

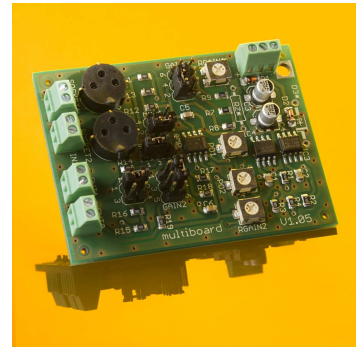
## MULTIBOARD

Multifunctional 2-Channel Photodiode Amplifier



### Introduction

Photodiodes generate only very small photocurrents. These currents ranging from a microampere down to some picoampere cannot be measured by commonly available multimeters – an amplifier is needed. This amplifier, such as the dual channel sglux MULTIBOARD converts small currents into a voltage of 0...4V. Thus, the amplifier links the small current generated by a photovoltaic element (photodiode) to usual signal conversion electronics like a voltmeter or a controller.



### Basics

Photocurrents can be converted to voltages by transimpedance amplifiers (TIA). The MULTIBOARD utilizes this approach. The schematic is shown in Appendix B. For basic knowledge about this device please refer for instance to application notes for device OPA128 from TI at <http://www.ti.com/>. Other technologies base on current-to-frequency converters, e.g. the sglux "DIGIBOARD".

### Specifications

The MULTIBOARD consists of two independent amplifier channels with adjustable gain. By using jumpers one can select the amplifier type (voltage or transimpedance amplifier) and configuration (two independent amplifiers or single two-stage amplifier) as well as the gain. The board provides current gain in the range  $10^5$  V/A... $10^7$  V/A and voltage gain from 2...1000 V/V in single-stage configuration. Additionally to the fixed gain factors are potentiometers for custom gain factors in the range  $10^4$  V/A... $10^6$  V/A. By two stages one may reach gains of  $10^{10}$  V/A respectively  $10^5$  V/V if offsets are carefully adjusted. The maximum usable output voltage range is  $\pm 4$  V and must be considered while calculating gain factors. The circuit is ideally operated with a dual power supply of  $\pm 9$  V... $\pm 24$  V. For lower performance measurements a single supply of 24 V...36 V may be used. In both cases stabilisation is not required. **Note:** Applying operating voltage with a wrong polarity can destroy the board. The photodiodes plug directly into sockets or are externally connected via screw terminals. The output voltages are available on screw terminals. Dimensions are W x D x H = 60mm x 45mm x 12mm

### Specifications overview

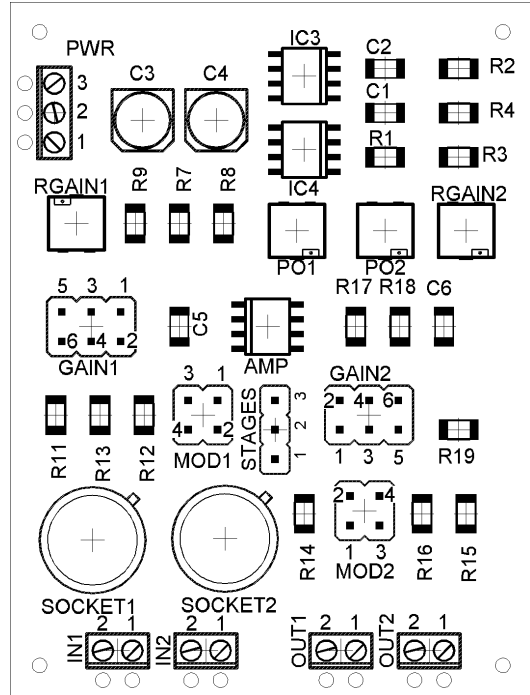
Signal out	Ranges	Setting facilities	U <sub>supply</sub>
0...4V	0 - 400pA 0 - 400nA 0 - 4nA □ 0 - 40µA 0 - 400µA 0 - 4mV	<ul style="list-style-type: none"><li>• 5 ranges configurable with jumpers</li><li>• continuously adjustable amplification 4µA - 400µ A</li><li>• offset control</li></ul>	24...36V single supply or  2 x 9...24V dual supply

## Starting

The index “x” in names relates to the channel number (“1” or “2”), for positions and pin numbers please refer to the picture on the right.

- Choose operation modes and configuration by setting jumpers MODx and STAGES; refer to Appendix A, tables 2 and 3.
- Set required gains with jumpers GAINx and/or potentiometers RGAINx; again refer to Appendix A, table 4.
- Connect voltmeter(s) to screw terminals OUTx. Right pin (#1) is the output, left pin (#2) equals to GND.
- Connect the power supply to screw terminal PWR. For dual power supply use top terminal (#3) for negative, middle (#2) for GND and bottom terminal (#1) for positive voltage. A single supply must be connected with positive pole to bottom pin (#1) and supply GND to top pin (#3), middle pin is left open.

**Note:** In case of single supply there is a floating virtual ground on the middle terminal to which the inputs and outputs relate and which must not be connected to power supply GND.



