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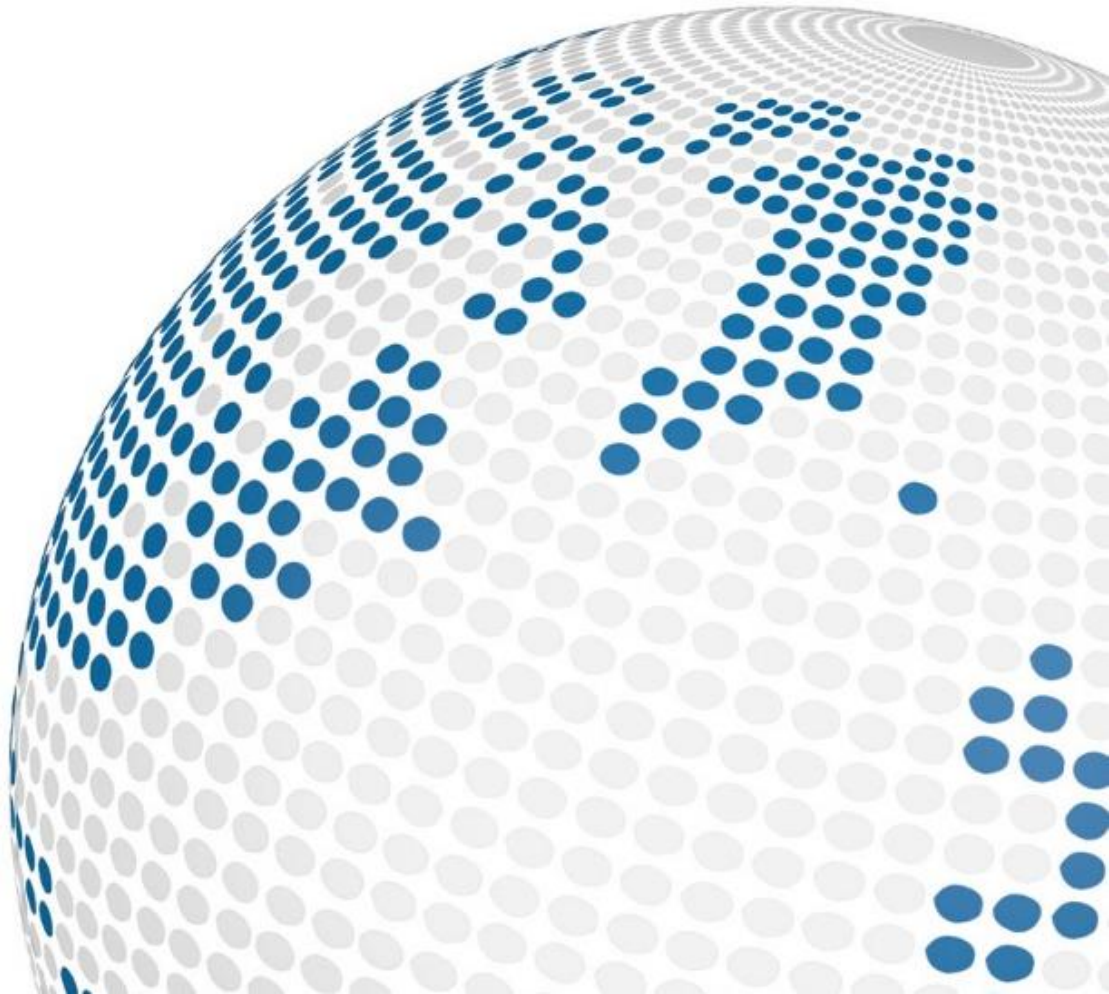
Shaping the world with sensor solutions

