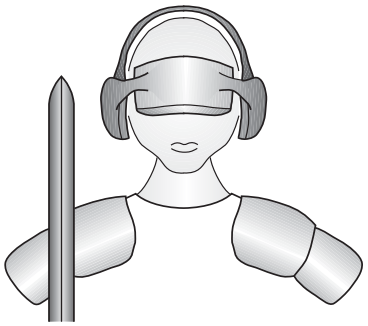
PhotonWarrior28A2

USB Digital Photoamplifier



Code Mercenaries

1. Features

- USB photoamplifier
- 1/2" cylindrical case
- USB full speed interface
- USB HID 1.1 compliant
- Optional: I2C slave interface up to 400 kHz
- 12 bit internal A/D converter
- 1 kHz data rate
- 16 times oversampling and internal filter for noise canceling
- 6 measurement ranges 10^3 to 10^8
- Calibration data can be stored internally
- Single 5V power supply via USB
- Low power consumption: 20mA max.
- Available as complete device in a 1/2" tube
- ca. 1.8 m USB cable attached
- Standard photodiode: BPX65

1.1 Variants

PhotonWarrior28A2 is currently available as the USB variant with six selectable ranges.
A I2C variant is available as a custom option, please contact sales for additional information.
Variants with other types of photodiodes are possible as custom versions.

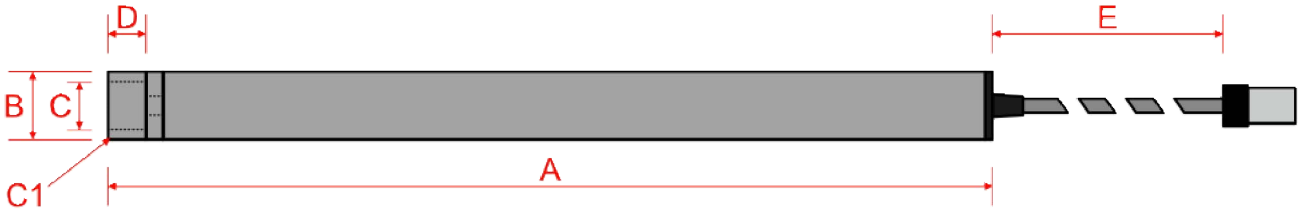
2. Functional overview

PhotonWarrior28A2 measures light intensity down to low levels.
It identifies as a joystick device, which allows easy access to the data without any special software.

2.1 Application

PhotonWarrior28A2 has the photodiode directly exposed inside the forward end of the tube. In front of it is an internal SM05 thread.
Additional optics, filters or adapters may be mounted here.
The PhotonWarrior28A2 is simply connected to the USB of the host computer. Measurement data is delivered as a joystick X-axis and can be accessed via the standard joystick API of the operating system (uncalibrated data needs to be read from the joystick API).
For better accuracy PhotonWarrior28A2 supplies calibration data to correct the data into voltage with ±10mV accuracy (signal at the ADC behind the amplifier).
Sample code is provided to show the handling of PhotonWarrior28A2.

2.2 Mechanical dimensions



A = 123 mm
B = 17.9 mm (diameter)
C = 12.9 mm (diameter)
C1 = Internal thread type SM05
D = 10 mm
E = ca. 1800 mm

3. Device operation USB

PhotonWarrior28A2 registers as a standard HID joystick and generic device. It requires no specific drivers, the data can be accessed via standard system functions on basically any platform.
PhotonWarrior28A2 has two interfaces. Interface 0 provides the actual sensor data in joystick format.
PhotonWarrior28A2 also allows to set the amplification factor by a Feature Report to Interface 0.
Interface 1 is used to store and access device data like the manufacturing and calibration data. It also allows to set the default amplification factor to which the sensor starts up when plugged in or reset.