- Adjust offsets for all channels. To do this shorten inputs for voltage amplifiers and leave inputs open (or insert photodiodes and darken them to compensate dark currents as well) for transimpedance stages. Now adjust the output voltages to 1mV or less by potentiometers POx.
- Connect photodiode(s) to either terminal INx or SOCKETx. The right pins (#1) of screw terminals INx are the inputs, the left pins (#2) equal to GND (cathode). If using the sockets the upper pinhole is the input and must be plugged with one photodiode pin in any case. Other pinholes are grounded and may be used as required. Polarity of the photodiodes within sockets depends only on desired output voltage polarity.

## Examples

### Problem 1:

Compare photocurrents of two different photodiodes. This task at first requires two identical channels and an estimation of the photocurrent generated with this experiment. This current can be calculated by the formula:

$$I = A_{\text{chip}} \cdot S_{\text{chip}} \cdot E_{\lambda} \cdot 10.000$$

where  $I$  is the photocurrent in nA,  $A_{\text{chip}}$  is the chip active area of the photodiode you plan to use in  $\text{mm}^2$ .  $S_{\text{chip}}$  is the chip's spectral sensitivity in  $\text{AW}^{-1}\text{nm}^{-1}$  and  $E_{\lambda}$  is the spectral irradiance of the UV light source in  $\text{mWcm}^{-2}\text{nm}^{-1}$ . Please get  $A_{\text{chip}}$  and  $S_{\text{chip}}$  from the photodiode's datasheet.  $E_{\lambda}$  needs some knowledge of the UV source you plan to use. Sun and purification lamps generate approx.  $1 \dots 10 \text{ mWcm}^{-2}\text{nm}^{-1}$ . For a very detailed tutorial have an internet search for: "SiC UV Photodiode Selection Guide". Further to the example experiment, the estimated photocurrent may be approx.  $1 \dots 2 \mu\text{A}$ . As the output of the MULTIBOARD is  $0 \dots 4\text{V}$ , you may expect to get  $1 \dots 2\text{V}$  output voltage by defining the gain as  $1\text{V}/\mu\text{A} = 10^6 \text{ V/A}$ .

### Solution:

- ✓ set jumper STAGES to position 1-2 (two channel mode), set MOD1 and MOD2 to position 1-2 (transimpedance amplifier)
- ✓ set GAIN1 and GAIN2 to position 2-4 (transimpedance gain  $10^6 \text{ V/A}$ )
- ✓ connect and turn on power supply
- ✓ insert photodiodes, darken them, compensate offsets (and dark currents) by adjusting PO1 and PO2
- ✓ illuminate photodiodes with visible and ultraviolet light, compare voltages on terminals OUT1 and OUT2

### Problem:

Convert a photocurrent of  $1\text{nA}$  to a voltage of  $2.0 \text{ Volts}$ . This requires a total gain of  $2\text{V}/\text{nA} = 2 \cdot 10^9 \text{ V/A}$ , which can be provided by two amplifier stages. The first stage converts the current to a voltage of  $10\text{mV}$  with a gain  $10^7 \text{ V/A}$ , which is then boosted to  $2.0 \text{ V}$  by the second voltage amplifier stage with a gain of  $200 \text{ V/V}$ . This voltage can be displayed easily by a standard digital panel voltmeter.

### Solution:

- ✓ set jumper STAGES to position 2-3 (two channel mode)
- ✓ set MOD1 to position 1-2 (transimpedance amplifier) and GAIN1 to position 1-3 giving  $10^7 \text{ V/A}$  in the first stage
- ✓ open MOD2 (voltage amplifier, pre-gain 2) and set GAIN2 to position 1-3 (giving overall voltage amplification of 200 in stage two)
- ✓ connect and turn on power supply

- ✓ insert photodiode into SOCKET1 and darken it; first compensate offset of first stage by adjusting PO1 until voltage on OUT1 is below 1 mV; then compensate offset of second stage by adjusting PO2 until voltage on OUT2 is below 1 mV
- ✓ illuminate photodiode and measure voltage on terminal OUT1

## Appendix A

**Table 1: pin, terminal and other assignments**

	Pin 1	Pin 2	Pin 3	If a single power supply is applied, the input and output GND terminals <b>must not</b> be connected to the power supply's GND. Free floating input & output GND is mandatory.
PWR	+8 V ... +24 V	GND	-8 V ... -24 V	
IN1	input terminal channel 1	GND		
SOCKET1	input socket channel 1	GND	GND	
OUT1	output terminal channel 1	GND		
PO1	offset compensation channel 1			
IN2	input terminal channel 2	GND		
SOCKET2	input socket channel 2	GND	GND	
OUT2	output terminal channel 2	GND		
PO2	offset compensation channel 2			

**Table 2: channel configuration**

STAGES	Function
1-2	two independent amplifier channels
2-3	single two-stage amplifier; note: channel two must be configured as voltage amplifier by setting MOD2 in any position but 1-2

**Table 3: amplifier mode**

MODx	Function
1-2	transimpedance amplifier
1-3	voltage amplifier pre-gain 10
3-4	voltage amplifier pre-gain 5
Open	voltage amplifier pre-gain 2

**Table 4: gain factor setting**

GAINx	transimpedance gain [V/A]	voltage gain (multiply by voltage pre-gain to get total voltage gain) [V/V]
1-3	$10^7$	100
2-4	$10^6$	10
3-5	$10^5$	1
4-6	adjustable by potentiometer RGAINx in range $10^4 \dots 10^6$	0.1...10

## Appendix B

Schematic:

