## Product Document

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#### **AMS** Shaping the world with sensor solutions

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#### AS7024 Eval Kit 1v2

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### Introduction





The AS7024 Eval Kit is designed to evaluate all functions of the AS7024 biosensor and test them in various applications.

For full flexibility, biosensor (AS7024), temperature sensor (AS6200), accelerometer (LIS2DH12) and electrodes are located on the break out board, which can be used in any application and reconnected to the main board via FPC cable. There is also the option to attach different electrodes.

After breaking off the Board it is also possible to connect the Add-On Board with the FPC cable or the Wristband with the PicoBlade connector.

The Eval Kit works with USB connection to the PC and comes with a GUI, which enables the user to change AS7024 register settings and see measurement results.

The SDK currently containing algorithms for HRM and HRV (GSR and BP will be available in the near future) is supplied with the Eval Kit and flashed onto the STM32 ARM Cortex-M4 low power MCU.

Any signals important for development can be probed easily at the pin headers.

#### How to use





- 1) Install the SDK on your computer
- 2) Start the PC GUI
- 3) Connect the Micro USB to USB cable to the Eval Kit and plug it into your computer
- 4) The green power LED will turn ON as soon as the board is powered
- 5) The green AS7024 LEDs will turn on
- 6) Hold the ECG INP and reference electrodes with pointer and middle finger of your left hand, put the pointer finger of your right hand on the ECG INN electrode and the middle finger of your right hand on the AS7024 to measure
- 7) The raw pulse and ECG data will be displayed in the GUI

### Safety Requirements



The AS7024 Eval Kit is supplied by USB connection to the PC. In order to avoid a direct connection from the electrodes to the power grid, an IEC 60601 compliant RECOM DCDC converter (R0.25S-0505/H) is assembled on the board as well as isolator ICs for any other signals, which means that there is no physical connection between the break out part of the board and the power grid.



### Buildup Top Side





Connection for External ECG REF Electrode Connection for External ECG INN Electrode Connection for External ECG INP Electrode

### **Buildup Bottom Side**





Connector for Break out Board Hirose FH12A-10S-0.5SH(55) Top Contact

#### **Glass Holder**





Mount glass holder on PCB
 Insert glass into holder

Bottom contact, 10 contacts





1) Break off the board at the break out line

2) Connect the mainboard to the Break-off Board (connector on rear side) by the FPC cable

3) It is *not* required to twist the cable, since one connector is a bottom contact connector and the other one is a top contact connector

Top contact, 10 contacts

#### Add-On Board





Hirose PN: FH12-10S-0.5SH(55), Bottom contact, 10 contacts

FPC Cable Molex PN: 15020-0105, 10 contacts



Pin 1 – 3V3\_ISO Pin 2 – 4V75\_ISO Pin 3 – 3V3\_ISO Pin 4 – 3V3 ISO Pin 5 - I2C1\_SDA\_ISO Pin 6 – I2C1\_SCL\_ISO Pin 7 – AS7024\_INT\_ISO Pin 8 – AS7024 GPIO ISO Pin 9 – AS7024\_EN\_ISO Pin 10 – GND\_ISO

> Temperature sensor AS6200

Vertical orientation, 10 contacts **BOTTOM SIDE** ams Biosensor Node

Connector for FPC cable Hirose FH12-10S-0.5SV(55),

> Test points to connect external electrodes

Accelerometer LIS2DH12



### Wristband





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- Connect the evaluation board to your computer using a Micro USB cable – the board will register as virtual COM board in Windows.
- The green power LED will turn ON as soon as the board is powered
- Select the correct COM port in the in the selection box in the lower left corner of the application. If no COM ports are listed click on "Refresh COM ports" button
- Use the "Connect" button to start up a connection to your board. The two status fields in the bottom status bar will turn green upon successful connection
- 5) After pressing the "Start" button the measurement of PPG and ECG starts.
- 6) Touch the ECG INP and reference electrodes with index and middle finger of your left hand, put the index finger of your right hand on the ECG INN electrode and the middle finger of your right hand on the AS7024 to measure