3.1 Sensor data

The physical data packet sent from PhotonWarrior28A2 is as follows:
2 bytes sensor data
2 bytes zero (may be used later)
2 bytes bitfield to indicate the amplification factor
Sensor data is reported as the X axis of the joystick data. The resolution is 12 bits.
A dummy Y axis is also transmitted for compatibility purposes, this data field may be used for some purpose in later versions.
The amplification factor is reported by abusing the joystick buttons. Buttons numbered 0 to 15 indicate the amplification factor as 10^n.
The actual bitmask for this is part of the manufacturing data programmed into the sensor during production testing to allow for models with various amplification factors based on the same PhotonWarrior.

3.2 Switching the amplification factor

PhotonWarrior28A2 offers six amplification factors and supports commands for setting them.
Sending a feature report to interface 0 with a single byte does set the amplification factor temporarily. After the next reset it will return to the last stored value.
To persistently set the amplification factor see the next chapters.

3.3 Commands on interface 1

Interface 1 is a generic HID function that can be accessed via standard file I/O. It is used to set and read various configuration data and calibration data.
Not all of the commands are intended for the use by the end user. In the standard retail version of PhotonWarrior28A2 these commands will be protected by a 64 bit PIN to avoid accidental access to data that is set during manufacturing. Sending a wrong PIN does lock up all PIN protected functions until the PhotonWarrior28A2 is unplugged.
USB uses a fixed 64 byte report format in both directions.
Generally commands do have the command number in the first byte. This tells interface 1 what to do.

3.3.1 Command 0x00 "Read Device Data"

Command 0x00 returns the basic device data. The out report to interface 0 contains only the command number.
The returned in report starts with the command number to which this is a reply:
00 - Get Device Data (0x00)
01 - unused
02/03 - Vref Cal (calibration data for ADC voltageref)
04/05 - Temp Cal1 (calibration data for onchip temperature sensor)
06/07 - Temp Cal2 (calibration data for onchip temperature sensor)
08/09 - Measured Ref value (actual measured value of internal reference)
0A/0B - Measured Temp value (temperature value)
0C-0F - Serial number
10/11 - Erase count (number of times main device memory was erased)
12/13 - Erase count param mem (number of times parameter FLASH was erased, this is where I2C address and the persistent amp factor are stored)
14-17 - Production date (Posix 32 bit format)
18-1B - Photo diode type
1C/1D - Amp factor 0
1E/1F - Amp factor 1
20/21 - Amp factor 2
22/23 - Amp factor 3
24/25 - Amp factor 4
26/27 - Amp factor 5
28-3F - unused

3.3.2 Command 0x01 "Read Data Block"

This command reads a 32 byte data block from the persistent memory (not used yet, intended for calibration data). The second byte of the command specifies the block number (0 to 30 are valid).
The returned report has the following format:
00 - 0x01 - Read Data Block
01 - Status (must be zero if ok)
02-03 - unused
04-23 - Data
24-3F - unused

3.3.3 Command 0x02 "Set Amp Factor"

Command 0x02 sets the amplification factor and writes the value to the internal flash memory so this value will be used on the next power up or reset.
The amplification factor index is passed in the second byte of the report, only values in the valid range for the PhotonWarrior are accepted.
A reply report with the result of the flash memory write operation is returned:
00 - 0x02 - Set Amp Factor
01 - Status (must be zero for write being ok)
02-3F - unused

4. Device data

PhotonWarrior28A2 has a set of data programmed into it at production. This data allows to identify the specific properties of the unit.
Reading the device data also provides calibration information for the internal ADC and the value of the temperature sensor as well as the calibration data for the temperature sensor.
Following is a detailed description of the data fields contained in the device data.

4.1 Vref Cal / Measured Ref Value

PhotonWarrior28A2 has a bandgap reference for which the ADC value at Vdda = 3.3 V ±10 mV is stored internally. This calibration value together with the measured reference value can be used to determine the absolute voltage measured by the ADC.

