronics necessary to measure the current through them and a microcontroller capable of digitizing such currents and transmit them, via serial communication, to an external processor.

The microcontroller is based on a Cypress PSOC chip that manages the readings. After reading and processing the data, they are sent by request, to a Computer, Raspberry PI, or similar system through a serial communication described in the ICD document (CP030_DOC2_External_ICD).

1.1 Acronyms

ADC, Analog Digital Converter

BGA, Ball Grid Array

DAC, Digital Analog Converter

ICD, Interface Control Document

GPIO, General Purpose Input Outputs

NO, Normally Open

NC, Normally Close

PCB, Printed Circuit Board

OC, Open Circuit

PSOC, Programmable System On Chip

RP, RaspberryPi

SC, Short Circuit

SMD, Surface Mount Device

SMT, Surface Mount Technology

TBD, To Be defined

TBC, To Be Confirmed

1.2 Document property

The information contained in this document belongs to the intellectual property of Cerro Electronic Design S.L. This information is strictly confidential and cannot be copied or distributed by third parties without the written permission of the company itself

1.3 References

- CP030_DOC3_UserManual_Vx.x
- CP030_DOC2_External_ICD_vx.x
- CP030_DOC06_PhotoArray_Brochure_vx.x
- Schematics CP030-PHOTOARRAY_V2.0

