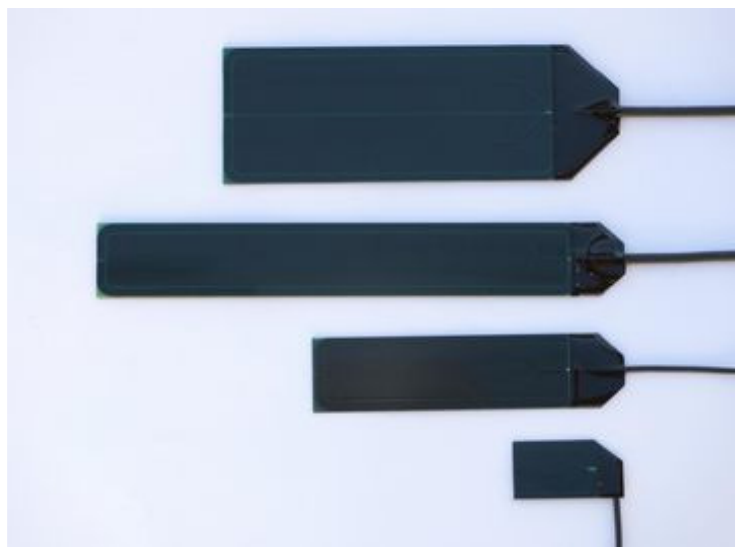


Air Gap Sensor **AGS**

Installation and user manual



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THIS INSTRUCTION MANUAL SHOULD BE READ CAREFULLY AND THE SAFETY INSTRUCTIONS OBSERVED BEFORE INSTALLING, CALIBRATING OR USING THE EQUIPMENT DESCRIBED HEREIN.

- Installation and maintenance must be performed by qualified personnel familiar with the construction, operation, and hazards involved with the equipment.
- Installation and maintenance must be performed with the control out of operation and disconnected from all sources of power
- Care should be taken when servicing electrostatic sensitive components. The manufacturer's recommendations for these components should be followed.
- Ventilation passages should be kept open.
- The means employed for grounding or insulating the equipment from ground should be checked to assure its integrity.
- Care must be taken to avoid damaging any delicate components and to avoid displacing dust, dirt, or debris in a way that permits it to enter or settle into parts of the control equipment.
- Enclosures should be inspected for evidence of deterioration. Accumulated dust and dirt should be removed from the top of the enclosures before opening doors or removing covers.

1. Overview

Air Gap Sensor (AGS) is high accuracy, non contact, capacitive type distance measuring sensor for measuring air-gap in air-cooled generators and electric motors.

AGS is made of low profile sensor probe with triaxial cable, preamplifier and shielded cable.

Our unique Edge Mount type for wind generators and electric motors with very small air gap.

High stability carbon particle semiconductive electrode made from glass-epoxy fiber (FR4).

DC/DC insulated power supply.

Optocoupler insulated output, 0...20 mA / 0...10V or 4...20mA / 2...10V.

Wide operating temperature range with +/-3% accuracy (Full Scale Deflection):

-Sensor probe: -20...140 °C,

-Signal Conditioner: -20...50 °C

Immune to magnetic fields, dust and oil vapours, EMI, RFI....

2. Application

Capacitive type distance measuring sensor for air-cooled generators and electrical motors.

High sensitivity, high resolution (up to 50 microns with oversampling).

Measuring of air-gap, rotor vibrations, rotor symmetry, power angle...

CAUTION: AGS is not certified for and shall not be installed in hydrogen-cooled alternators.

2.1. AGS selection table

In order to ensure **measurement headroom** please select Air Gap Sensor measuring range according to **the true air gap range** per Table 1. Given dimensions are absolute maximum values. Actual value of the true air gap shall be selected as close to the middle of true air gap range as possible. If in doubt please contact Mikrotrend.

Sensor type	AGS-4S	AGS-7,5S	AGS-13	AGS-25	AGS-50	AGS-51
Linear measuring distance (mm)	0,8...4	1,5... 7,5	2,6...13	5...25	10...50	5...50
Min / Max. true air gap range (mm)	1,7...4,9	2,7...8,7	3,8...14,2	8,3...28,3	13,3...53,3	8,3...53,3

Table 1. Linear measuring distance from the sensor surface vs. true air gap
(other ranges available per request)