#### **AS7024 Configuration Settings**

At power up the board starts with default a configuration:

- The two green LEDS LED1(VD1) and LED2(VD2) are enabled, the LED current set to 50 mA
- Sequencer period set to 2000 microseconds
- Photodiode Trans-Impedance amplifier (TIA) is on and used
- All filters are on and used
- ADC is set to measure only the optical front end 1 after the gain stage (ofe1)

The individual settings of each of the AS7024 blocks can be viewed/changed in the dedicated configuration sub menu (see next slides)





#### **AS7024 Configuration settings**



To enter the submenus press the corresponding button

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#### **LEDs Configuration**



LED current and LED mode can be set in the "LEDs configuration" window. It is recommended to configure the current only when the output is not active as there is no latch implemented to keep the 10 bits consistent. New values are applied directly and immediately.



#### **TIA Configuration**

Photocurrent Amplifier

Enable

2

The TIA has to be configured according to the information in the AS7024 datasheet (table in figure 30).

It is recommended to **always** set "OpAmp Offset" to 15.

 $\times$ 

?

OpAmp Compensation

Cancel

Threshold high Resistor value 1064mV 7 MOhm Threshold Low Capacitor value -371mV Mode OpAmp Offset Normal 15 If seg itg is set

0

OK



pd ampres



#### **Photodiodes Configuration**



Select the photodiodes which to connect to the TIA input. The offset current is optional, this allows cancellation of constant light sources like sunlight. Default for the input offset current is 0 for both – LEDs off and any LED on.

For an external photodiode or any other sensor with (low) current output, the pins GPIO0 and GPIO1 can be used as input.

The sequencer controls the diodes – see diode\_ctrl described in register MAN\_SEQ\_CFG.

Photodiodes Config	uration	?	×
✓ Enable PD1	<ul> <li>Enable</li> </ul>	PD4	
✓ Enable PD2	Enable	gpioo (pi	D_10)
✓ Enable PD3	Enable	PD_B (PD	_l1)
Input offset current			
LEDs off 0 nA	LED on	11	0 nA
	ОК	Ca	ancel





#### Synchronous demodulator

**OFE Configuration** 

The AS7024 has two optional synchronous demodulators that can be used to detect small optical signals in the presence of large unwanted noise (ambient light). They have an input filer (the Prefilter block on the schematics - high pass at 200Hz, adjustable low pass) and a 2nd order adjustable output low pass (ofe\_gs\_aa). The demodulator itself multiplies the signal by +1 / 0 / -1 with a timing which is controlled by the sequencer.

#### **High Pass Filter**

Two optional high pass filters can be used to remove DCcomponents from the signal and allow further amplification - four cutoff frequencies can be chosen.

#### **Gain Stage**

Two optional gain stage can be used to amplify the signal after the DC-component has been removed.



#### **OFE Configuration**

Check OFE1 and/or OFE2 check box to enable the corresponding OFE block shown on the previous slide.

The "Prefilter" tab is setting the configuration of the input filters of the two synchronous demodulators. For reference, please see OFE\_CFGA, OFE\_CFGB, OFE\_CFGC and OFE\_CFGD register descriptions in the AS7024 datasheet.





#### **Light to Frequency Configuration**



Light to frequency can be used to convert a light source into a frequency signal. Several settings can be done. For details check the AS7024 datasheet.

The following registers can be shown/configured in the dialog: ITIME, LTF\_CONFIG, LTF\_SEL and LTF\_GAIN. When selecting sensor diodes for LTF0/LTF1, make sure the selected diode is not connected to the TIA at the same time (its checkbox in the "Photodiodes" window should be unchecked), currently the SW will not take care of that.

Integration time 3.072 ms	Integration time unit
	Normal, LSB=3.072ms
Continuous integration	Gain
Automatic autozero	0.25 👻
Run in FIFO mode	Sensor diode for LTE0
Counter running	A
Chanel 0 OpAmp offset	Sensor diode for LTF1
0	A
Chanel 1 OpAmp offset	
0	Autozero channel 0
	Autozero channel 1



#### **Electrical Analog Frontend Configuration**



The electrical analog front end consists of three identical signal paths with independent settings of bias condition, gain and offset.