2 PHOTOARRAY VISUAL ASPECT

The following images show the aspect of the board

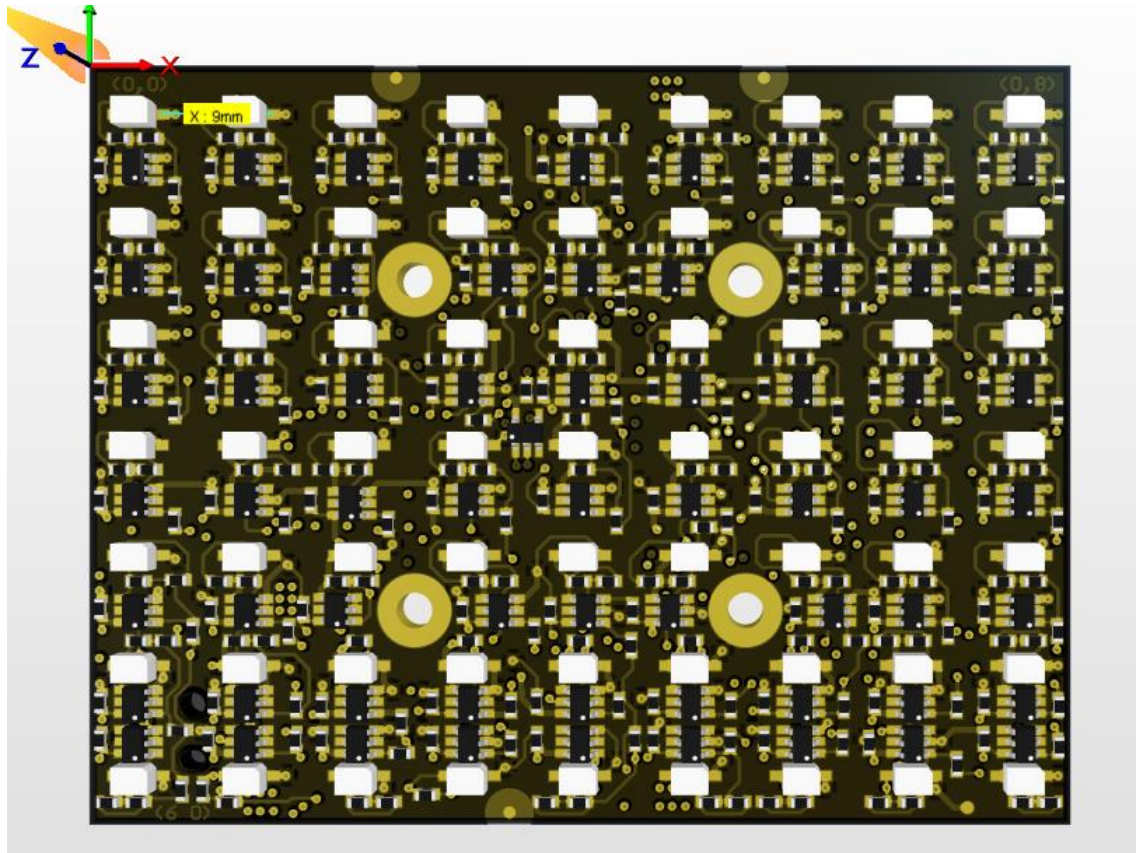


Figure 2: Top side of Photoarray board

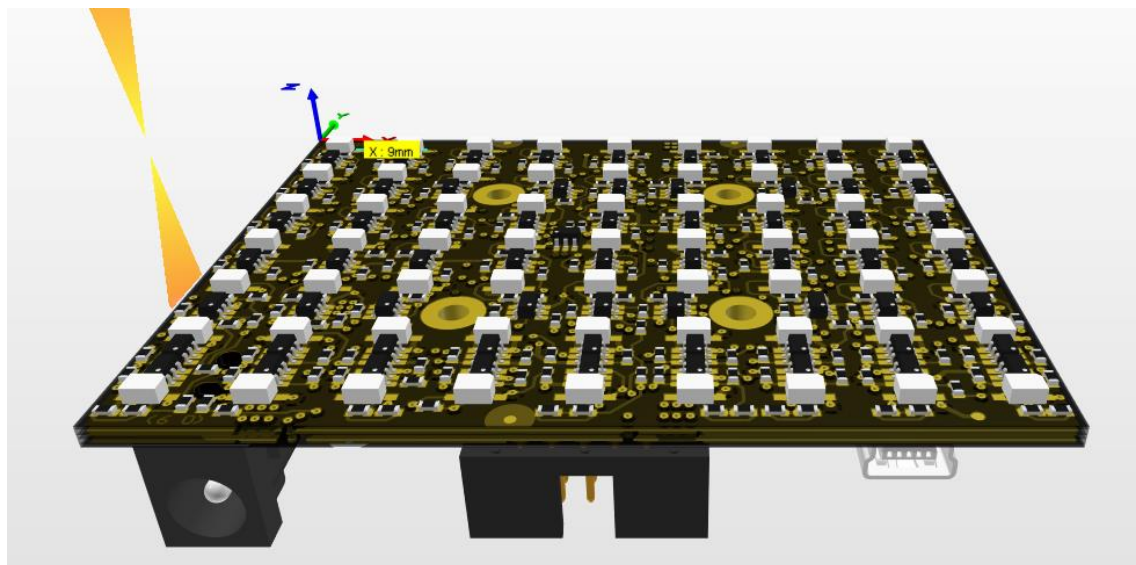


Figure 3: 3D view of top side

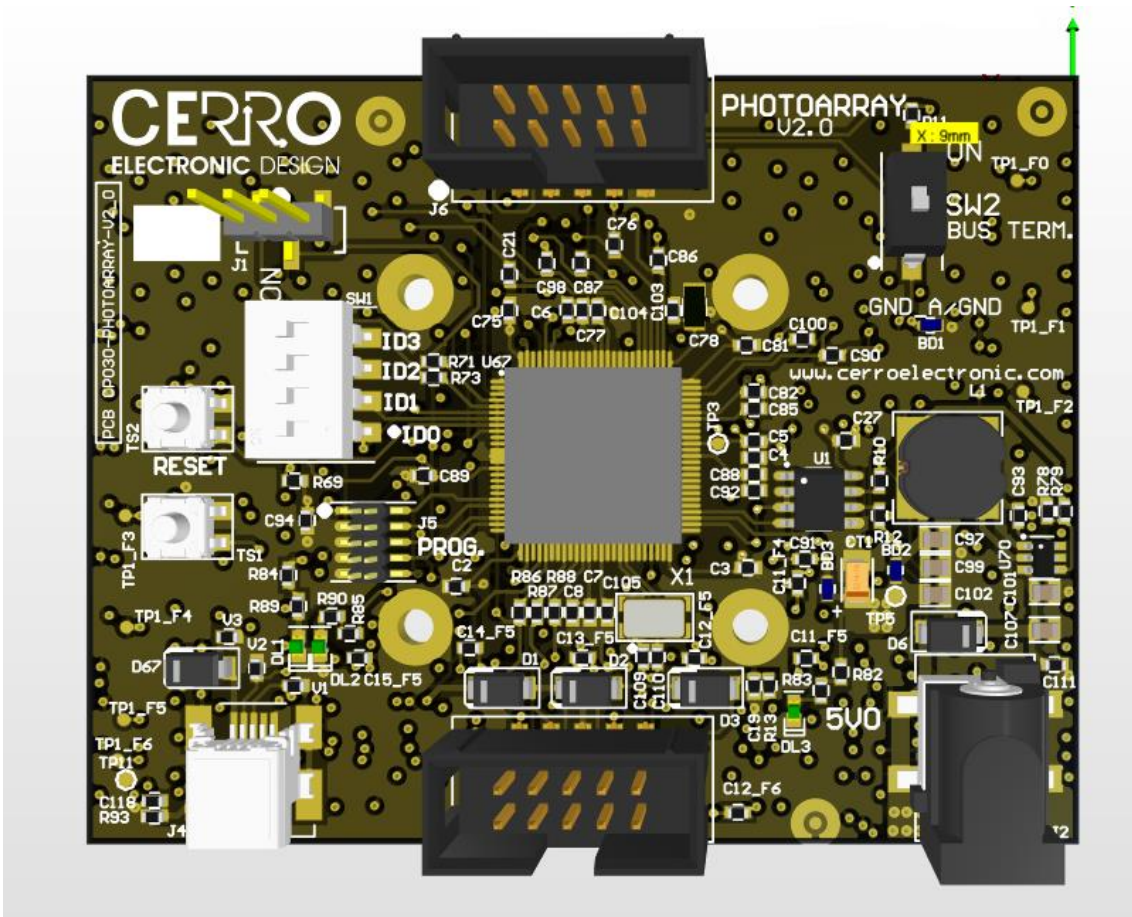


Figure 4: Bottom side

A detailed description of the board can be found on CP030-DOC2-UserManual document.