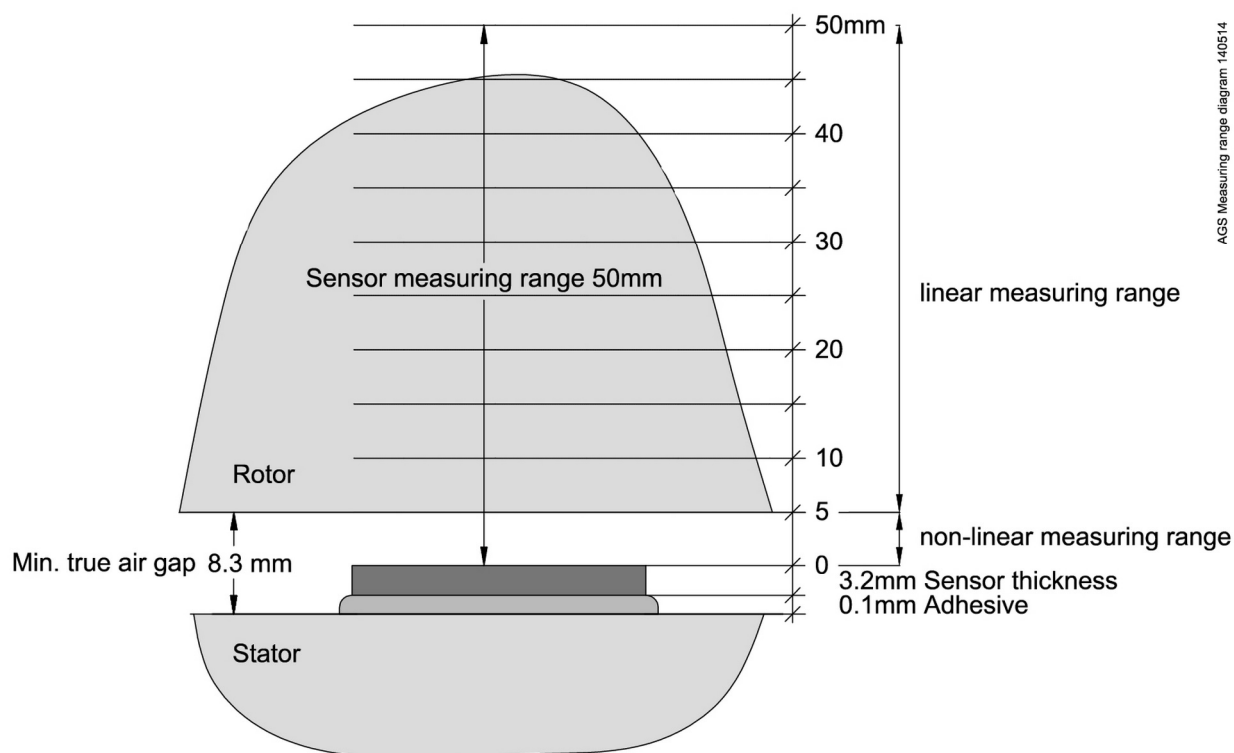


Figure 1. Minimum true air gap vs. measuring range

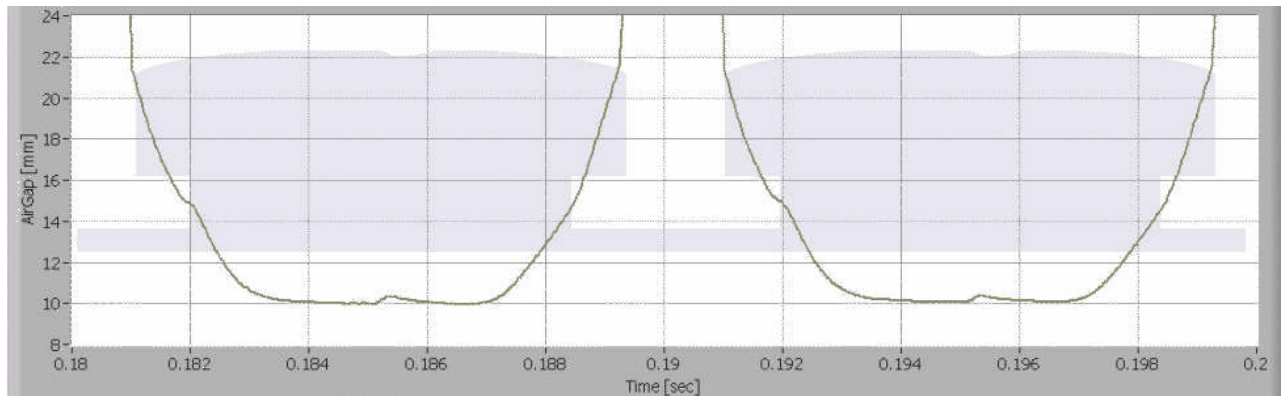


Figure 1b: Image of AGS pole profile output signal, zoom of two poles only

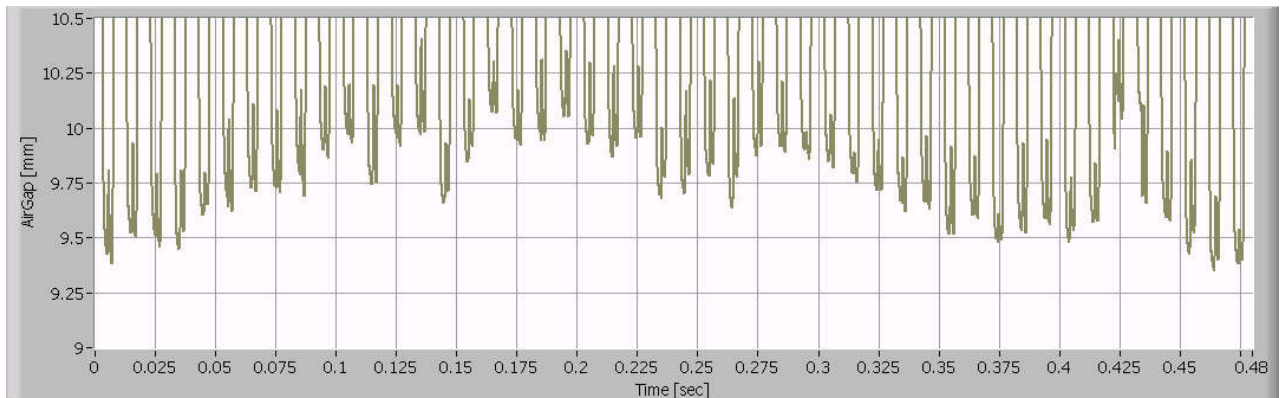


Figure 2: AGS Pole profile output signal (one rotation)

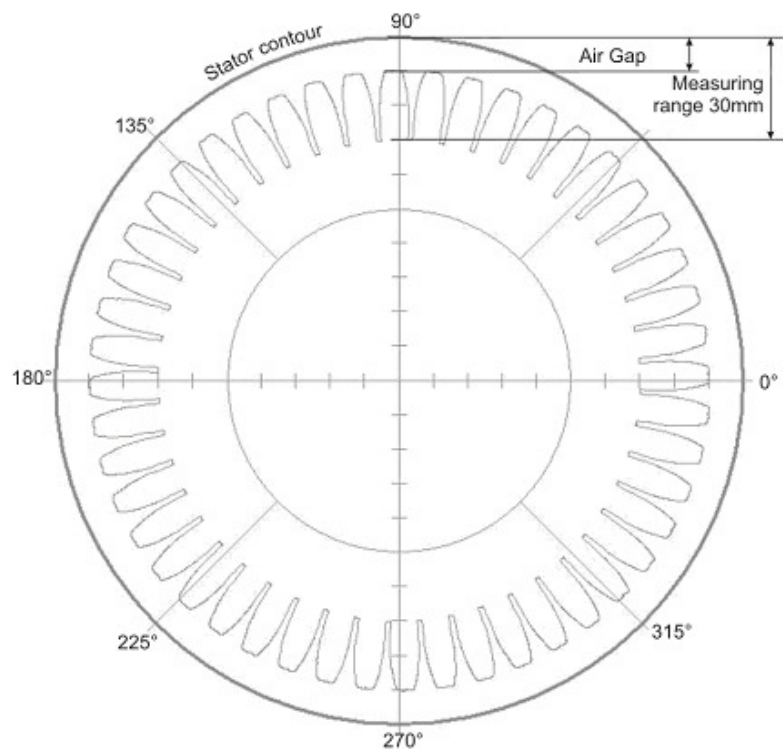


Figure 3: Image of AGS output signal, polar data

3. Technical specifications

	AGS-4S	AGS-7,5S	AGS-13	AGS-25	AGS-50	AGS-51
Measuring range (mm) (from sensor surface)	0...4	0...7,5	0...13	0...25	0...50	
Linear measuring range (mm) (from sensor surface)	0,8...4	1,5...7,5	2,6...13	5...25	10...50	5...50
Min / Max true air gap (mm)	1,7...4,9	2,7...8,7	3,8...14,2	8,3...28,3	13,3...53	8,3...53
Linearity FSD (25°C)	+/-1,5%	+/-1,5%	+/-1,5%	+/-1,5%	+/-3%	
Linearity FSD (-20...50/80/125°C) (1)	+/-3%				+/-5%	
Linearity FSD (-20...50/80/140°C) (2)	+/-3%				+/-5%	
Output noise (% of FSD)	0,5%					
Output pole profile	0...20mA, (0mA=0mm), or 4...20mA (4mA=0mm) with 500 Ohm termination resistor 0...10V (2...10V), opto-insulated					
Sensitivity 0...20mA output	5mA/mm	2,667mA/mm	1,539mA/mm	0,8mA/mm	0,4mA/mm	
Sensitivity 0...10V output	2,5V/mm	1,334V/mm	0,769V/mm	0,4V/mm	0,2V/mm	
Sensitivity 4...20mA output	4mA/mm	2,134mA/mm	1,231mA/mm	0,64mA/mm	0,32mA/mm	
Sensitivity 2...10V output	2V/mm	1,067V/mm	0,615V/mm	0,32V/mm	0,16V/mm	
Typical frequency response	0...1000Hz, (-3dB) other bandwidth optional					
Magnetic flux density withstand	+/-2 Tesla					
Operating temp. (AGS probe)	-20...125°C or -20...140°C					
Operating temp. (AGS preamp.)	-20...80°C					
Operating temp. (AGS conditioner)	-20...50°C					
Storage temperature (AGS conditioner)	-20...80°C					
Power input	+24Vdc, ±10%, 0,15A max.					
Warm-up time	approx. 20 min.					
Relative humidity	95% non condensing					
Vibration	IEC 68 2.27, 5 g peak, 10 Hz to 150 Hz					
Shock	IEC 68 2.27, 15 g peak, 11ms					
EMC	Sensor probe not affected by magnetic fields +/- 2 Tesla, 50/60 Hz					
Probe immunity	magnetic fields, dust and oil vapours, without degradation of material					
AGSP probe dimension (mm)	51x25x0,8	68x29x1,1	120x29x1,1	232x32x3,3	175x60x3,3	
AGSP cable length (m)	0,8 or 1,8 + 10					
AGSC sig. conditioner dimension (mm)	220 × 120 × 80 w/o cable inlets					
AGSC sig. conditioner protection class	IP66					
Weight AGS probe + cable	6g + 230g	10g + 230g	15g + 230g	50g + 250g	100g + 250g	
Weight AGSC signal conditioner	1500g					

(1) AGSC (signal conditioner) at 50°C, AGS (preamp.) at 80°C, AGS (probe) at 125°C

(2) AGSC (signal conditioner) at 50°C, AGS (preamp.) at 80°C, AGS (probe) at 140°C