Here the EAF\_CFG, EAF\_GST, EAF\_BIAS, EAF\_DAC and EAF\_DAC\_CFG registers are set.





#### **ECG Amplifier Configuration**



The ECG (electrocardiography) amplifier is a high impedance, low noise instrumentation amplifier with analog circuitry to band pass filter the signal and amplify it before converting it with the ADC.

The ECG signal can be used independently or together with PPG in further computation. (eg. Blood pressure)

ECG Configura	tion		? ×
<ul> <li>Enable ECG amp</li> <li>Enable leakige of</li> <li>Enable reference</li> </ul>	olifier compensation ce feedback amplifier		
Low pass filter	Gain stage	Leads detection	High pass filter
<ul> <li>Enable</li> <li>Bypass</li> </ul>	<ul> <li>Enable</li> <li>Bypass</li> </ul>	Enable Sync to ADC Polarity	✓ Enable Bypass
Frequency	Gain	Current	Frequency
80Hz 🔽	16 💌	20nA 🕆	Filter=1953Hz, Cutoff=5.28Hz
			OK Cancel



## AS7024 PC Software ADC Configuration



The ADC is a 14bit successive-approximation register (SAR) type. It supports 14bit with conversion time up to 50ksps.

At the output of the ADC converter a digital threshold can be enabled. If the output of the ADC exceeds the threshold adc\_threshold, it triggers an interrupt. This mechanism can be used to identify if an object is in proximity of the sensor and then to interrupt the host. In cases where no object is detected, the host can be sleeping therefore reducing power consumption of the system.

For detailed description of the threshold calculation see the register ADC\_THRESHOLD and ADC\_THRESHOLD\_CFG description.









In order to synchronize the LED-currents, the integration time and the ADC-sampling time, a built in sampling Sequencer is used. The sequencer generates the 8 bit-timings based on a 1µs clock. The input clock can be pre-scaled with the "Clock divider" (SEQ\_DIV register). The sequencer will trigger the ADC do a measurement of its enabled channels (configured in the "ADC Configuration" dialog) with a period of (Period \* (Clock divider +1) \* 1µs. For the default configuration this gives a period of 2000 µs.

<ul> <li>Enable sequ</li> </ul>	encer							
Clock divider	Period	LED driver		Synchronous demo	odulator 1	Synchronous demo	odulator	2
9 Measurements	Subsampling	Start time	Stop time	Positive start time	1	Positive start time	0	
0	0	1	50	Positive stop time	40	Positive stop time	0	
Enable manual mode	Secondery Start time	LED timing Stop time	Negative start time 126		Negative start time	0		
Ultra low por	always wer mode	0	0	Negative stop time	165	Negative stop time	0	
ADC		Integrator		Diode control				
Sampling ti	ime 180	Start time	Stop time	PD1-PD4 conne	ected			
2nd sampling ti	ime 0	1	0	Sync PD1 to LE	ED1, PD2 to LE	ED2, PD3 to LED3, PD4 to L PD3 and PD4 to LED2	.ED4	
3d sampling ti	ime 0			Sync PD1 and	PD2 to LED1,	PD3 and PD4 to LED4		
Sart sequen	cer					OK	Can	cel

#### **Interrupts Configuration**

An interrupt output pin INT can be used to interrupt the host. The following interrupt sources can be selected:

- ADC: End of ADC conversion
- Sequencer: End of sequencer sequence reached.
- LTF: A light-to-frequency conversion is finished.
- ADC threshold: ADC threshold triggered see ADC threshold.
- FIFO threshold: FIFO almost full (default is each sample triggers an interrupt)
- FIFO overflow: FIFO overflow (error condition, data is lost
- Cipdetect: TIA output and/or SD output exceeded threshold
   – see details in CLIPSTATUS
- LED supply low: led supply low comparator triggered see details in LEDSTATUS

🗱 Dialog		?	×
LED low suppl	у	ADC thres	hold
Clipdetect		LTF	
FIFO overflow		Sequencer	
✓ FIFO threshold		ADC	
Γ			
	OK	Cano	cel



#### **GPIOs Configuration**

To set a GPIO to analog mode check the check box from the "GPIO mode" group box. If left unchecked, then the GPIO is a digital output or input, depending on the state of the "GPIOx enable output" check boxes - unchecked means the pin is digital input. If the pin is set as digital output, it's state can be set via the corresponding check box in the "Output state" group box.