Gernot Hehn

April 2019



AS702x Design-in Guidelines

Power supply Scheme

IO Signals

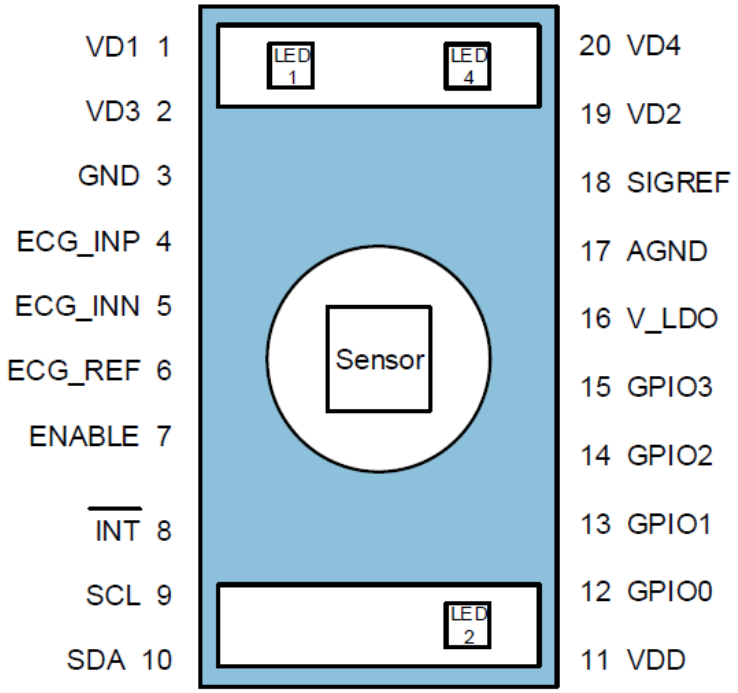
PPG Signal

ECG

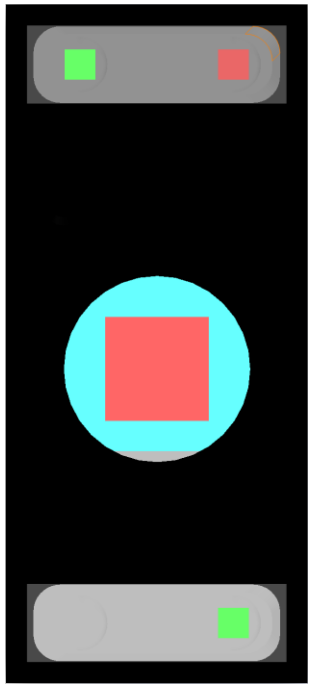
Optical-Mechanical Integration

AS702x

Overview



AS702x
Pin Description

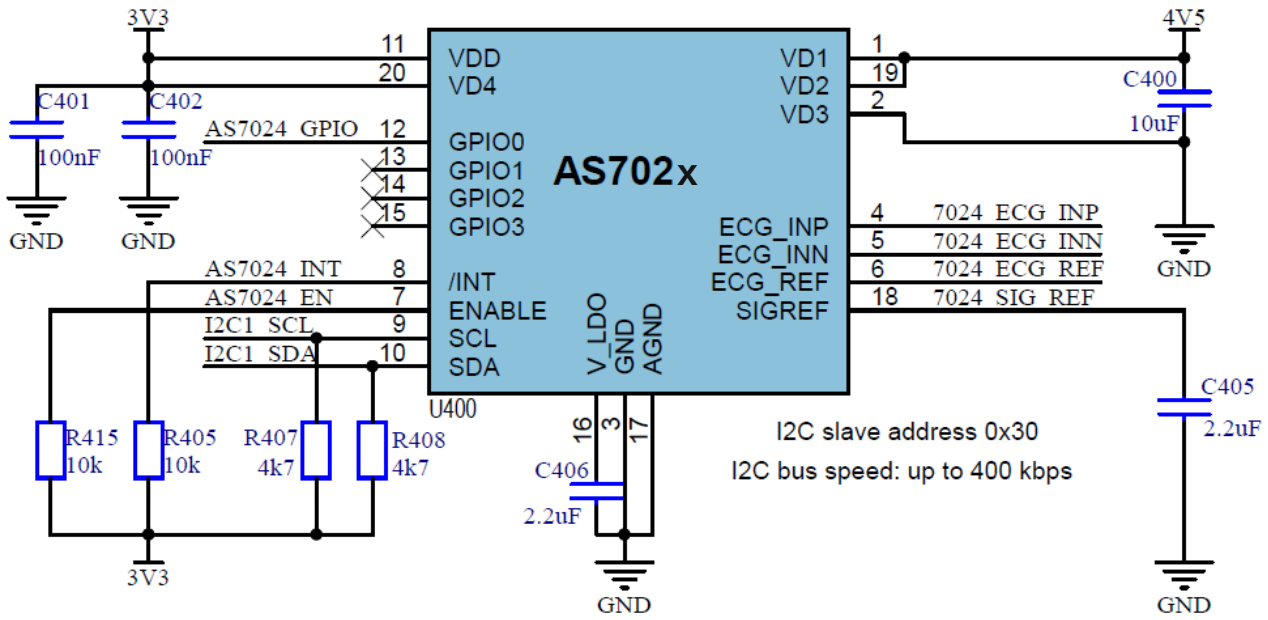


AS702x
3D-TopView

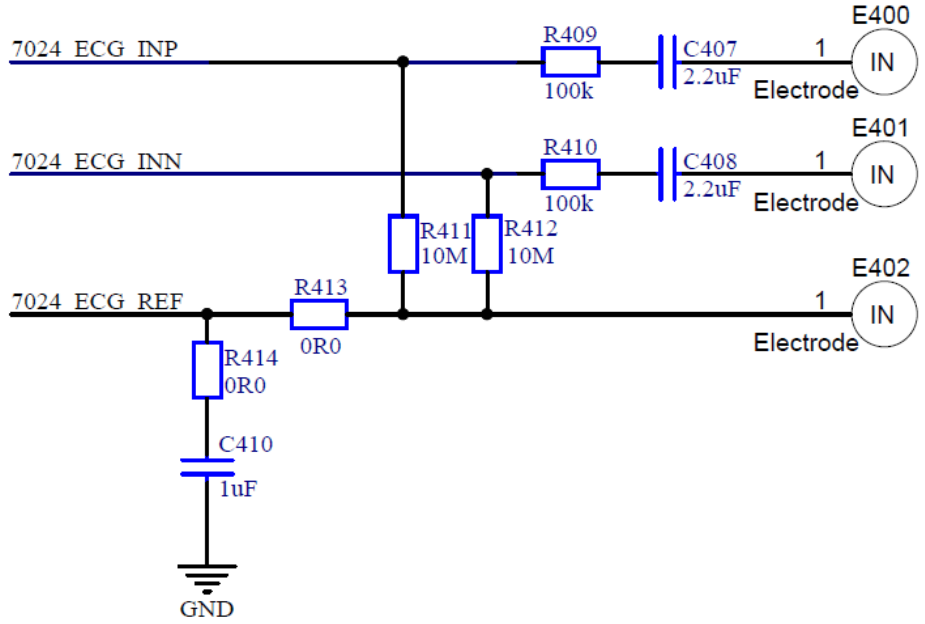
AS702x

Recommended design

AS702x design



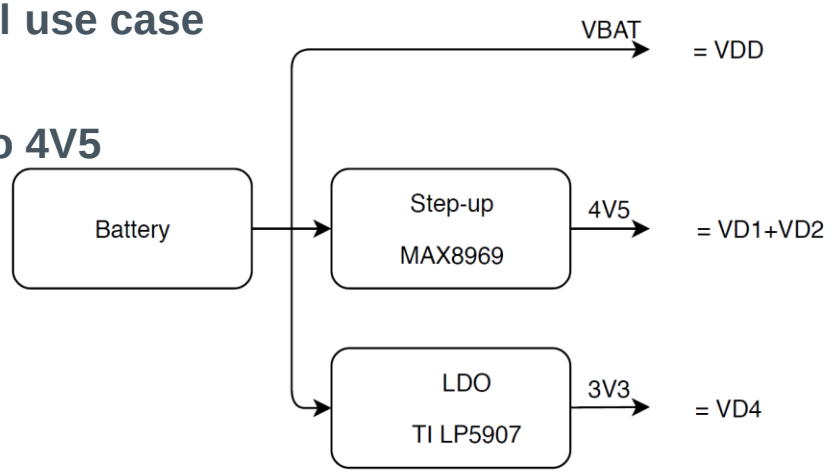
electrode design

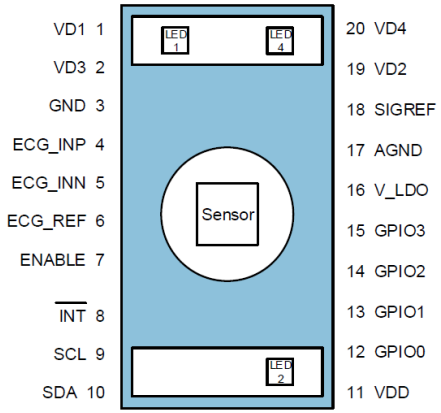


Power Supply Scheme

Pin description

- Battery supply with Step-up
- Battery supply with step up converter for the green LEDs is the typical use case
- The AS702x VDD pin is supplied by the battery directly
- The step up converter boosts the supply voltage for the green LEDs to 4V5
- Typically the MAX8969 is used as step up converter
- TI LP5907 is recommended as LDO
- USB supply with Isolator





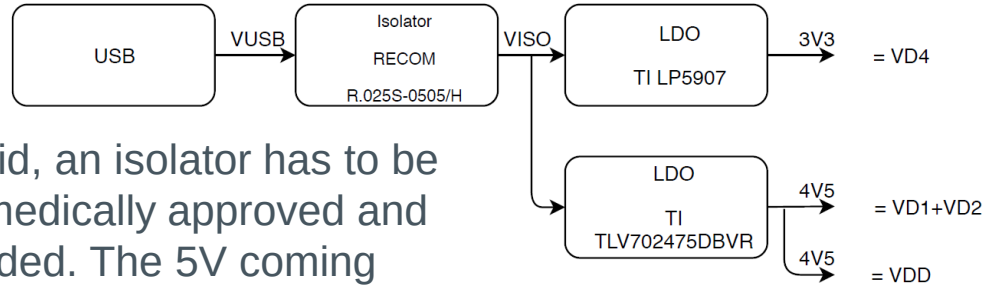
Pin No.	Pin Name	Description	Recommended Voltage [V]	Decoupling Capacitor [F]
1	VD1	Supply Voltage for LED D1 (Green LED)	4V5	10u to GND
2	VD3	Connection to current sink 3 (GND)	connect to GND	-
3	GND	Power Supply ground	connect to GND	-
11	VDD	Supply Voltage for AS7024	2V7 - 5V5	2.2u to GND
16	V_LDO	1.9V output voltage. Connect 2.2uF capacitor to GND	connect to GND	2.2u to GND
17	AGND	Analog Ground. Connect to low noise GND	connect to GND	-
19	VD2	Supply Voltage for LED D2 (Green LED)	4V5	10u to GND
20	VD4	Supply Voltage for LED D4 (IR LED)	3V3	10u to GND

*Recommended design Schematics on Page 4

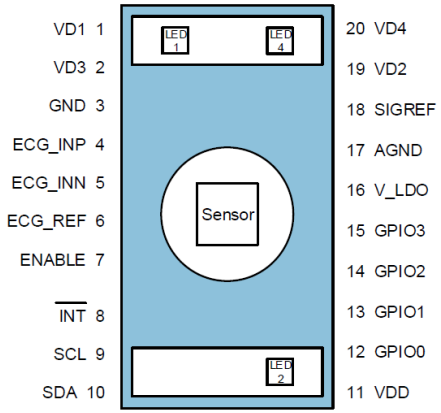
Power Supply Scheme

Pin description

- Battery supply with Step-up
- **USB supply with Isolator**



In case the AS702x is supplied by USB or voltage supply from the grid, an isolator has to be used in the power path as well as signal path. The isolator must be medically approved and provide at least 3kV isolation. RECOM R0.25S-0505/H is recommended. The 5V coming from the USB are converted to 4V5 by an LDO to supply the green LEDs and the AS702x VDD. TI LP5907 with fixed output voltage is recommended as LDO and another LDO converts the USB voltage to 3V3 for the IR LEDs.



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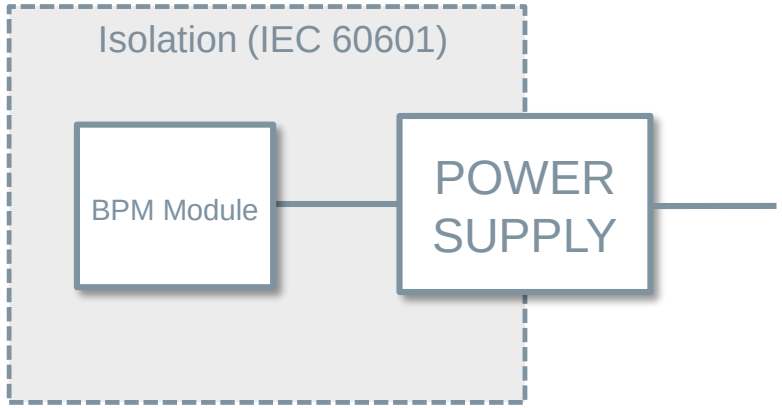
17	AGND	Analog Ground. Connect to low noise GND	connect to GND	-
19	VD2	Supply Voltage for LED D2 (Green LED)	4V5	10u to GND
20	VD4	Supply Voltage for LED D4 (IR LED)	3V3	10u to GND

*Recommended design Schematics on Page 4

Safety Requirements

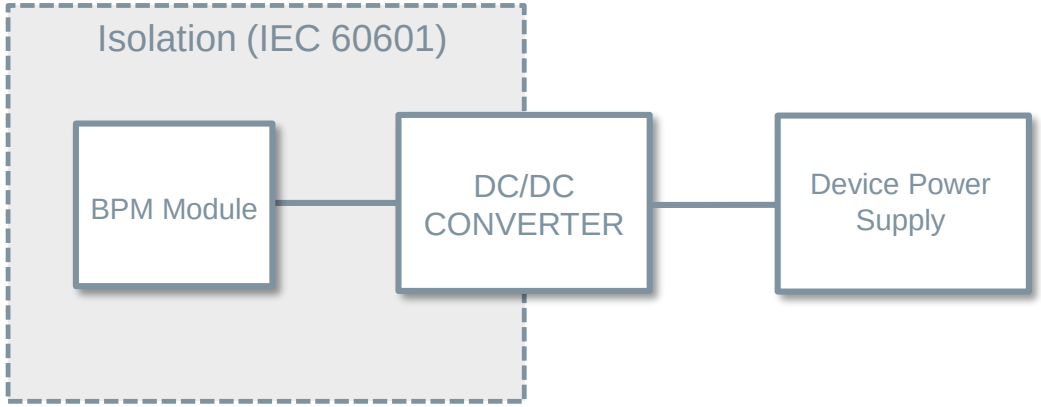
USB with Isolator

The power supply used to power the BPM Module must be IEC 60601 certified, if the end device is connected to a wall plug, in order to guarantee isolation from the electricity network when touching the electrodes.



Application option 1:

Device internal power supply compliant to IEC 60601 with separated ground.



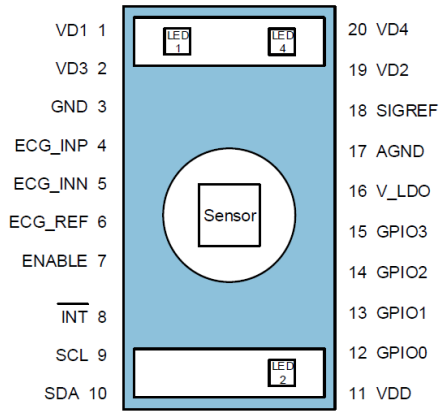
Application option 2:

Additional DC/DC-Converter (IEC 60601 certified), to power the BPM Module in the device.

IO Signals

Pin description

- After setting the pin ENABLE=1 the AS702x registers can be accessed by the I2C interface. Before enabling any additional function (current source, TIA, ADC…) set the bit ldo_en=1 to set the internal LDO to normal mode. For operating the ADC or the sequencer enable the oscillator by setting osc_en=1.
- An interrupt output pin INT can be used to interrupt the host.
- The AS702x includes an I2C slave using an I2C address of 0x30 (7-bit format; R/W bit has to be added) respectively 60h (8-bit format for writing) and 61h (8-bit format for reading). Fast mode (400kHz) and standard mode (100kHz) support.



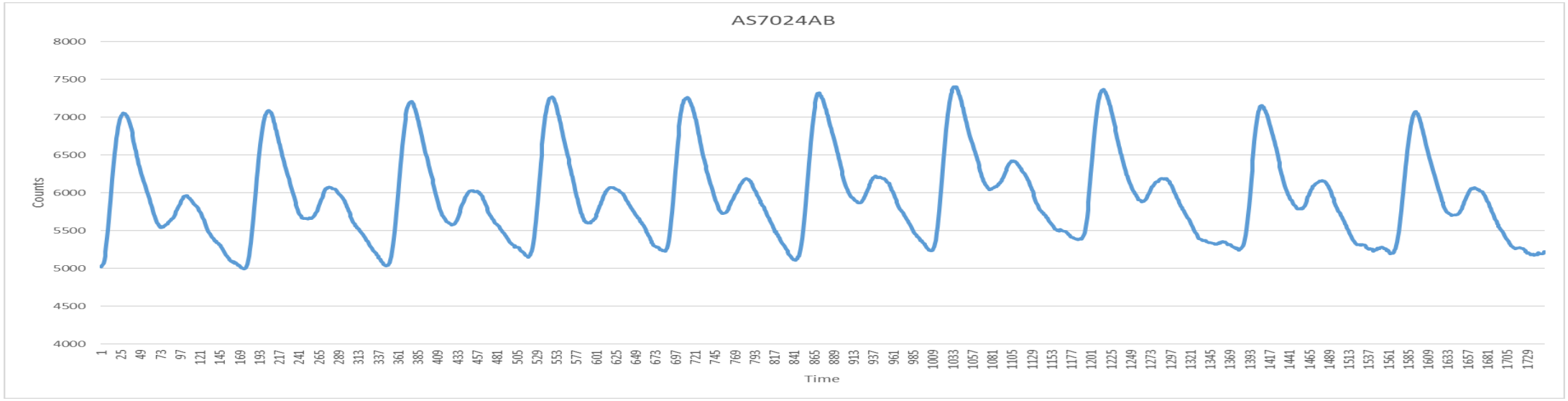
Pin No.	Pin Name	Description	Decoupling Capacitor [F]	Pull-up Resistor [Ohm]
7	ENABLE	Enable input for AS7024. Acitve High. If ENABLE is not used, connect to VDD	-	10k
8	INT	Open drain interrupt output pin. Active low.	-	10k
9	SCL	I2C serial clock input terminal	-	4k7 Resistor value depends on I2C bus
10	SDA	I2C serial data I/O terminal - open drain	-	4k7 Resistor value depends on I2C bus
12	GPIO0	General purpose input/output	-	-
13	GPIO1	General purpose input/output	-	-
14	GPIO2	General purpose input/output	-	-
15	GPIO3	General purpose input/output	-	-

*Recommended design Schematics on Page 4

PPG Signal

General Information

- Make sure your fingers are warm -> a pulse signal cannot be detected on cold fingers
- Do not press the finger too hard on the sensor -> if pressed to hard, the blood flow my be disrupted and no signal can be detected



PPG signal

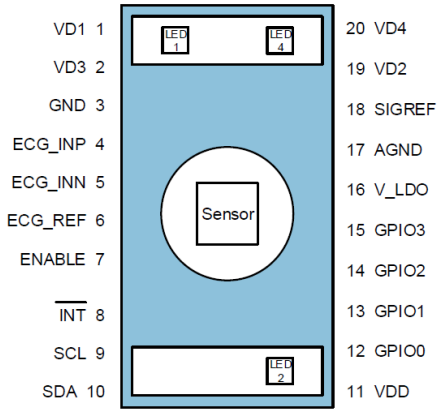
Counts vs Time

ECG

Pin description

- The ECG (electro cardiogram) amplifier is a high impedance, low noise instrumentation amplifier with analog circuitry to bandpass filter the signal and amplify it before converting it with the ADC.

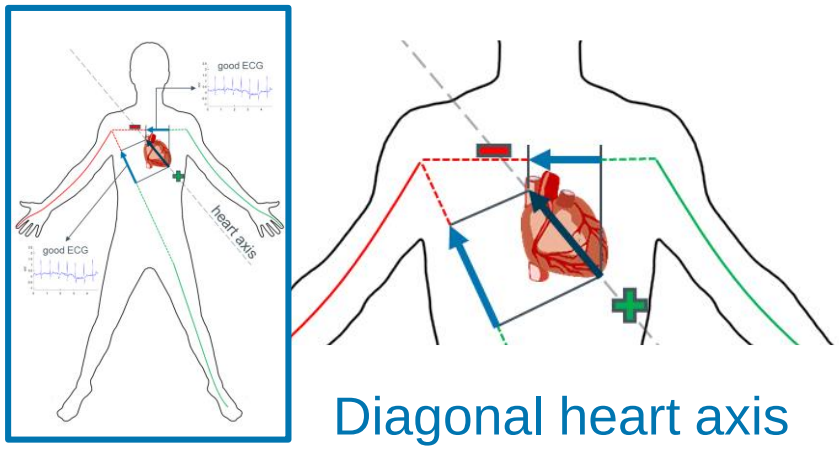
- The ECG lead OFF detection can be used for detection if the user actually touches the leads. It is a circuitry to measure the capacitor and/or resistance between the two lead inputs ECG_INP and ECG_INN.



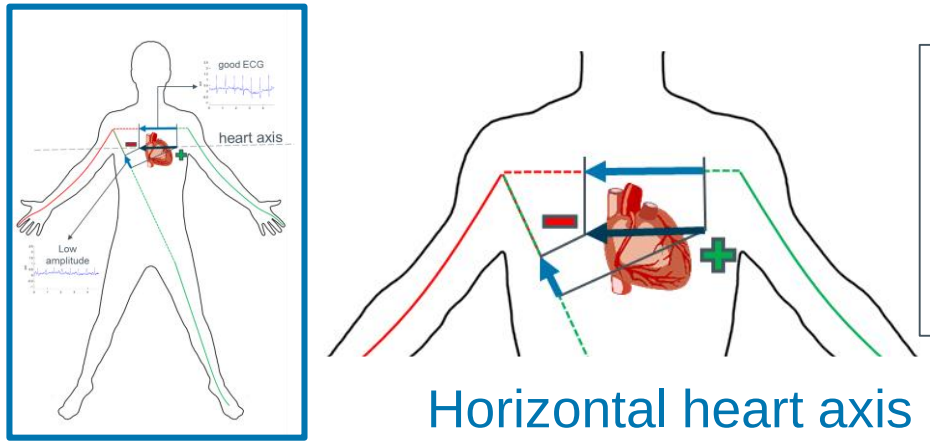
Pin No.	Pin Name	Description	Decoupling Capacitor [F]	Pull-up Resistor [Ohm]
4	ECG_INP	ECG amplifier positive input	2.2u in series 16V,5%,X7R Kemet C1206J225J4RACAUTO	100k in series 10M to ECG_REF
5	ECG_INN	ECG amplifier negative input	2.2u in series 16V,5%,X7R Kemet C1206J225J4RACAUTO	100k in series 10M to ECG_REF
6	ECG_REF	ECG amplifier refernce output	1u to GND	-
18	SIGREF	Analog reference output	2.2u to GND	-

*Recommended design Schematics on Page 4

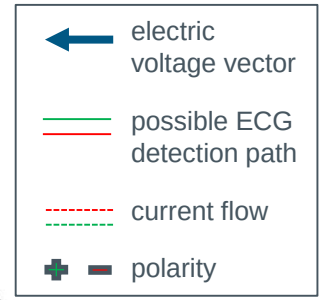
ECG Signal



Diagonal heart axis



Horizontal heart axis



- ECG recording is similar to voltage measurement in batteries
- The recorded amplitude depends highly on the orientation of the electrical heart axis relatively to the recording axis of the electrodes.
- There is considerable variation of the axis orientation even in healthy people.
- A reference electrode is used to filter out pick-up noise (common mode rejection)
- Make sure the electrodes are clean and do not have any kind of fat film on them
- The ECG signal may be too weak to be detected due to dry skin
- The signal strength of the ECG signal depends on orientation of the heart axis, which varies from individual to individual and may not be detectable in some cases

Signals

- Weak signals ranging from 0.5mV to 5.0mV
- High DC component of up to +/- 300mV (electrode skin contact)
- Common-mode component up to 1.5V (potential electrodes – ground)

Noise

- Power-line interference: 50-60 Hz
- Electrode contact noise (baseline drift)
- Motion artifacts (shifts in baseline)
- Muscle contraction
- Electromagnetic interference from other electronic devices (higher frequencies)

Electrode Properties

Recommendations

Electrodes

- Based on our measurements with 20 subjects, a skin-to-electrode resistance up to 350-400kΩ is recommended
- Based on this we recommend a round electrode of >14mm for each ECG contact.
- A differently shaped electrode with equivalent surface area is also possible
- A typical material to use would be stainless steel sheet electrodes (material 1.4301)