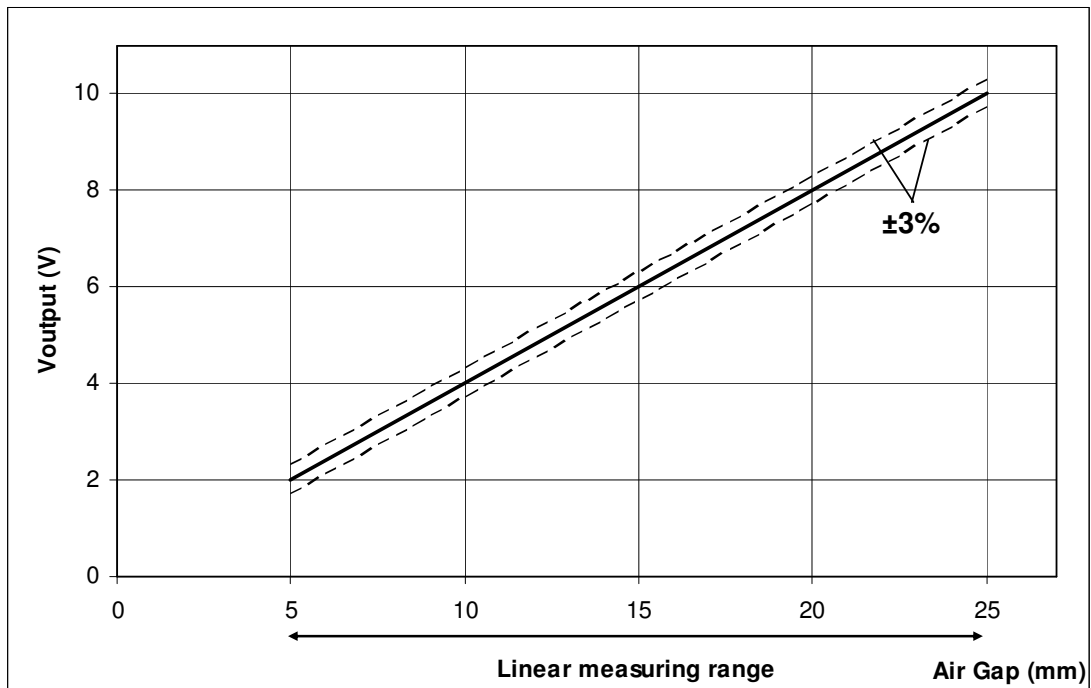


Figure 4. AGS-25 Linearity definition Full Scale Deflection (FSD)