#### Additional ADC channels and Light-to-Frequency data display

To display a data plot of an ADC channel other than OFE1 and ECG Output, click on menu "View  $\rightarrow$  ADC Channels" and then on the desired ADC channel.

For Light-to-Frequency data output, click on "View  $\rightarrow$  LTF". A separate plot window will open.

Soon Soon Soon Soon Soon	AS7024 Vital Sign Sensor			
File	View Settings	Help		
i k	Register Map			
	ADC Channels	•	TIA	1
	Ma LTF		Pregain	
			OFE1	
	LEDs		SD1	
			OFE2	
	TIA		SD2	
Г	Photodiodes		ECG input	
			ECG output	
	OFE		Electrical analog frontend	
			GPIO2	
	Light to frequency		GPIO3	
	Electrical analog frontend	-	Temperature	
	ECG amplifier		5	2

#### **Register map**

The "Register Map" window is used to view/change the contents of the complete set of AS7024 user register. To open it, click on the "View  $\rightarrow$  Register Map" menu.

Changing a register value can be done either by modifying its value in the relevant "Value" field or by toggling a bit by clicking on the relevant bit cell. Changing a value in the register map will not update the current selection in the configuration windows of the GUI. Also, a change in any of the configuration windows will not trigger an automatic update of the already opened register map window. To update the values, click on the refresh button marked with the orange rounded rectangle on the "Register Map" picture on the right.



I Register Map							_			×
View										amırı
e l										
	Addr.	7	6	5	4	3	2	1	0	Value 🔷
CONTROL	0x00	1			0			1	1	0x83
GPIO_A	0x08					1	1	1	1	0x0F
GPIO_E	0x09					0	0	0	0	0x00
GPIO_O	0x0A					0	0	0	0	0x00
GPIO_I	0x0B					0	0	0	0	0x00
GPIO_P	0x0C	0	0	0	0	0	0	0	0	0x00
GPIO_SR	0x0D					0	0	0	0	0x00
GPIO_T	0x0E					0	0	0	0	0x00
LED_CFG	0x10		1	0	0	0	0	1	1	0x43
LED1_CURRL	0x12	1	1							0xC0
LED1_CURRH	0x13	0	1	1	1	1	1	1	1	0x7F
LED2_CURRL	0x14	1	1							0xC0
LED2_CURRH	0x15	0	1	1	1	1	1	1	1	0x7F
LED3_CURRL	0x16	0	0							0x00
LED3_CURRH	0x17	0	0	0	0	0	0	0	0	0x00
LED4_CURRL	0x18	0	0							0x00
LED4 CURRH	0x19	0	0	0	0	0	0	0	٥	0x00

#### Saving current configuration settings to a file

Sensing is life.

The current configuration settings can be exported to a file. To do this, click on the "File  $\rightarrow$  Save Configuration" menu. This will open the "Save Configuration File" dialog box on the second picture on the right. Enter file name and choose the file location, then click "Save".