3 TECHNICAL DESCRIPTION

3.1 Block Diagram

Next figure shows a block diagram of the board

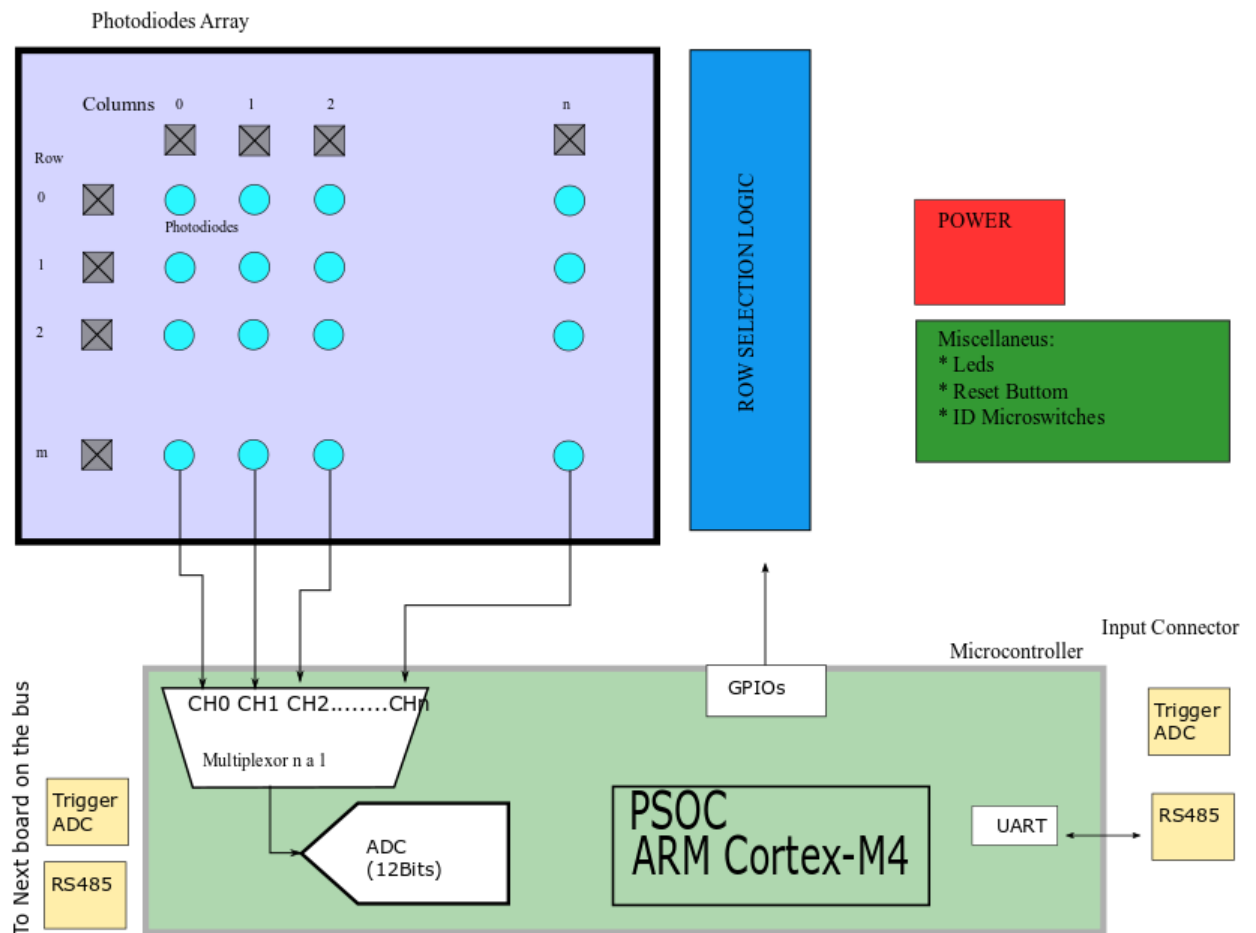


Figure 5: Block diagram

Some of the features that the block diagram show are:

- Array of individually selectable photodiodes according to its column and row.
- Microprocessor or PSOC, which includes:
 - (1) Multiplexer to select the current to be measured. Select by columns.
 - (2) Digital output blocks (GPIOs) for row selection.
 - (3) Digital Analog Converter (ADC), 12 Bit
 - (4) RS485 for data transmission
- Power block, to convert external power supply to the internal voltages required by the board. The power supply external input of the board is 9-12V. This power will be external to the board and may come from an AC/DC adapter or from a laboratory power supply
- Miscellaneous block, which includes power indication LEDs, general purpose LEDs, reset button, microswitches for hardware configuration, etc.

The LEDs can be disabled by means of jumpers so that they do not influence the currents of the photodiodes when the board is in normal operation. These LEDs are very important in the development and debug phases.

3.2 Generic working process

The normal way to work is described here:

- (1) The microprocessor (PSOC) receives from an external master system (a PC, a RaspberryPi...) the order to measure
- (2) The order can be software or hardware:
 - Receive a command through the serial port (Trigger Software) or
 - Using an external hardware trigger (TTL signal)
- (3) Microprocessor, using the GPIOs and the multiplexer, set the row and column of the photodiode to be measured.
- (4) The microcontroller measures and digitalizes the current of the photodiodes by means of the ADC and saves the result in an internal memory.
- (5) Finally, the measured data are sent by the serial port.