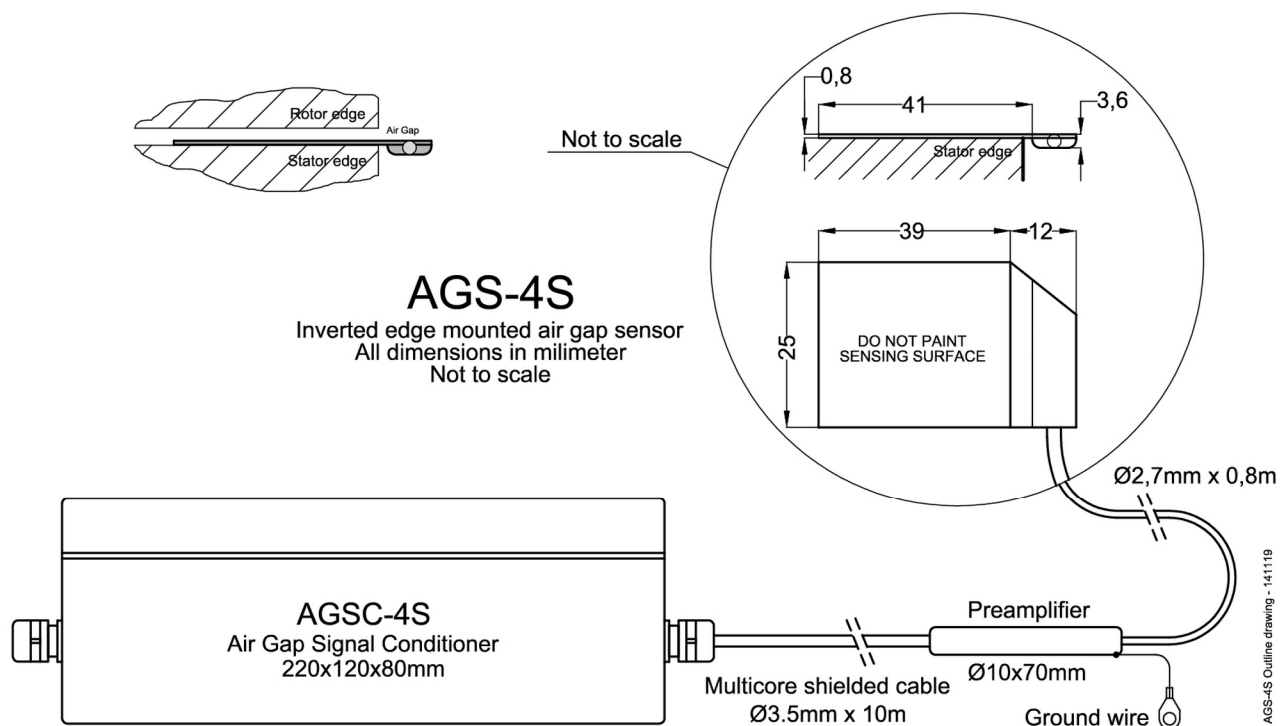


Figure 5. AGS-4S outline drawing

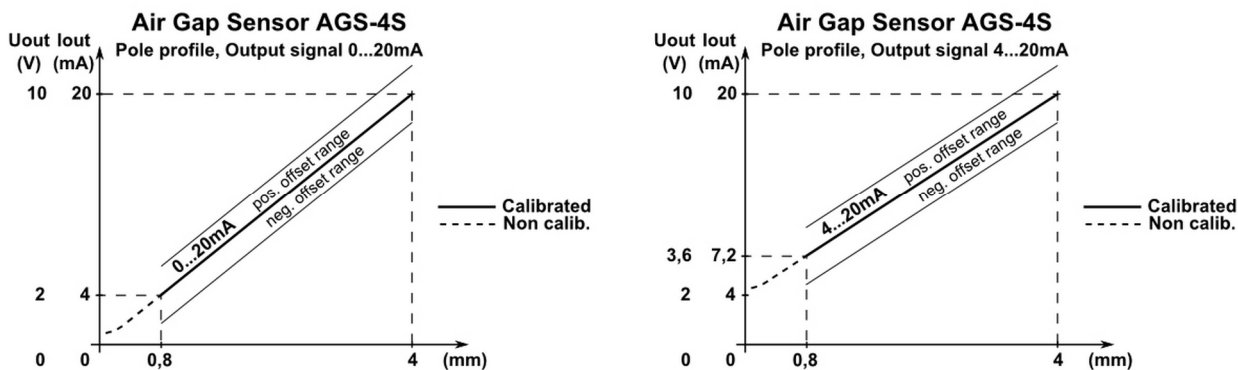


Figure 5a. AGS-4S output signal diagrams

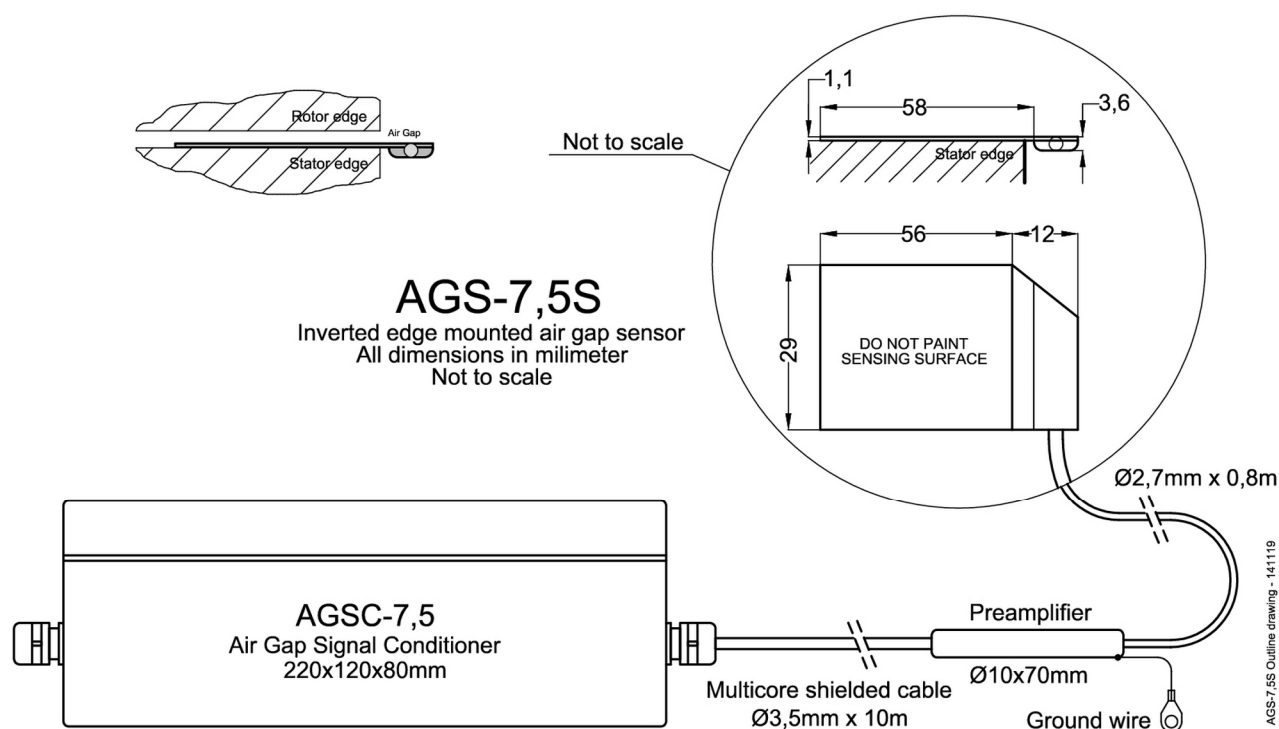


Figure 6. AGS-7,5S outline drawing

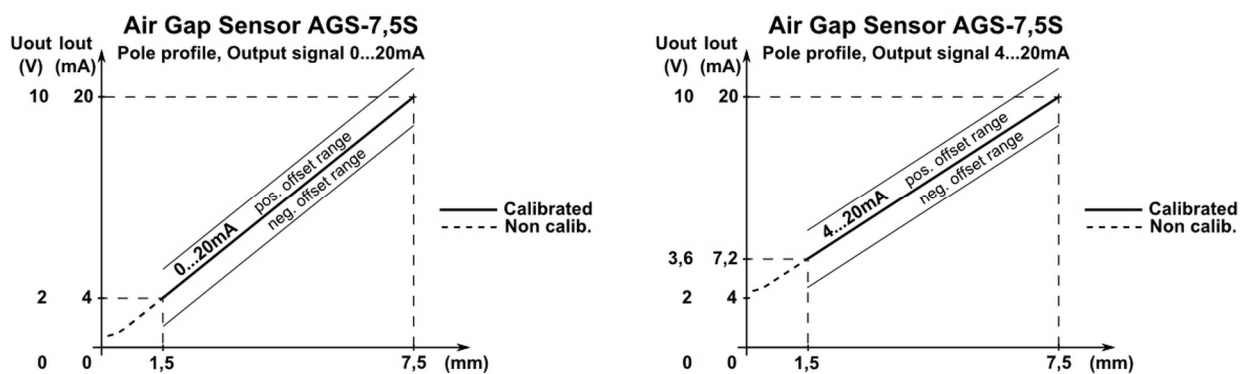


Figure 6a. AGS-7,5S output signal diagrams

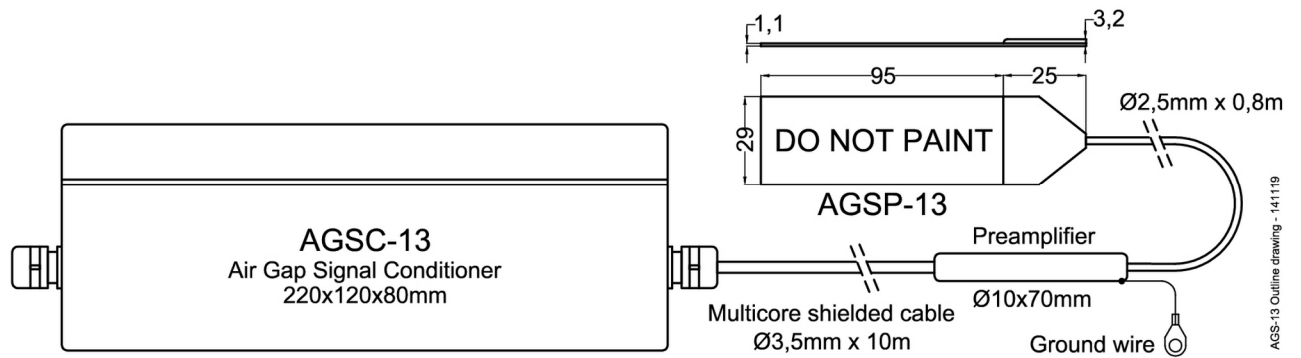


Figure 7. AGS-13 outline drawing

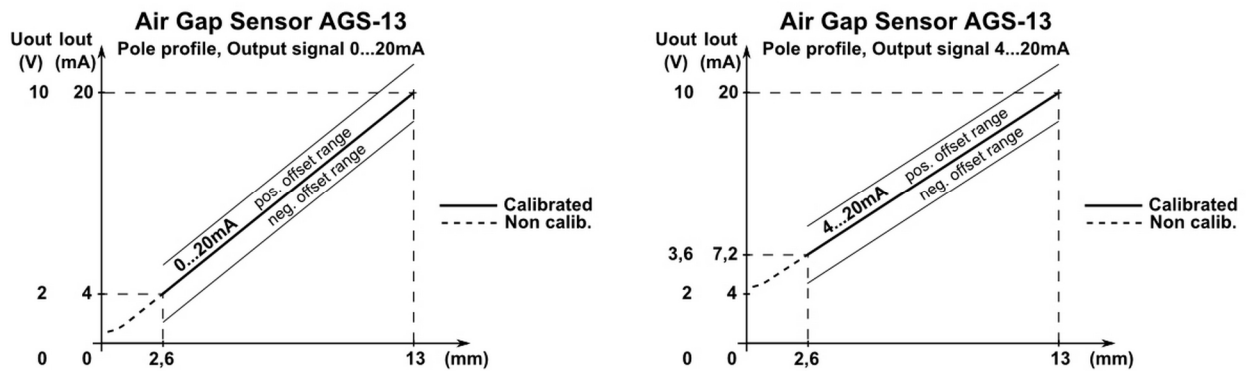


Figure 7a. AGS-13 output signal diagrams

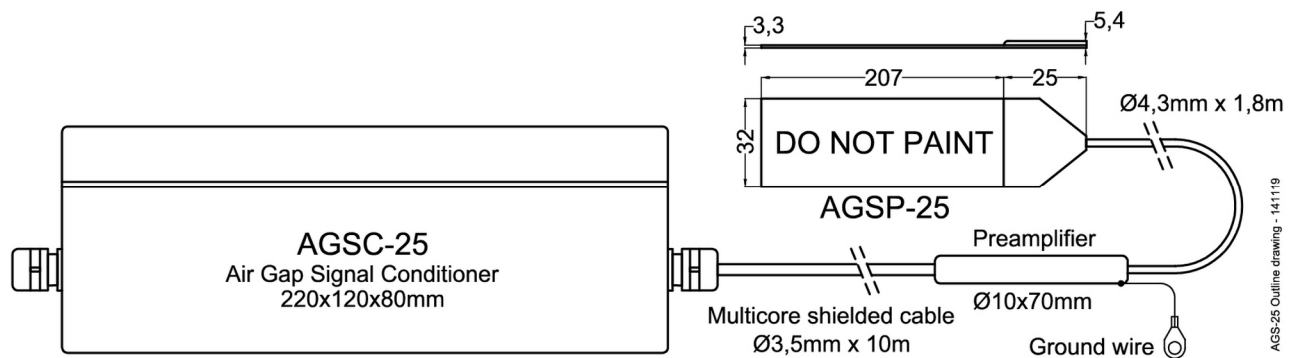


Figure 8. AGS-25 outline drawing

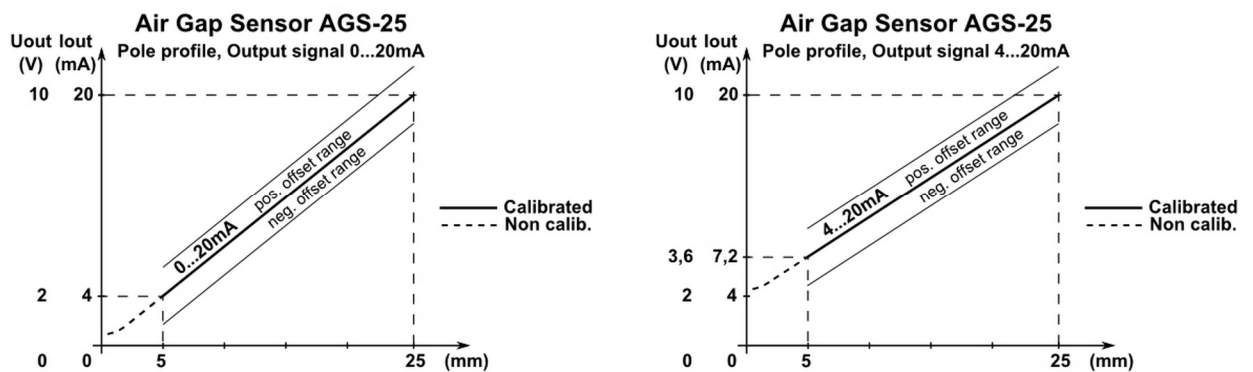


Figure 8a. AGS-25 output signal diagrams

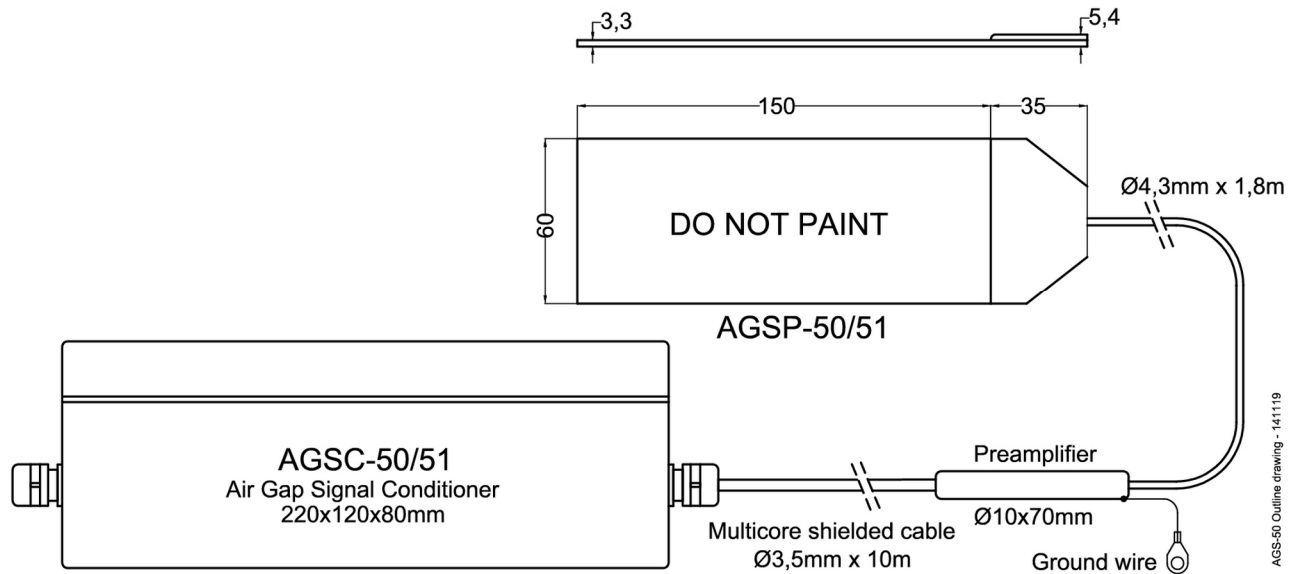


Figure 9. AGS-50 / AGS-51 outline drawing