MS7024 Vital Sign Ser	isor					
File View Settings	Help					
Save Configuration						
Load Configuration						
Export Dow Data						
Export Raw Data						
Exit						
	PPG		hannol			
Save Configuration File						>
+ + 🕆 🦲 « Program Files (	(x86) > ams > AS7024_Vital_	Sign_Sensor + configuration	15	✓ ð Search cont	liguntions	p
Organize - New folder						0
This PC Name		Date modified	Туре	Size		
Desktop 🗋 defai	ult	18.03.2018 14:02	file	1 KB		
Documents		11.04.2018 10:01	File	1.KB		
🕹 Downloads 🗌 PP9-	ecg	22.03.2018 23:35	File	1 KB		
Music						
Fictures						
Videos						
Local Disk (Ci)						
softwarepool (\\     m sont 0) foundata						
epol (\\fuguedata						
= xsite (\\fsupdata						
Metunde V						
File name						
Save as type:						
				· · · · · · · · · · · · · · · · · · ·	- 17	
Christeller				1 million (1997)	- Conned	

#### Loading configuration settings from file



To load a previously exported configuration settings, click on the "File  $\rightarrow$  Load Configuration" menu. This will open the "Select Configuration File" dialog box. Select the configuration file from which to load settings and click "Open" button.

The settings imported from the file can be reviewed in the relevant configuration windows.

If the GUI is connected to the board, the newly imported settings will be applied immediately, otherwise upon successful connection to the board.

888 ACT024 VII-LC								
AS/024 Vital S	ign Sensor							
File View S	ettings He	elp						
Save Configu	ration							
Load Configu	ration							
Export Raw D	ata							
Exit	-							
LAN		PPG		nnol				
LED	s	FF0-						
Select Configuration File								×
> 🛧 📙 « Pro	ogram Files (x86) »	ams > AS7024_Vite	I_Sign_Sensor > configuration	15	~ 0 -	Search configurations		9
Organize + New folde	er					Hes +		0
(S) ShareFile	Name	^	Date modified	Туре	Size			
This PC	default		18.03.2018 14:02	File	1 KI	à		
Desktop	last		11.04.2018 10:01	File	1 KE	1		
🔂 Documents	D ppg_wcg		E2103/2010 23:30	EHW.	1.64			
🕹 Downloads								
🔰 Music								
Pictures								
Videos								
Local Disk (C!)								
= eool (\\fsupdata								
public (\\fsupva								
🛖 xsite (\\fsupdata								
📣 Network 🗸 🗸								
File n	ame: ppg ecg							~
	[b.b.37===3					Open	Cancel	1
						Stheu	cancel	

#### Raw data logging and exporting



By default, during measurement the raw data from the AS7024 is logged in memory. When a measurement is stopped, this data can be exported to a comma delimited file by clicking on the "File  $\rightarrow$  Export Raw Data" menu and selecting the file location and file name in the save file dialog box.

Raw data file format:

- first raw has the column captions
- first column has the timestamp in milliseconds
- columns 2<sup>nd</sup> to the last have the data from the enabled ADC channels

Raw data logging can be disabled by unchecking the "Log raw data" check box in the "Settings" menu.

III AS7024 Vital Sign Sensor	
File View Settings H	lelp
Save Configuration	
Load Configuration	
Export Raw Data	
Exit	
LEDs	PPG - OFE1 ADC channel
TIA	15000



# Firmware Update over USB Starting in DFU mode



In order to update the FW over USB on the AS7024 Evaluation Board the MCU has to be started in DFU mode. To do so follow the steps below:

- Start the DfuSeDemo.exe from the "extras\DFU" folder located at the installation folder of the GUI (if not changed during installation should be "\Program Files (x86)\ams\AS7024\_Vital\_Sign\_Sensor".
- Connect a USB cable to the AS7024 Evaluation Board
- Press the button marked with yellow on the picture below
- Connect the USB cable to the computer whilst keeping the button pressed
- Release the button as soon as the device appears in the DfuSeDemo tool



# Firmware Update over USB Starting in DFU mode



If the MCU was booted in DFU mode successfully, the device will be listed and selected in the drop down menu under "Available DFU Devices".

The next step is to flash the new FW onto the MCU. Under "Upgrade or Verify Action" press the "Choose" button.

STM Device in DF	U Mode	•	Application Mod	e: DFU Mode:
<ul> <li>Supports Uplow</li> <li>Supports Down</li> <li>Can Detach</li> </ul>	ad 🗌	Manifestation tolerant Accelerated Upload (ST	) Procuct ID:	Procuct ID: DF11
Enter DFU mode/	'HID detach	Leave DFU mode		
Actions		123	Q	
Select <u>T</u> arget(s):	Target Id	Name	Available S	ectors (Double Click for more)
	00	Internal Flash	256 sectors	8
	01	Option Bytes	2 sectors	
	02	OTP Memory	1 sectors	
Upload Action		Upgrade or	Verify Action	
Upload Action File:		Upgrade or File: Vendor ID:	Verify Action	ts in file:
Upload Action File:	. <u> </u>	Upgrade or File: Vendor ID: pload Procuct ID:	Verify Action	ts in file:
Upload Action File: K Choose Transferred data	. U	pload Upgrade or File: Vendor ID: Procuct ID: Version:	Verify Action	ts in file:
Upload Action File: Choose Transferred data 0 KB(0 Bytes) of	size 0 KB(0 Bytes	Pload Upgrade or File: Vendor ID: Procuct ID: Version: Optimize	Verify Action Targe	ts in file: Remove some FFs)
Upload Action File: <u>Choose.</u> Transferred data 0 KB(0 Bytes) of Operation duratio	. U size 0 KB(0 Bytes) n 10:00:00	Upgrade or File: Vendor ID: Procuct ID: Version: Verify al Optimize	Verify Action Targe Iter download a Upgrade duration (Upg	ts in file: Remove some FFs) grade

# Firmware Update over USB Flashing the FW onto device



Select the .dfu file containing the new FW and click on "open".

After loading the .dfu file press the "Upgrade" button, which will be available.

The pop-up window shown in the figure below will then open. Click on "Yes" to continue.

	AC7034 Vital Size Same	022220	and all factors	1.16	
⇒ т 📙 « ams	AS/024_vital_sign_Sensor > firm	ware	V O Searc	:h firmware	م م
rganize 🔻 🛛 New folder				•	
ShareFile	Name	Date modified	Туре	Size	
This PC	as7024_fw_v410.dfu	06.04.2018 09:54	DFU File	60 KB	
Desktop					
Documents					
Jownloads					
👌 Music					
E Pictures					
Videos					
🏭 Local Disk (C:)					
🛫 softwarepool (\\					
🛫 epol (\\fsupdata					
🛫 public (\\fsupva					
🛫 xsite (\\fsupdata					
•			1.1		
	e: as7024 fw v410 dfu		✓ Dfu	Files (*.dfu)	~
File <u>n</u> am			1.1.1	and a second second second	



### Firmware Update over USB

#### Flashing the FW onto device

The flashing will start and the progress is shown as a green bar at the bottom of the tool. The process takes only a few seconds.

When finished the message "Upgrade successful" is shown.

Last and to finish the FW update, press "Leave DFU mode".

The AS7024 Evaluation Board is ready for use again.

🧼 DfuSe Demo (v3.	0.5)						
Available DFU Dev STM Device in DF Supports Uploa Supports Dowr Can Detach Enter DFU mode/ Actions	ices U Mode ad Manifesta nload Accelerat HID detach	▼ ation tolerant ted Upload (ST) DELL mode	Applic Vendo Procu Ver	cation Mode: or ID: ct ID: sion:	DFU Mode Vendor ID: Procuct ID: Version:	0483 DF11 2200	
Select Target(s):	Target Id     Name       00     Internal FI       01     Option By       02     OTP Mem	ash tes iory	;	Available Sectors 256 sectors 2 sectors 1 sectors	(Double Click	for more)	
Upload Action File: Choose Upload Transferred data size 55 KB(57280 Bytes) of 55 KB(57280 Bytes) Operation duration 00:00:09		Upgrade or V File: Vendor ID: Procuct ID: Version: Version: Optimize Choose.	/erify Act AS7024 0483 0000 0000 ter downl Upgrade	iion 4_SDK1.0.6_Brid Targets in fil 00 ST. 0ad e duration (Remov	SDK1.0.6_BridgeBoard.dfu Targets in file: 00 ST d luration (Remove some FFs)		
	Target	00: Upgrad	e succe	essful !			
Abort						Quit	







## Thank you!

Please visit our website www.ams.com