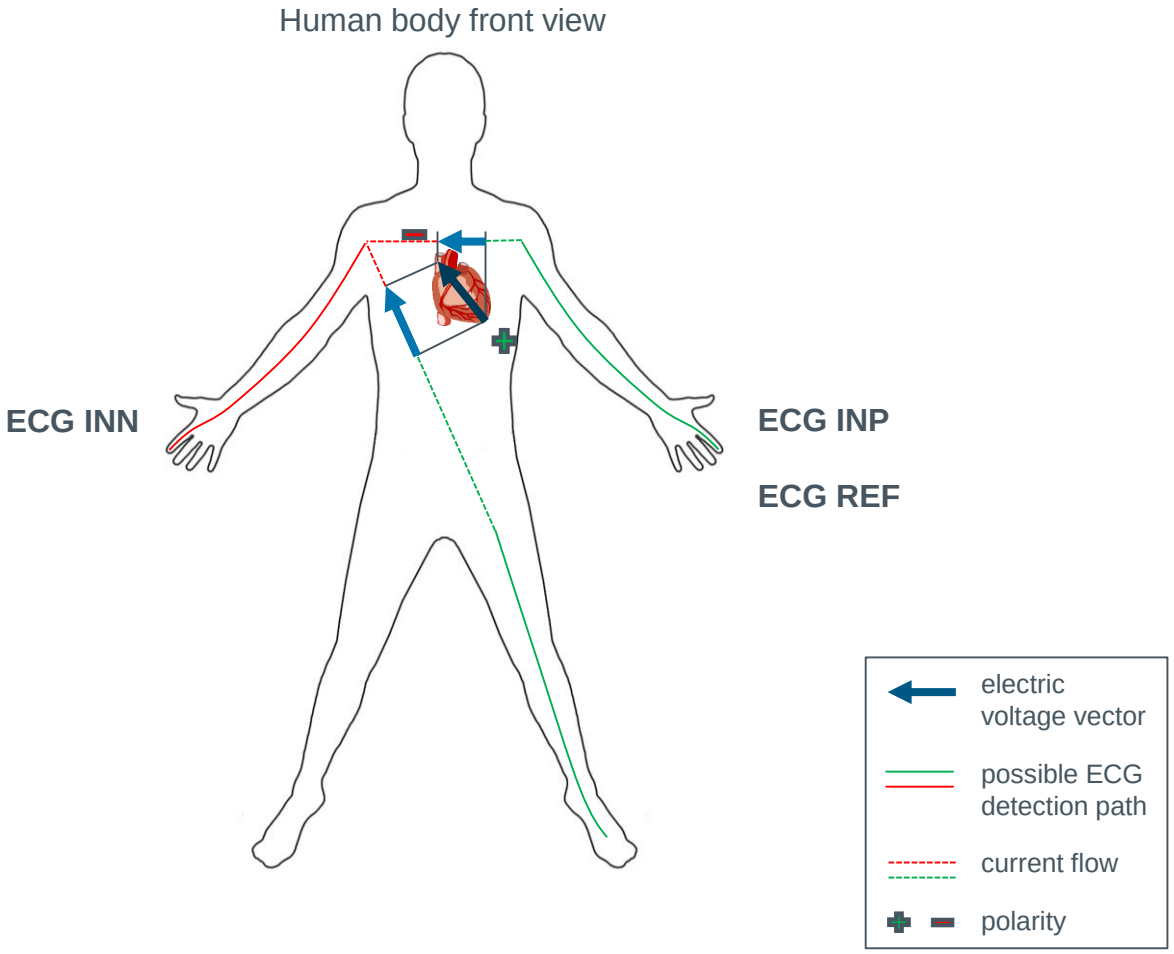
Electrode Cables

- For longer electrode cables (>20cm) or in EMC polluted environments a shielded cable is highly recommended
- The shield should be connected to GND

Electrode Connections

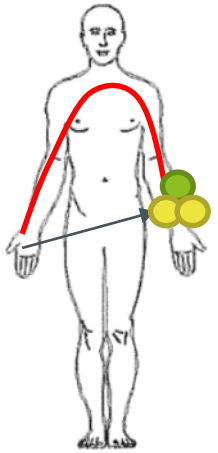
- Positive and negative electrode to detect ECG signal (across the heart)
- Reference electrode for common mode rejection

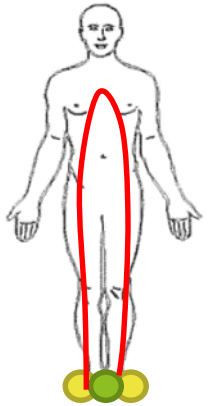
- ECG INN should be connected to the right hand of the user
- ECG INP and ECG REF should be connected to the left hand of the user
- ECG INP and ECG REF should not share an electrode but rather have individual electrodes that both connect to different parts of the left hand

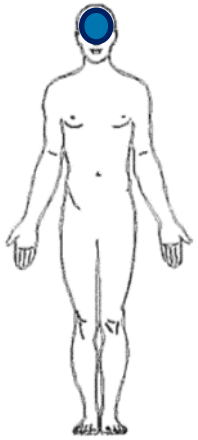


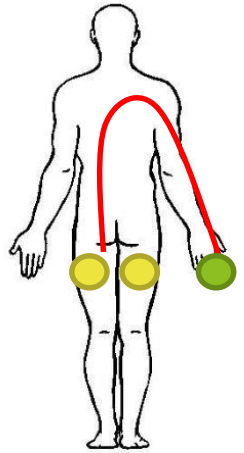
Electrode Positions

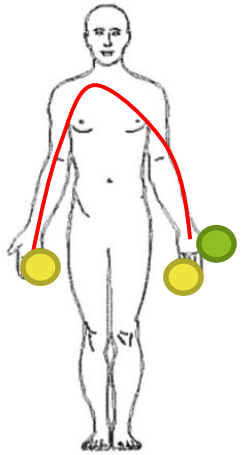
For various use cases











Electrode PPG Electrode + PPG

Optical-Mechanical Integration

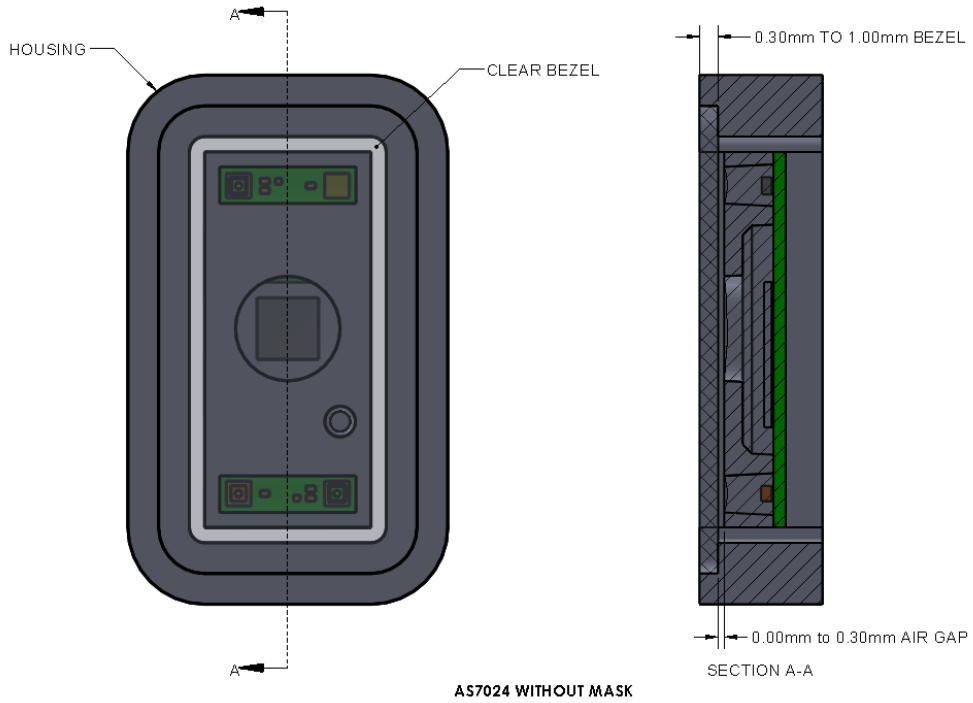
- No air gap between glass and skin
- Do not make glass thicker or air gap wider to keep optical cross talk low
- Signal gets stronger with increasing air gap, but also cross-talk increases and SNR decreases