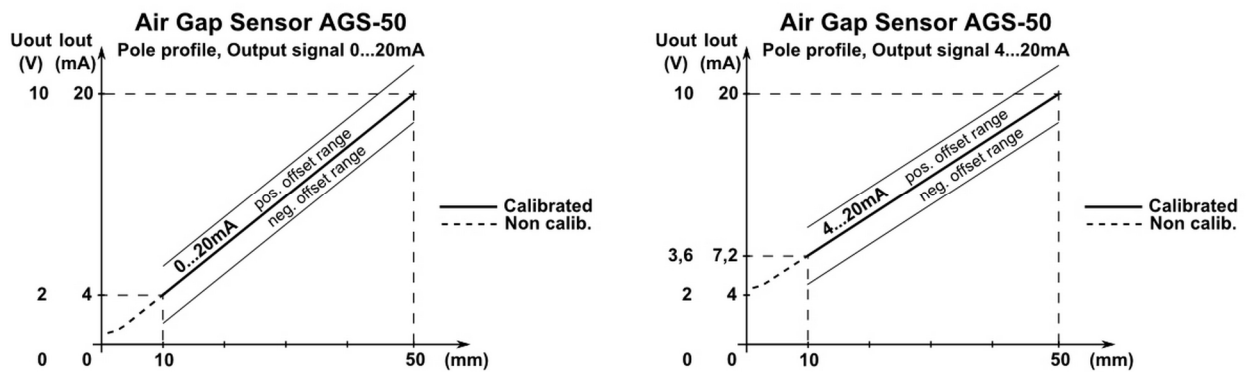


Figure 9a. AGS-50 output signal diagrams

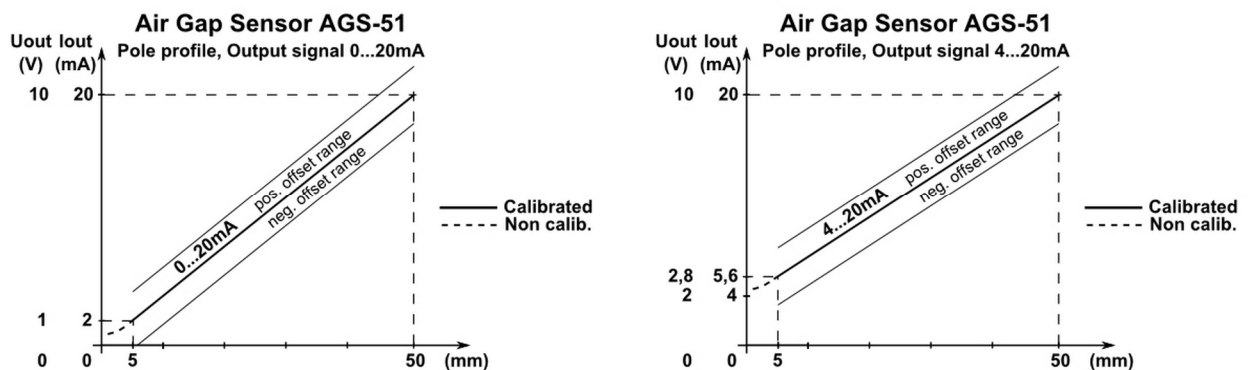


Figure 9b. AGS-51 output signal diagrams

4. Installation instructions

4.1. AGSC Signal Conditioner unit installation guide

Please select AGSC signal conditioner enclosure type:

a) Sealed enclosure with connectors, preferred enclosure type, use for Stator installation. Water and oil proofed IP64 cable connectors allow for easy installation **without opening** enclosure cover. Offset adjustment possible from outside without opening. Practical and simple installation within door and hinge box for EMC protection of cable wires. No need to open and no replacement of desiccant needed.