3.3 Photodiodes

The photodiode used is:

- Manufacturer: Everlight
- Reference: PD93-21C / TR8
- Digikey Code: SD040-101-411CT-ND
- The following images show some characteristics of it:



Technical Data Sheet Top Silicon PIN Photodiode

PD93-21C/TR8

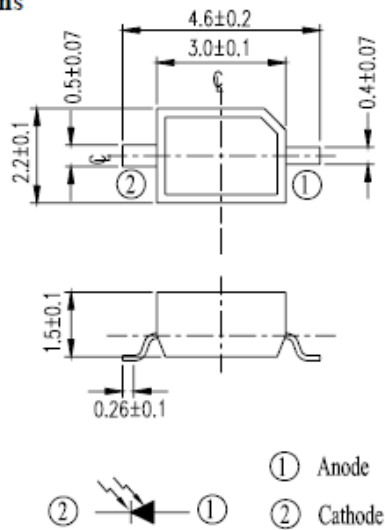
Features

- Fast response time
- High photo sensitivity
- Small junction capacitance
- Pb free
- The product itself will remain within RoHS compliant version.



Figure 6: Main features of the photodiode

Package Dimensions



- Notes:** 1. All dimensions are in millimeters
2. Tolerances unless dimensions ± 0.1 mm

Figure 7: Photodiode package

PD93-21C/TR8

Electro-Optical Characteristics (Ta=25°C)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Rang Of Spectral Bandwidth	$\lambda_{0.5}$	---	400	---	1100	nm
Wavelength Of Peak Sensitivity	λ_p	---	---	940	---	nm
Open-Circuit Voltage	V_{OC}	$E_e=5mW/cm^2$ $\lambda_p=940nm$	---	0.42	---	V
Short- Circuit Current	I_{SC}	$E_e=1mW/cm^2$ $\lambda_p=875nm$	---	1.2	---	μA
Reverse Light Current	I_L	$E_e=1mW/cm^2$ $\lambda_p=875nm$ $V_R=5V$	---	1.2	---	μA
Reverse Dark Current	I_D	$E_e=0mW/cm^2$ $V_R=10V$	---	---	10	nA
Reverse Breakdown Voltage	B_{VR}	$E_e=0mW/cm^2$ $I_R=100 \mu A$	32	170	---	V
Total Capacitance	C_t	$E_e=0mW/cm^2$ $V_R=5V$ $f=1MHz$	---	5	---	pF
Rise Time	t_r	$V_R=10V$ $R_L=1000\Omega$	---	6	---	nS
Fall Time	t_f		---	6	---	