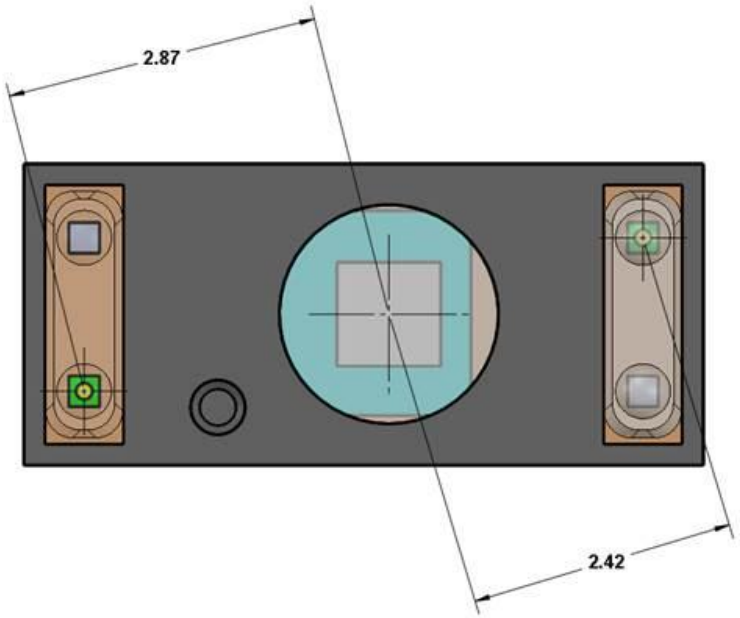
Glass or plastic disk (0.5 mm thick, Plexiglas)
Air gap to sensor 0 - 0.2 mm max)
AS702x (may be placed on a spacer to raise the component)

Optical Simulation

Cross-Talk vs Signal Strength

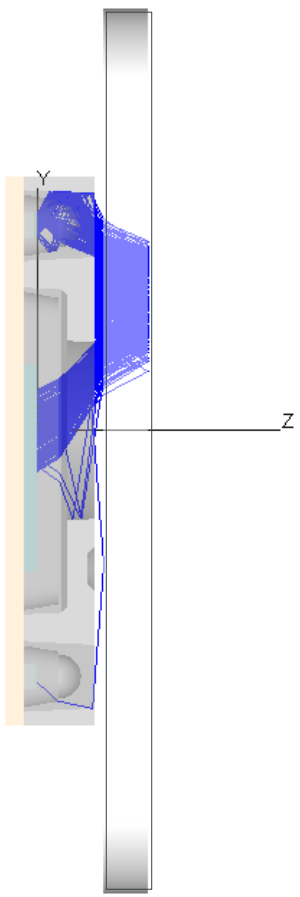
The simulation results shown here are just for reference and understanding of how the optical signal changes depending on air gap and cover thickness
The setup in this simulation
Separate simulations need to be run for every end device and
Note:
All simulations given represent ideal alignment and properties and do not take into account manufacturing tolerances or oil or dirt on glass.
cover material = clear polycarbonate
Simulation parameters: cover thickness 0.5mm to 1.0mm; air gap 0.0mm to 0.3mm
crosstalk criterion of SXR>4