NOTE: *Sealed enclosure must be placed inside auxiliary door and hinge enclosure for EMC protection of connection wires.*



Figure 10a. AGSC Signal Conditioner unit enclosure with connectors (CON)

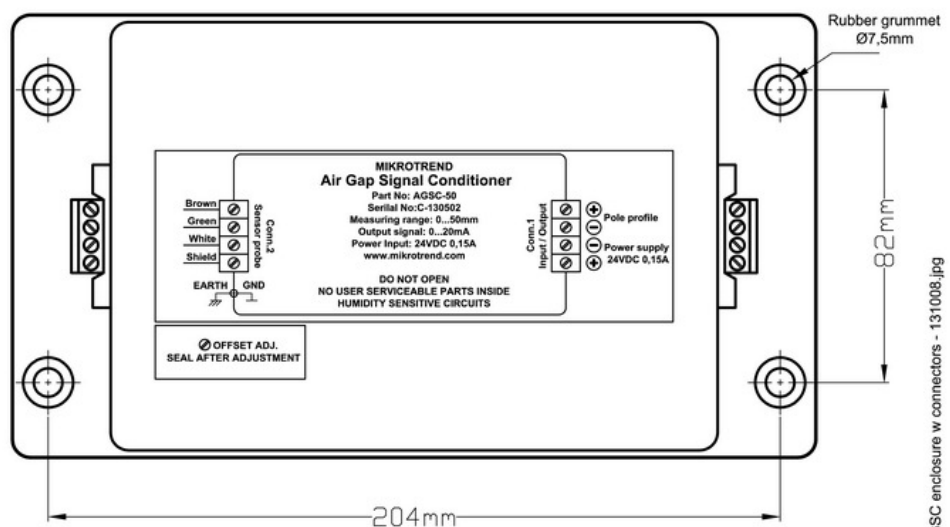


Figure 10b. AGSC Signal Conditioner unit enclosure with connectors (CON), (mounting dimensions)

b) Enclosure with cable inlets, use for Rotor mounted and stand alone installation **where no door and hinge enclosure is available** for protection.
Cables can be installed with tight fitting, oil and water proofed up to IP64.

NOTE: *AGSC must be closed during operation, contains humidity sensitive circuits. Replace desiccant after opening and allow at least 12h to dry-up before calibration and /or measuring .*



Figure 10c. AGS Signal Conditioner unit enclosure with cable inlets (CAB) (before S/N 144701)



Figure 10d. AGS Signal Conditioner unit enclosure with cable inlets (CAB) (after S/N 144701)

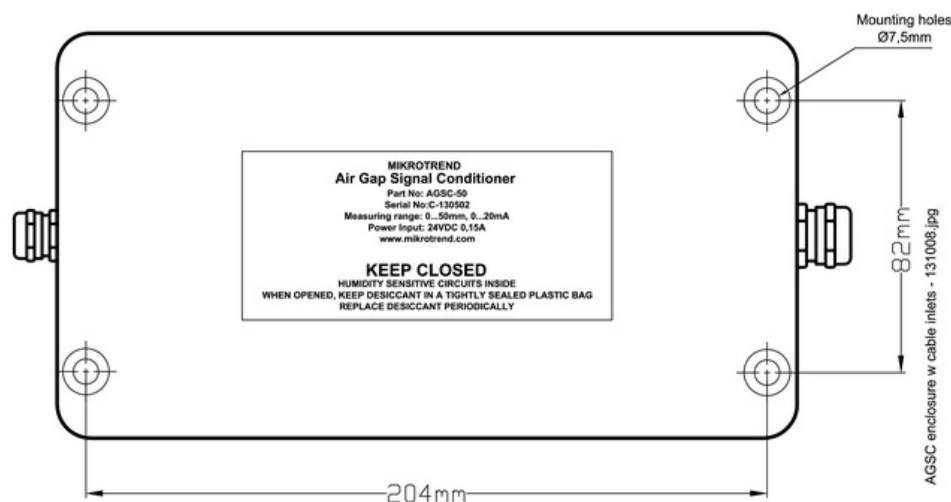


Figure 10d. AGS Signal Conditioner unit enclosure with cable inlets (CAB), (mounting dimensions)

4.2. Appropriate location for AGSC Signal Conditioner unit

Distance up to 10 meters from the sensor probe (longer distance is possible, please enquire), up to 200 meters from acquisition unit with 0...20mA loop. If voltage output is used, interference free distance may vary, depending on type of wiring and nearby equipment which may generate electromagnetic disturbance.

- Prefer well ventilated, dry area free of vibrations and stray magnetic fields,
- Ensure adequate grounding for enclosure with minimum length of wire,
- Ensure access to 24 VDC / 0,15A power supply.

NOTE: *When using enclosure with connectors auxiliary enclosure with door and hinge is mandatory to shield AGSC signal conditioner wires from environmental influences, for EMC protection etc.*

4.3. Grounding of AGSC Signal Conditioner unit

CAUTION: *Grounding is essential for system operation integrity as well as for protection against hazardous voltages. For best grounding, provide the shortest path possible between the AGSC signal conditioner unit and the grounded structure. Use flexible steel conduit to protect all cables from electromagnetic fields except inside of stator winding where PVC conduit shall be used. Keep ample distance from nearby power lines, (see Figure 15b).*

WARNING: *MULTICORE CABLE SHIELD SHALL BE GROUNDED AT ACQUISITION CARD INPUT ONLY. MULTIPLE GROUND POINTS WILL CAUSE NOISE PICK-UP AND CAN DAMAGE CONDITIONER UNIT ELECTRONICS.*

4.4. Power supply connection

Power to AGSC signal conditioner unit shall be 24VDC, $\pm 10\%$, 0,15A max. Conditioner unit input has insulated DC-DC converter allowing any pole to be grounded or floating power supply as well as daisy chain of several Conditioner units.

4.5. Calibration

The **AGSP** sensor probe and **AGSC** signal conditioner units are factory matched and calibrated for best performance. However if needed, may be calibrated at site. For details please contact www.mikrotrend.com

4.6. AGSP Sensor probe installation guide

CAUTION: *AGSP sensor probe shall be handled with care. Do not apply paint or silicone to the sensor surface. Never pull or use excessive force on the sensor cable or preamplifier.*

The sensor surface is treated with high quality insulation varnish, it shall not be scratched as damage to semiconductive electrodes may occur.

4.7. Placing the sensor

Choose position for AGSP sensor probe considering number of sensors and machine poles. **True accurate rotor/stator geometry** can be obtained with only one **Rotor mounted Air Gap Sensors**, and four **Stator mounted Air Gap Sensors**.
(<http://www.mikrotrend.com/wrm-wireless-hydrogenerator-rotor-monitor.htm>)

If **Wireless Rotor AGS** is not used than good practical results are achieved with:
-4 sensors per generator for diameters of less than 7,5 meters,
-8 sensors per generator with diameter 7,5...12 meters
-and 12 to 16 sensors for larger diameters.

For vertical machines place the sensors on the upper side of the stator as it will have higher excentricity than the lower side. For stator height of more than 1,8 meters Air Gap sensors should be placed on the lower side also.

Sensor shall be glued against stator laminations as deep as practical in the air gap or at stator edge if EDGE type of sensor probe is to be used.

In general, this is beneath the second ventilation hole. The preamplifier (small cylinder shape integrated within the cable) **must** stay outside of the air gap and outside of the endwindings, if possible outside of the stator casing.