Figure 8: Electro-optical features

Typical Electro-Optical Characteristics Curves

Fig.1 Power Dissipation vs. Ambient Temperature

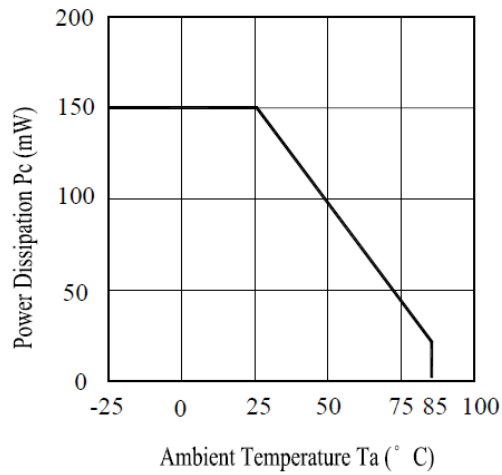


Fig.2 Spectral Sensitivity

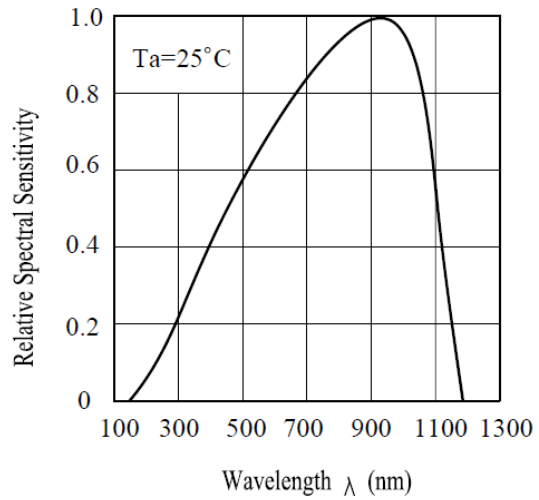


Fig.3 Dark Current vs. Ambient Temperature

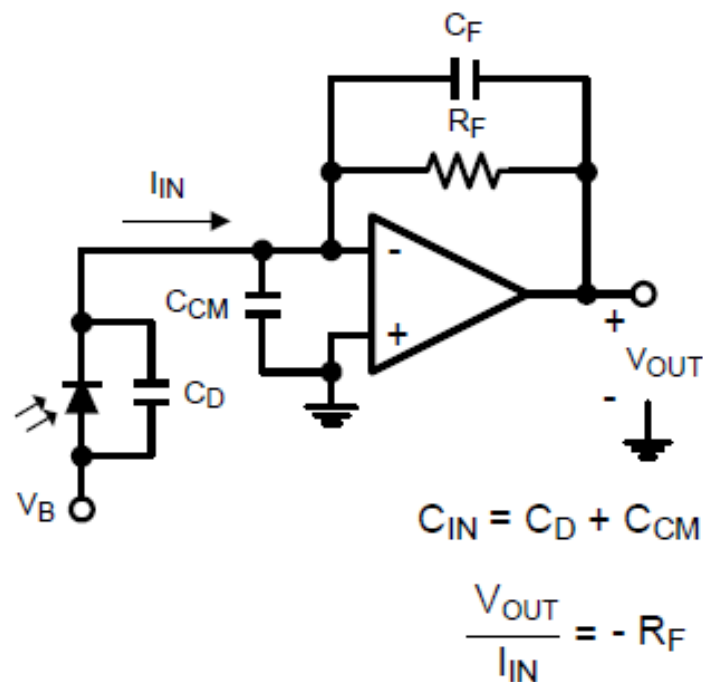
Fig.4 Reverse Light Current vs. E_e

Figure 9: Power dissipation & Spectral sensitivity

3.4 Reading of the current through a photodiode

The objective of the board is to measure the current through a reverse polarized photodiode. This current is proportionally to the light power that falls on them.

We use an operational amplifier on Transimpedance configuration as shown in next figure:



Transimpedance Amplifier

Figure 10: Transimpedance amplifier configuration

With this configuration the current on the photodiode is converted to a voltage, which can be measured by the ADC of the microcontroller.

Depending of the current to be measured the system can be adjusted so the range on the ADC can be used totally and therefore have the best resolution available.

On the actual schematic the maximum current has been supposed to be 2uA and this produce a voltage of 2V on the input of the ADC. The input range of the ADC is 0-2.048V.

You can download the file LMP7711_PhotodiodeSimulation_Double.TSC from the downloadable documents on the www.cerroelectronic.com page and using the free analog simulator TINA from Texas Instruments (<http://www.ti.com/tool/TINA-TI#>), play with the best configuration for your system requirements.

For any doubt please contact us at support@cerroelectronic.com.

3.5 Low Pass Filter & Full frame time needed

At the output of the amplifier there is a RC low Pass Filter.

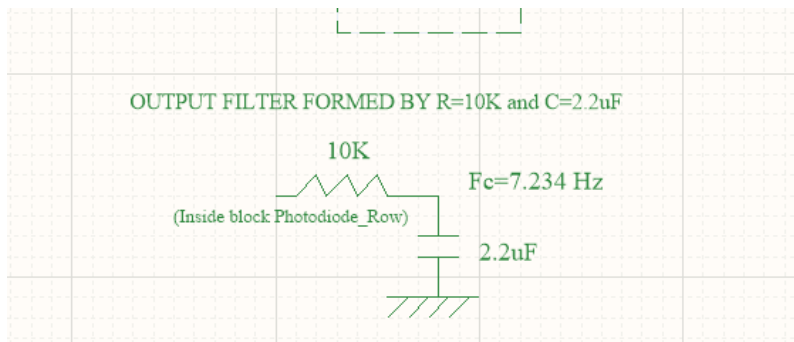


Figure 11: LOw pass filter actual configuration

This filter can also be configured according to the user requirements.

This filter is very important in terms of speed of the system. Each time a new row must be read, the capacitor must be charge/discharge, so value to be measure be the real value we must take.

As seen in the figure the filter has is form with R01oK and C=2.2uF. With these values, the time to charge/discharge is about 250ms, so to take a full frame the time is approx. $250\text{ms} * 7 \text{ rows} = 1.75 \text{ Seconds}$.

This time can be adjust depending of the project. Please contact us at support@cerroelectronic.com to talk about your project requirements.

3.6 Photodiodes Matrix

7x9 Matrix Photodiodes, pitch de 9mm.

3.7 ADC sampling frequency

The ADC to be used is of the SAR type (Successive Approximations).

The main characteristics are:

- 12 Bit Resolution
- Multiplexing up to 64 "Single Ended" channels
- Type SAR
- Internal Vref
- Internal clock frequencies of 12M