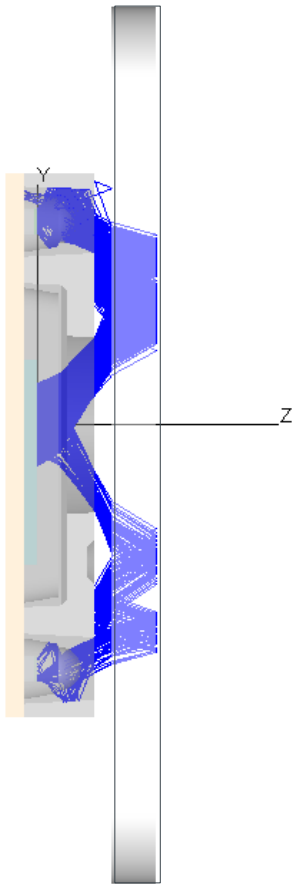


AS7024AB Simulation Results

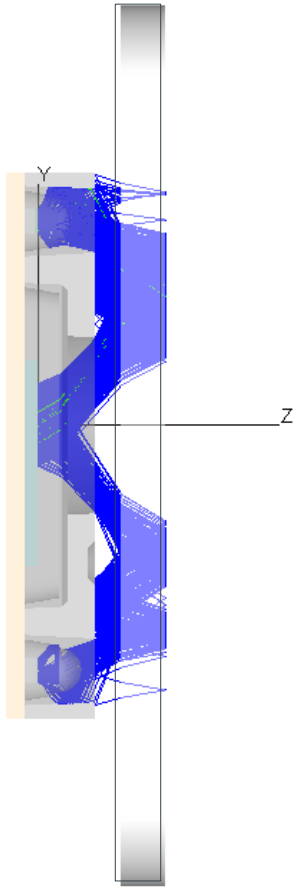
0.5 mm cover thickness



Airgap: 0.1mm



Airgap: 0.2mm

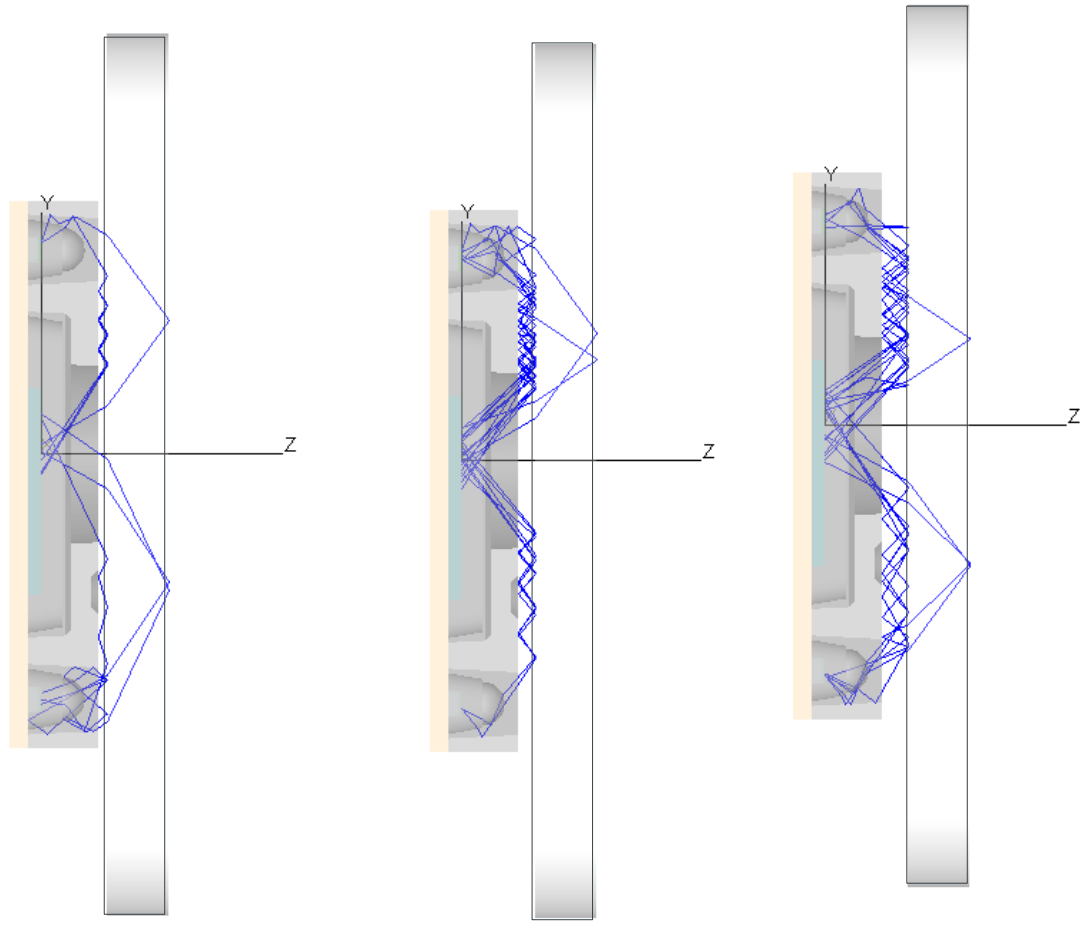


Airgap: 0.3mm

	COVER 0.5mm		
AIR GAP	SIGNAL	X-TALK	SXR
0.00MM	487,010.00	2,090.30	232.99
0.10MM	1,017,600.00	44,211.00	23.02
0.20MM	1,168,400.00	119,740.00	9.76
0.30MM	1,227,500.00	194,050.00	6.33

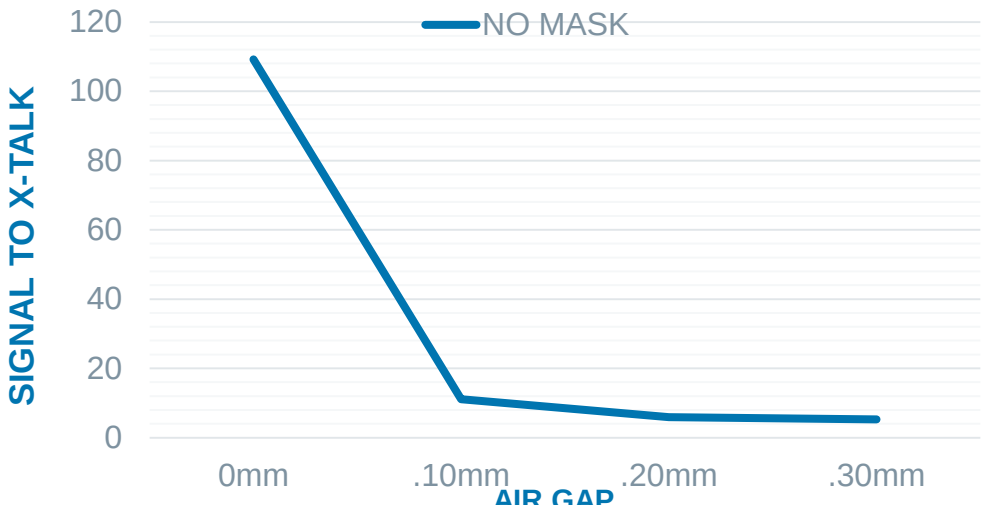
AS7024AB Simulation Results

0.7 mm cover thickness



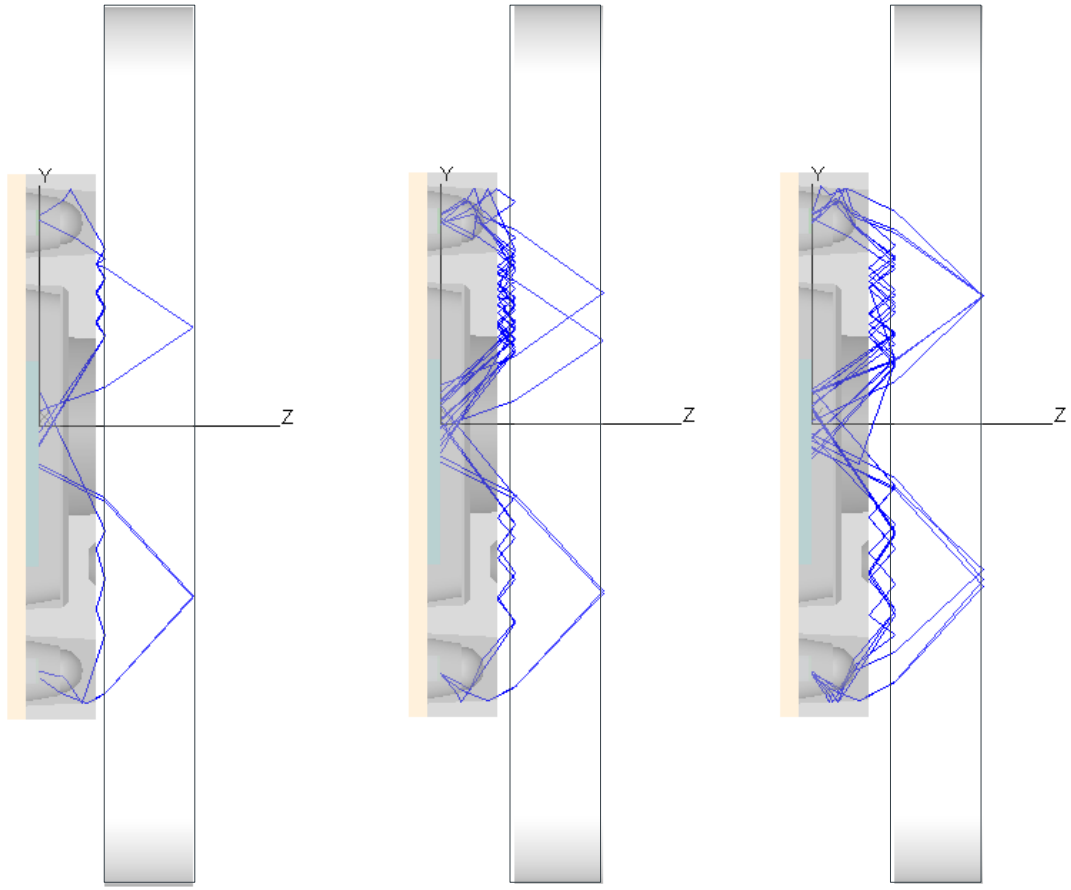
Airgap: 0.1mm Airgap: 0.2mm Airgap: 0.3mm

	COVER 0.7mm		
AIR GAP	SIGNAL	X-TALK	SXR
0.00MM	583,580.00	5,346.30	109.16
0.10MM	921,040.00	83,230.00	11.07
0.20MM	1,105,900.00	188,130.00	5.88
0.30MM	1,471,300.00	278,840.00	5.28



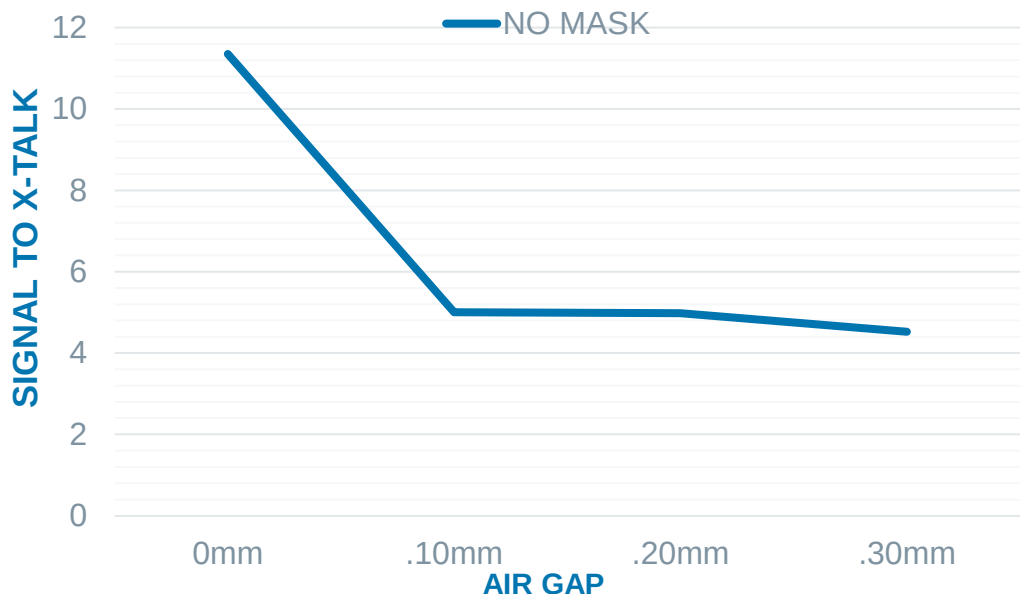
AS7024AB Simulation Results

1.0 mm cover thickness



Airgap: 0.1mm Airgap: 0.2mm Airgap: 0.3mm

	COVER 1.0mm		
AIR GAP	SIGNAL	X-TALK	SXR
0.00MM	623,150.00	54,883.00	11.35
0.10MM	1,021,600.00	204,130.00	5.00
0.20MM	1,279,400.00	257,050.00	4.98
0.30MM	1,364,700.00	302,110.00	4.52



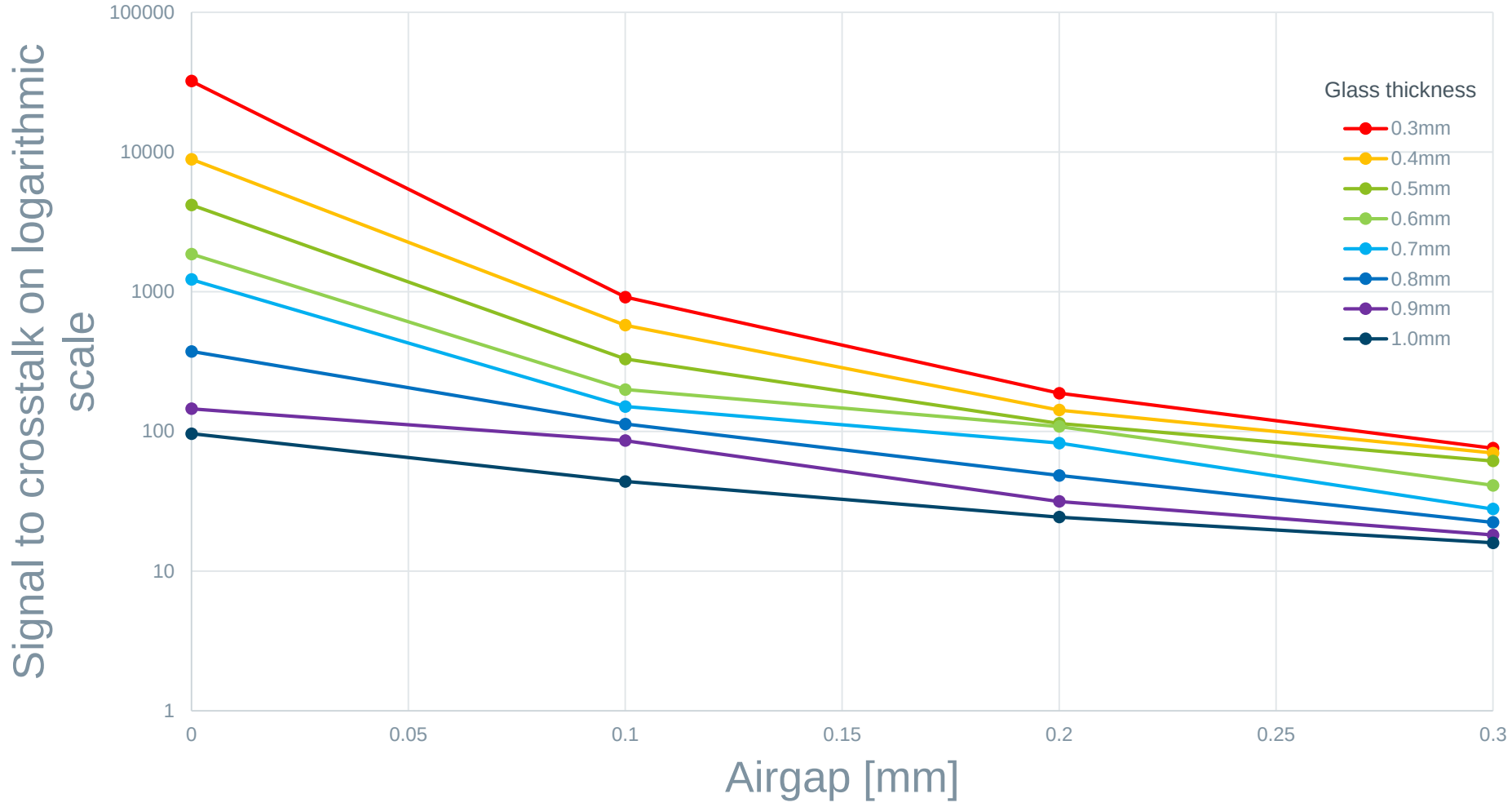
AS7026 MULTIPLE BEZEL AND AIR GAP

OPTICAL DESIGN SIMULATION – SIMULATION RESULTS

	0.30mm BEZEL			0.40mm BEZEL			0.50mm BEZEL			0.60mm BEZEL		
AIR GAP	SIGNAL	X-TALK	SXR	SIGNAL	X-TALK	SXR	SIGNAL	X-TALK	SXR	SIGNAL	X-TALK	SXR
0.00MM	211,050.0	6.6	32172.7	247,470.0	27.9	8868.6	302,430.0	72.5	4172.6	336,110.0	180.7	1859.1
0.10MM	443,650.0	484.9	914.0	470,510.0	816.7	575.1	533,690.0	1,616.4	329.2	572,450.0	2,863.0	198.9
0.20MM	525,430.0	2,786.7	187.5	550,870.0	3,849.6	142.1	578,620.0	5,028.3	114.1	649,750.0	5,951.0	108.2
0.30MM	587,050.0	7,650.0	75.7	628,760.0	8,861.0	70.0	664,680.0	10,651.0	61.4	681,390.0	16,239.0	41.0

	0.70mm BEZEL			0.80mm BEZEL			0.90mm BEZEL			1.00mm BEZEL		
AIR GAP	SIGNAL	X-TALK	SXR	SIGNAL	X-TALK	SXR	SIGNAL	X-TALK	SXR	SIGNAL	X-TALK	SXR
0.00MM	365,040.0	298.7	1221.1	369,090.0	986.9	373.0	377,290.0	2,584.8	145.0	394,010.0	4,051.8	96.2
0.10MM	587,970.0	3,877.7	150.6	608,180.0	5,347.9	112.7	608,170.0	6,998.4	85.9	616,140.0	13,759.0	43.8
0.20MM	669,790.0	8,041.5	82.3	663,190.0	13,441.0	48.3	710,890.0	21,901.0	31.5	734,620.0	29,004.0	24.3
0.30MM	711,620.0	24,738.0	27.8	715,730.0	30,669.0	22.3	743,640.0	38,919.0	18.1	777,250.0	46,033.0	15.9

AS7026 Simulation results



Thank you!

Please visit our website
www.ams.com