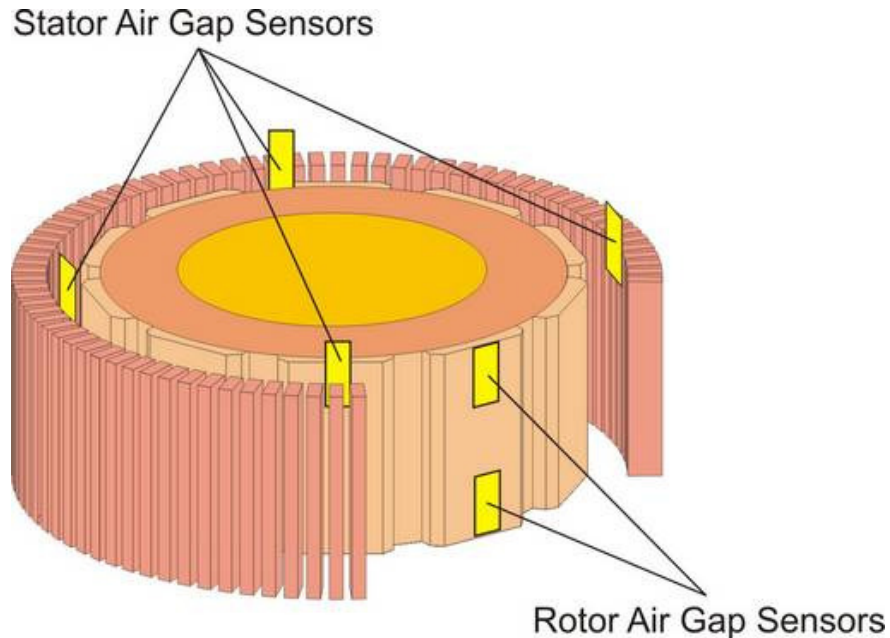


Figure 11. Air Gap Sensor probe positions

4.8. Preparing the stator surface

Thoroughly clean the stator surface, use allowed cleaning liquid such as isopropanol alcohol, disposable cotton rags and fine non-metallic sandpaper.

WARNING: **DO NOT USE ACETONE OR OTHER SOLVENTS.**

Use a clean rag moistened with isopropanol over the stator surface to remove oil and carbon deposits.

Epoxy coated or painted stator laminations inspect for **mechanical stability**. If necessary polish the surface and/or remove unstable particles with **non-metallic** sandpaper.

CAUTION: *Sensor's bottom surface shall be insulated from stator iron.
Sensor's bottom surface is coated with insulating varnish and a thin coat of adhesive will provide additional insulation.*

After sanding, once again clean stator surface with a rag moistened with isopropanol. The glue surface should be flat, without protruding laminations, Slight unevenness can be tolerated ($\pm 0.5\text{mm}$).

Let the isopropanol evaporate at room temperature for about 10minutes before proceeding with glue application.

4.9. Mounting the sensor

The **AGSP** sensor probe shall be aligned with the plane area of the rotor pole. A small misalignement may be compensated with offset adjustment. The sensor measuring surface shall be entirely covered by the pole surface.

We recommend three methods for fastening the sensors, each with different curing times and operating temperatures:

CAUTION: *Commonly found Epoxy adhesive is not flexible enough. The sensor may come off due to uneven surface tensions during high load periods on generator.*

A. Double sided tape, (150°C):**Double Side adhesive 3M Scotch Acrylic Foam Tape VHB 4611.**

With glue thickness of 1 mm, a foam type tape will allow stator unevenness of up to 0,3 mm. Allowed temperatures of 149°C (for weeks) and short time up to 230°C (hours).

Clean the back surface of the sensor with a cotton rag moistened with isopropanol.

Place double sided adhesive tape on the back side of the sensor. Remove protective foil and carefully place sensor in position without touching adhesive surface. Using protective gloves or a rag press the sensor firmly against the stator surface. Adhesive is pressure sensitive and reacts on the first applied pressure. The sensor can be put in use immediately after gluing, full strength will be reached after 24 hours.

**B. Silicone sealant-adhesive, non-acid (neutral), high temperature
TEMPFLEX Loctite 5145 (250 °C)**

Our preferred mounting technique with high flexibility and high holding force. This is only method recommended for **Wireless Rotor AGS** where high G-forces are present. Standard operation temperatures from -85...250 °C, short time up to 300 °C.

A must for locations where stator surface coating has low adhesion to stator laminate.

Silicone adhesive/sealant effectively compensates uneven surface tensions during high load periods on generator thus ensuring stable mounting of the sensor.

With paper adhesive tape, mark border area about 5 mm larger on each side than sensor surface. Apply Silicone sealant about 1mm thick, evenly spread over entire **back surface** of the sensor.

Carefully place sensor within paper covered opening and firmly press until sealant stops coming out.

Wipe of excess sealant with paper towel until clean and remove adhesive paper border.

Fix the sensor in position with adhesive tape (Power-Tape) for at least 6 hours. Full curing times up to 24 h. shorter with higher ambient moisture.

**C: Two component glue (short curing time) LOCTITE MULTIBOND 330
continuous operation temperature not exceeding 80 °C**

If stator laminate coating is strong and stable, You can use two component adhesive type **LOCTITE MULTIBOND 330**. It is quick and simple application, but flexibility is not great and above mentioned precautions about surface stability and operating temperature shall be observed.

When generator is under heavy load and if surface is not stable enough, the sensor may come off due to stator core tensions which adhesive cannot compensate.

Clean the back surface of the sensor with a rag moistened with alcohol.

Follow manufacturers instructions. Curing times will vary with surface temperature, 50% of the final strength is reached after 10...30 minutes, full strength after approx. 5 hours.



Figure 12. AGSP sensor probe installed at stator surface
(AGS sensor pictured on the left, magnetic field sensor on the right side)



Figure 13. AGSP sensor probe installed at rotor pole
(AGSP sensor pictured next to Magnetic field sensor in the middle of rotor pole)

4.10. True Air-Gap and offset

The output of the signal conditioner provides the distance value between **the sensor surface and rotor pole**.

Offset is the distance between the stator surface and sensor surface, including the thickness of the glue:

Offset = glue thickness+sensor thickness, varies with sensor type and mounting method.

True air-gap is sum of measured and offset value.

Offset compensation shall be made at the monitoring system and displayed value will be True air gap distance.

NOTE: *Before attempting new offset adjustment let AGSC Signal conditioner unit be powered for 20...30 minutes.*

Slowly turn trimmer potentiometer labeled **Offset adj.** until reaching required output current or voltage. Normally, very small rotation will provide large changes on output.