To calculate the actual input voltage of an ADC channel the calibration data is used with the following formula:
Vin = 3.3 V * VrefCal * ADC / Vref /4095

4.2 Temp Cal / Measured Temp

The internal temperature sensor of PhotonWarrior28A2 is located inside the microcontroller. It may be used when it is assured that the whole device is at the same temperature. If that can not be guaranteed the photodiode is likely at a different temperature as the distance between the parts is rather large (almost opposite ends of the case).
Though the linearity of the sensor is not bad (typ. ± 1K) the absolute precision of the temperature sensor is limited since the TempCal1 and TempCal2 values are measured with just ±5°C accuracy. For more precise results the calibration may be done externally.
The temperature calibration values and the voltage calibration values have to be used to calculate the chip temperature as follows:
t = 80°C / (TempCal2 - TempCal1) * (Temp * VrefCal / Vref - TempCal1) + 30

4.3 Erase counts

PhotonWarrior28A2 uses two internal banks of flash memory to keep persistent data. For each an erase count is kept that allows to determine how many times the data block has been rewritten
The first erase count indicates the number of times the main memory block has been rewritten. This is the block that contains the device and calibration data and should have a very low count as it is only written in the production process.
The second count is for the parameter memory that keeps the amp factor (if used) and the I2C address. This block gets erased and rewritten after 511 writes of the I2C address or amp factor.

4.4 Production date

This 32 bit POSIX date indicates when this individual unit was manufactured or more exactly when it did receive its device data.

4.5 Photodiode type

As PhotonWarrior28A2 can be equipped with various photodiodes this data field is used to identify the diode type.
The 32 bits of this field are used as follows:
0-3 - Photodiode type
4-11 - Photodiode spectral peak
12-19 - Photodiode efficiency, BCD value
20-27 - Photodiode size in mm2, BCD value
28-31 - Photodiode material
Photodiode type encodes the actual part type.
0 means this is a non standard diode.
1 = BPX65
Photodiode spectral peak defines the peak sensitivity in 10s of nm.
Photodiode efficiency defines the quantum efficiency of the diode in percent, the value is coded as a two digit BCD value, each nibble going from 0…9.
Photodiode size specifies the active area of the sensor element in mm^2. This is coded as a mostly 2 digit BCD value. The lower nibble is valid for 0…9 and specifies the decimal place, the upper nibble is valid for 0…15, so the maximum area that can by specified is 15.9 mm^2.
Photodiode material specifies the semiconductor material the diode is based on, which implies the rough spectral sensitivity.
0 = Unknown
1 = Silicon
2 = InGaAs
3 = SiC

4.6 Amp factor

The amp factor or factors specify the amplification factor as a 16 bit bitfield indicating the power of 10. If the device supports multiple amplification factors then there are multiple values. This is the same value that will be reported in the sensor data packets, i.e. on USB as the buttons.
A value of 0x0001 means 10^0, 0x0800 is 10^{11}.
Since the ADC has a resolution of 12 bits or 4096 steps, for the magnitude of the resolution 3 can be added to the exponent.

5.0 Absolute maximum ratings

Storage Temperature .....-65°C to +150°C
Ambient Temperature with power applied.....-40°C to +85°C
Supply voltage on Vcc relative to Gnd .....-0.3 V to +6.5 V
DC input voltage .....-0.3 V to +6 V
Power Dissipation.....max. 170 mW
Static discharge voltage.....>2000 V
Latch-up current .....>200 mA

5.1 DC characteristics

	Parameter	Min	Max	Units	Remarks
V_{cc}	Operating Voltage	3.6	5.5	V	typ. 5 V recommended
I_{dd}	Operating Supply Current		20	mA	absolute maximum
V_{ith}	Input Threshold Voltage	2.3		V	

5.2 ADC characteristics

	Parameter	Min	Max	Units	Remarks
V_{ain}	Input Conversion Range	0	3.3	V	
V_{ref}	Internal Reference Voltage	1.2	1.25	V	typ. 1.23 V
V_{refCal}	Accuracy of Calibration Value		± 10	mV	bandgap calibrated at 3.3 Vdda
$V_{refTemp}$	Reference Voltage Temperature Offset	-100	100	ppm	over full operating temperature
AD_{et}	ADC Total Unadjusted Error		±2	LSB	typ. ±1.3
AD_{eo}	ADC Offset Error		±1.5	LSB	typ. ±1
AD_{eg}	ADC Gain Error		±1.5	LSB	typ. ±0.5
AD_{et}	ADC Differential Linearity Error		±1	LSB	typ. ±0.7
AD_{el}	ADC Integral Linearity Error		±1.5	LSB	typ. ±0.8
T_{cal1}	Temperature Calibration Value 1	25	35	°C	tested value
T_{cal2}	Temperature Calibration Value 2	105	115	°C	tested value
T_{lin}	Temperature Sensor Linearity Error		±2	°C	typ. ±1°C

5.3 Amplifier characteristics

	Parameter	Min	Max	Units	Remarks
I_{bc}	Input Bias Current at 25°C		±1	pA	typ. ±0.25
I_{bc}	Input Bias Current at 85°C		±25	pA	typ. ±8
V_{noise}	Input Noise Voltage		85	nV/√Hz	at 10 Hz
V_{offs}	Input Offset Voltage		80	μV	typ. 15 μV
Acc	Amplification Accuracy		±0.6	%	25 ppm/K

5.4 Noise characteristics

Parameter	Typ.	Remarks
Overall noise density, 10^3 to 10^7 amplification	≤ ±1 Digit	
Overall noise density, 10^8 amplification	≤ ±2 Digits	

5.5 Sources of errors

While the amplifier and ADC stage have a rather high absolute accuracy and low thermal drift, the photodiode is subject to a higher tolerance. Refer to the data sheets of the photodiode used in PhotonWarrior28A2 for more information.
Mechanical offset relative to the light source can also cause variations in the absolute values measured. Calibration in the actual setup is advised.

6. Ordering Information

PhotonWarrior28 A2 - 01 - USB

Product family

Interface

Specific type	
A2	6 amplification factors

Photodiode	
00	Custom
01	BPX65

Partname	Order Code	Description	Package
PhotonWarrior28A2-01-USB	PW28A2-01-USB	Standard part equipped with BPX65 and USB cable	case

6.1 Shipping info

PhotonWarrior28A2 is shipped in a carrying case.

6.2 USB VendorID and ProductID

By default all PhotonWarriors are shipped with the USB VendorID of Code Mercenaries (0x7C0 or decimal 1984).
The ProductID for the standard PhotonWarriors are:
PhotonWarrior28A2 0x1185

6.3 Serial numbers

The serial numbers are factory assigned and can neither be changed by the customer nor ordered specifically.

7. ESD Considerations
PhotonWarrior has an internal ESD protection to withstand discharges of more than 2000V without permanent damage.
For the typical office environment the 2000V protection is normally sufficient.

8. Revision History
The current shipping version of PhotonWarrior28A2 is V1.0.2.5

V1.0.2.5 - Initial release version

8.1 Document Revision History
V1.0.0.1 Corrected semiconductor material identification in chapter 4.5.

V1.0.0.0 Intial release

9. RoHS conformity
PhotonWarrior28A2 conforms to the requirements RoHS.

10. CE conformity
PhotonWarrior28A2 is CE compliant

Legal Stuff

Code Mercenaries
Hard- und Software GmbH
Karl-Marx-Str. 147a
12529 Schönefeld
Germany
Tel: +49-3379-20509-20
Mail: support@codemercs.com
Web: www.codemercs.com

HRB 9868 CB
Geschäftsführer: Guido Körber, Christian Lucht

WEEE: DE 51974060