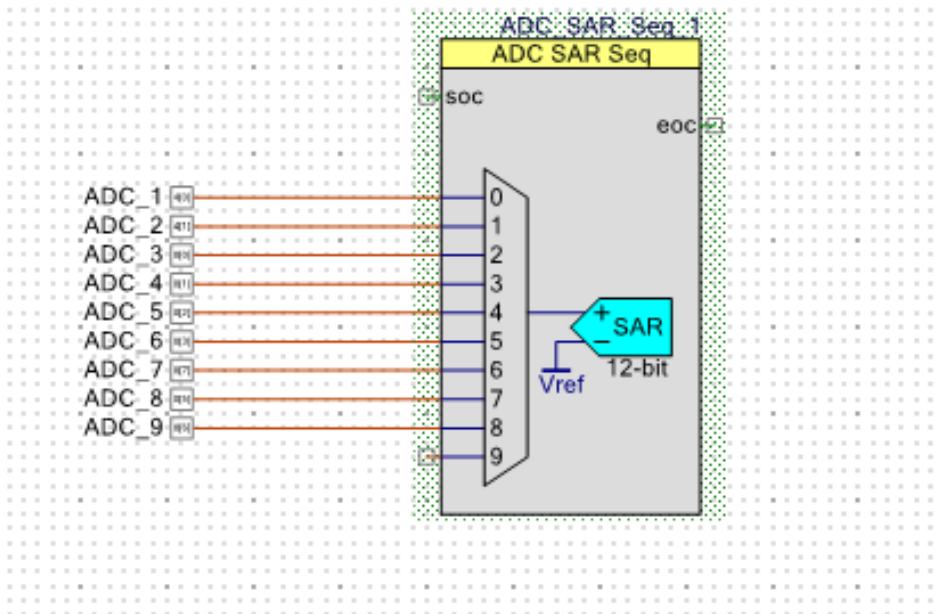


Figure 12: ADC Symbol

Next figure shows the ADC configuration:

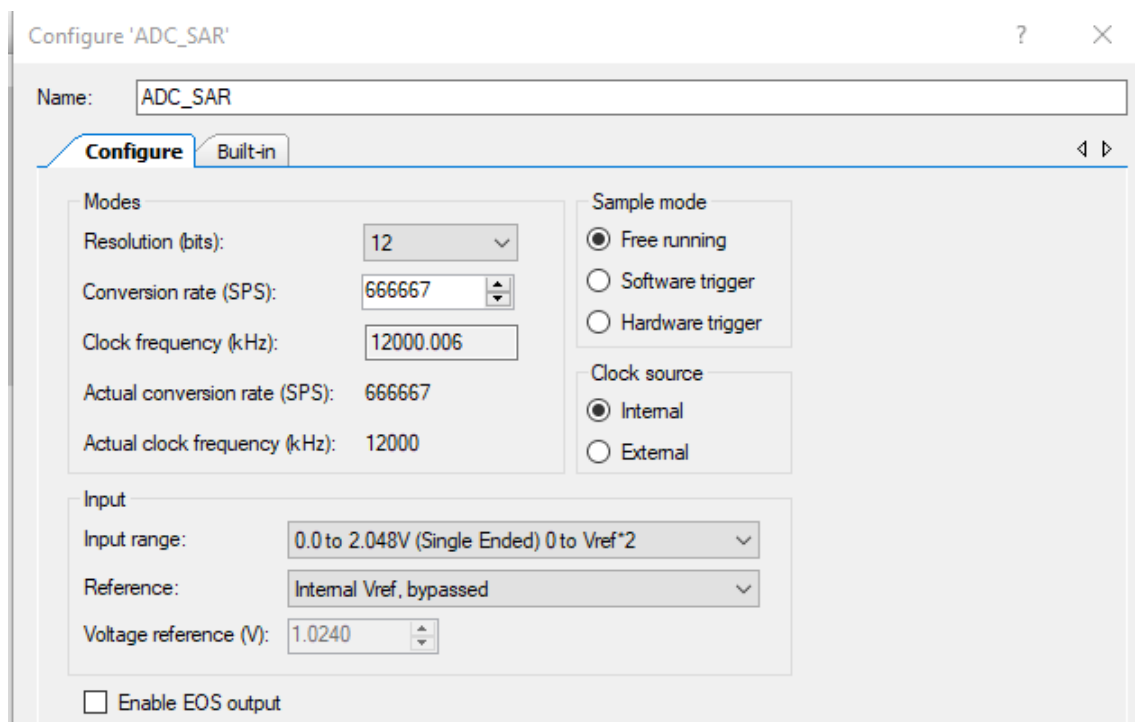


Figure 13: ADC Sampling Configuration

Channel Sample Rate (1 channel) = 66667 SPS(Samples Per Second)

Sample Rate (9 channels): 7407 SPS

So, to take a sample of one row we need $1/7407 = 135$ us.

A full frame (that is 7 rows): $7 * 135 = 945$ us

However, as seen in the chapter 3.5, the time need to have a full frame is depending of the output filter.

3.8 Trigger Hardware

It is possible to initiate a full frame measurement with external TTL signal.

The trigger signal is set to be active at low level, that is, in its idle state it will have a "High" logic level. The falling flank is detected, so the pulse width does not matter.

3.9 Dimensions

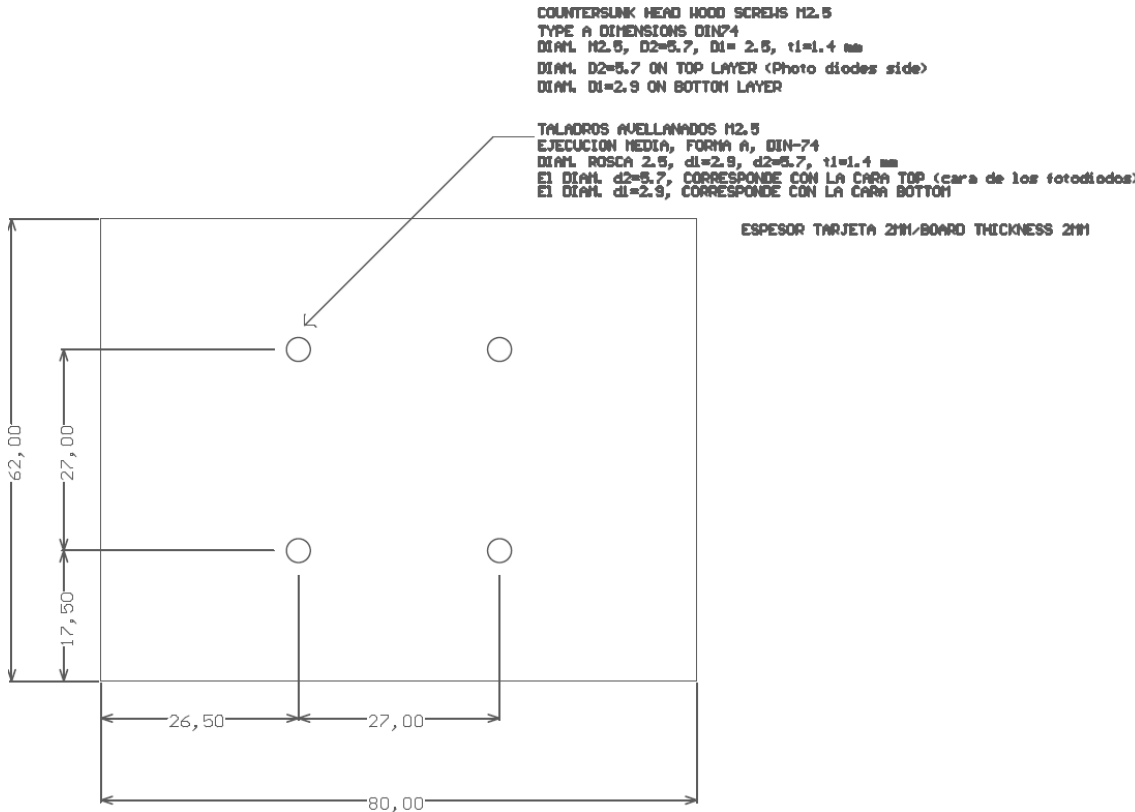


Figure 14: Dimensions of the board

Thickness board: 2mm.

The card will have a black color, to avoid as much as possible the reflections of light.

3.10 Photodiodes Identification

The position of each photodiode will be fixed by two coordinates (X, Y), where X is the indicative of the columns and Y of the rows.

The photodiode (0, 0) will be located at the top left.

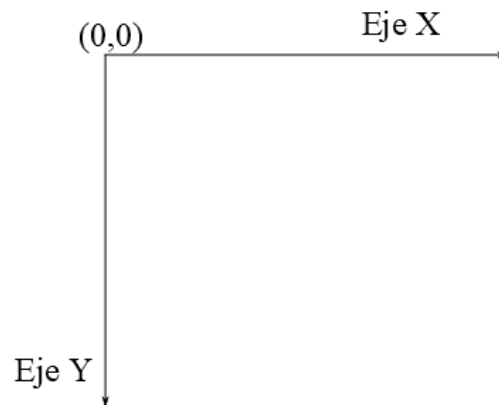


Figure 15: Photodiodes identification by coordinates

3.11 Communication

The following image shows schematically the communications between the PhotoArray system and a Master system, which for reasons of understanding we can say that it is a computer or a raspberryPi.

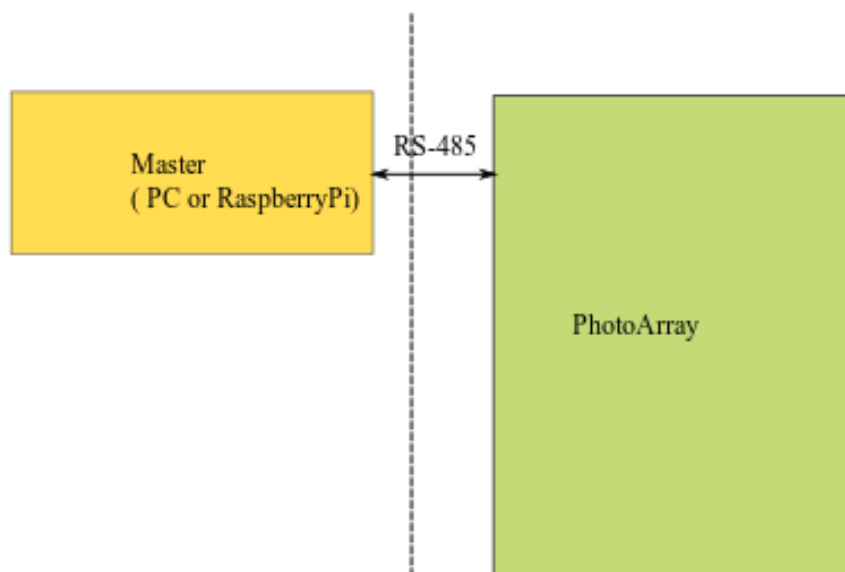


Figure 16: Communication block diagram

3.12 Scalability

To give PhotoArray greater versatility and be able to address projects that require the use of more photodiodes, PhotoArray will implement a scalability system. The following figure shows the concept.

Port 0 and 1 are just two identical connectors with the same pinout, so we can pull a cable from one board to another. That is, the data to be transmitted / received will be available in the two connectors.

Each photodiode in the full system is identified by its coordinates (X, Y, Z). X and Y refer to the coordinates of the diode within its board and Z refers to the ID board within the system.

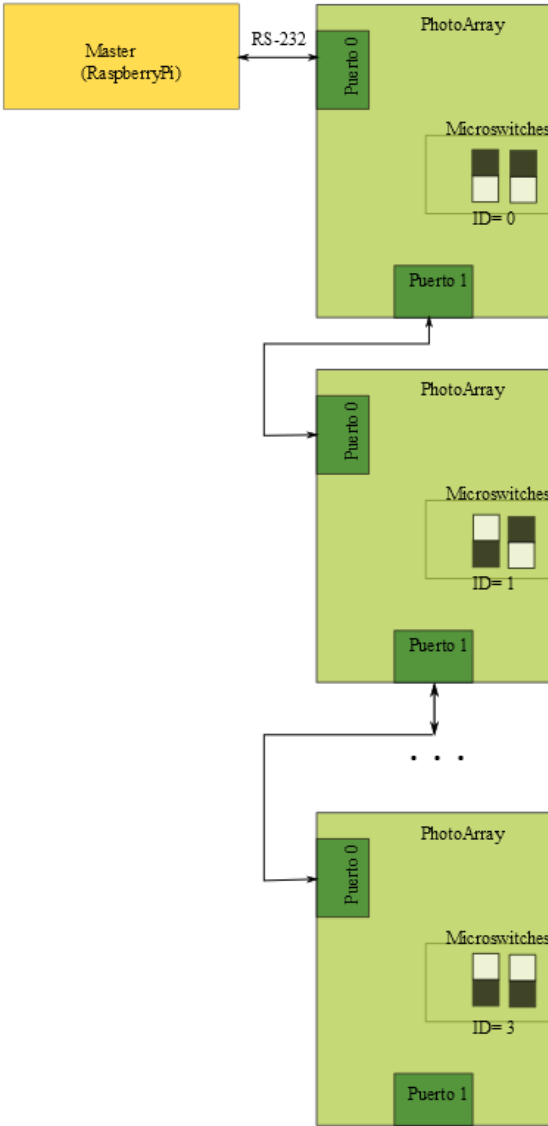


Figure 17: Several board in the same bus

3.13 Temperature measurement

The current of the photodiodes depends on the temperature also.

To control the temperature and, if necessary, to make corrections, a temperature sensor is placed on the same side as the photodiodes and in a centered place.

The proposed sensor is Analog Devices TMP05 with an accuracy of $\pm 1^\circ\text{C}$.

The main characteristics of it are given in the following image:

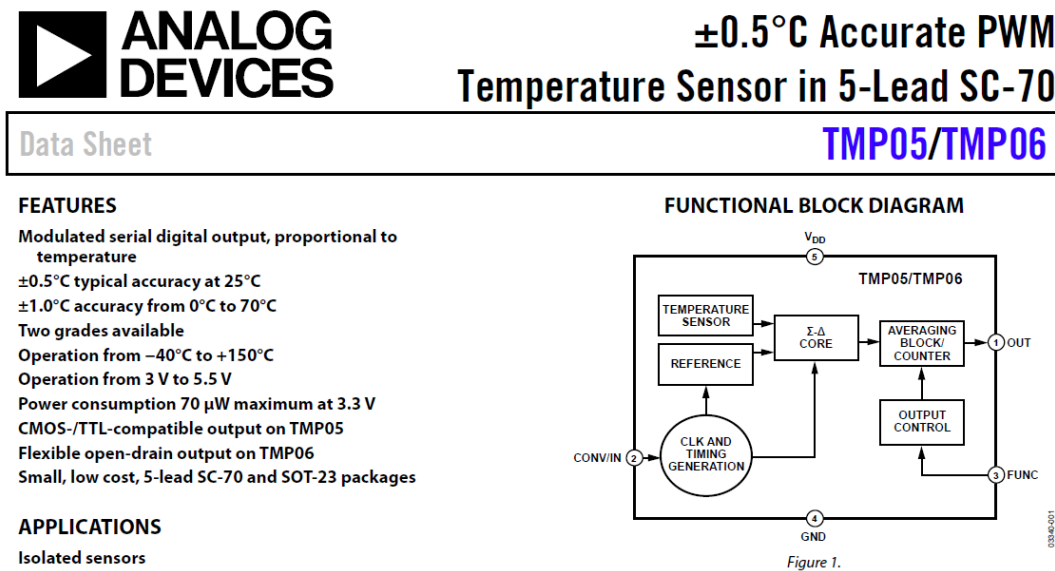


Figure 18: Temperature sensor

3.14 Bootable System

The system is able to be updated by means of a USB port. In this way, if an update of the internal firmware of the card is needed, Cerro will provide a file with the new software and the user will be able to update it without the need for any programmer or external device.

The operation will be as follows: at startup, the system will wait for the new software through the USB port for 2 seconds, if this new software is available, it will be loaded and it will start normally with the new software. On the other hand, if it is not available, after 2 seconds it will start up with the current software.