CAUTION: *DO NOT adjust other trimmer potentiometers (factory adjustment only).*

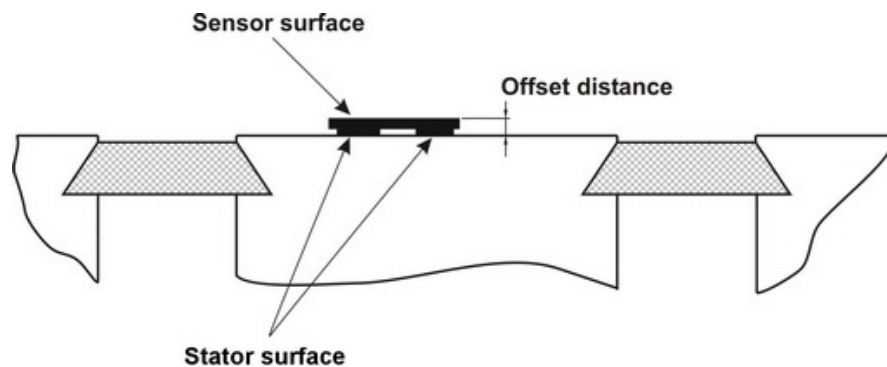


Figure 14. AGS - Offset distance

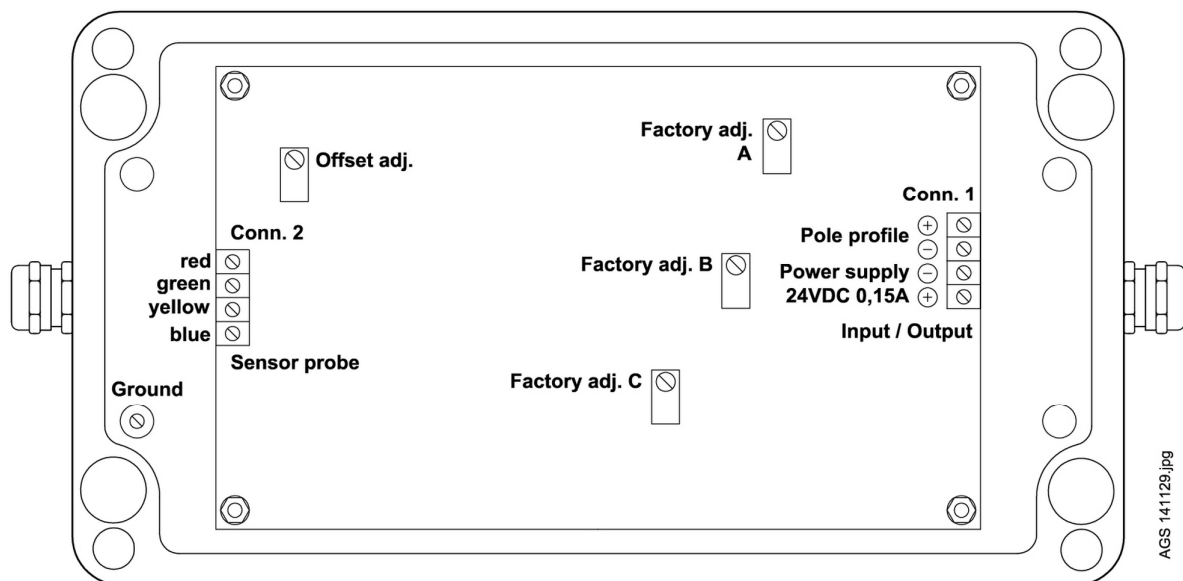


Figure 15. AGSC - signal conditioner, cable inlet enclosure, adjustments (before S/N 144701)

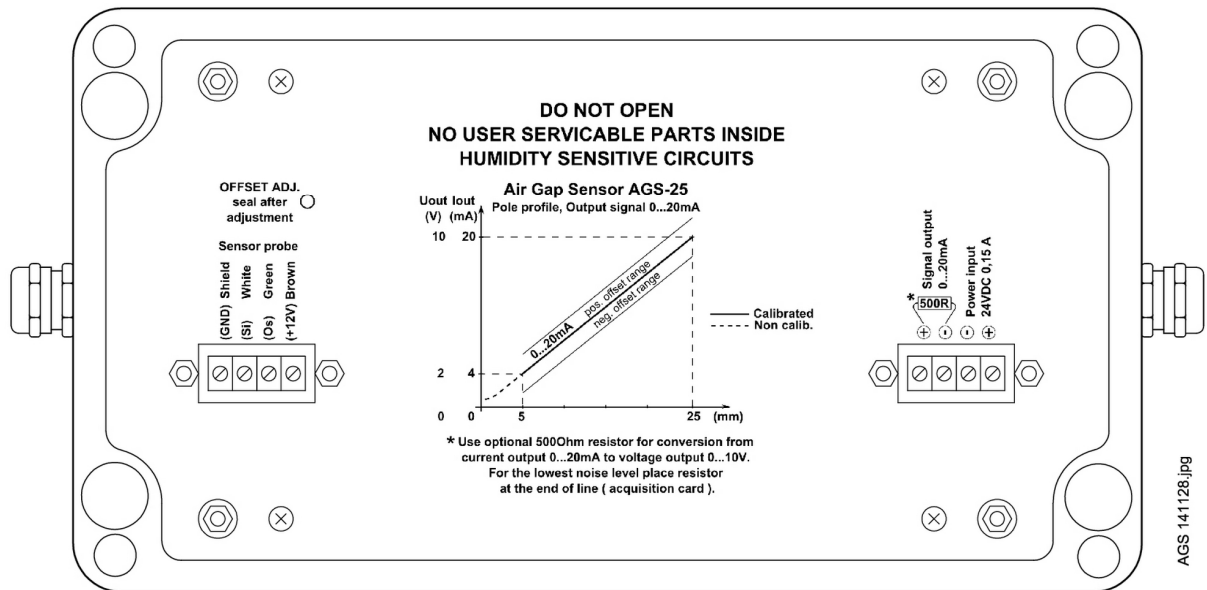


Figure 15a. AGSC - signal conditioner, cable inlet enclosure, adjustments (after S/N 144701)

4.11. Cable installation

WARNING: *BEWARE OF HIGH VOLTAGES ON THE STATOR BARS (5...22 KV). DO NOT ATTACH TRIAXIAL CABLE DIRECTLY TO THE STATOR BARS. THE TRIAXIAL CABLE, PREAMPLIFIER AND MULTICORE SHIELDED CABLE MUST BE PROTECTED BY A FLEXIBLE OR SEMI-RIGID STEEL WITH POLYETHYLENE (PVC) CONDUIT, (SEE FIGURE 15B).*

CAUTION: *The triaxial cable shall not be modified.*

Multicore shielded cable (between preamplifier and signal conditioner unit) **may be shortened** if necessary. This will change output readings approx. 3% / met. Please adjust offset accordingly.

Gently preshape the triaxial cable by hand to get the right form, avoid to bend it beyond a right angle with minimum bending radius of 30mm.

Immobilize the triaxial cable inside the air gap to prevent vibrations and/or mechanical displacement:

- hold the triaxial cable temporary with Cyanoacrylate type glue, point-glued to the stator laminations (iron) surface.
- apply Silicone sealant along the cable in the air gap up to the exit making a strong permanent bond.

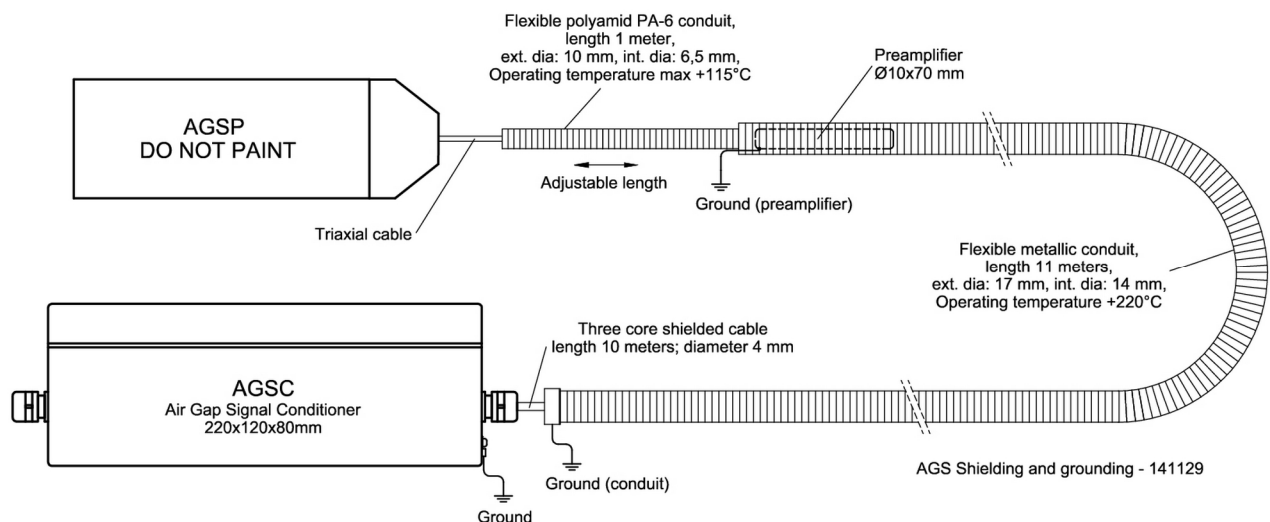


Figure 15b. Air Gap Sensor AGS Shielding and grounding

4.12. Connection to AGSC conditioner unit

The Figure 16 illustrates how to connect the multicore cable to the AGSC conditioner unit.

Pole profile output gives instantaneous air-gap value measured by the sensor (Fig.1b). It is optocoupled and insulated from sensor ground and also from power supply negative. Output shall be grounded at acquisition card input. Output signal can be ordered as 0...20mA or 4...20mA.

NOTE: *When 0...10V output is needed instead of 0...20mA, a current to voltage conversion resistor of 500 ohms should be placed at the end of line at the acquisition unit (the lowest noise level).*

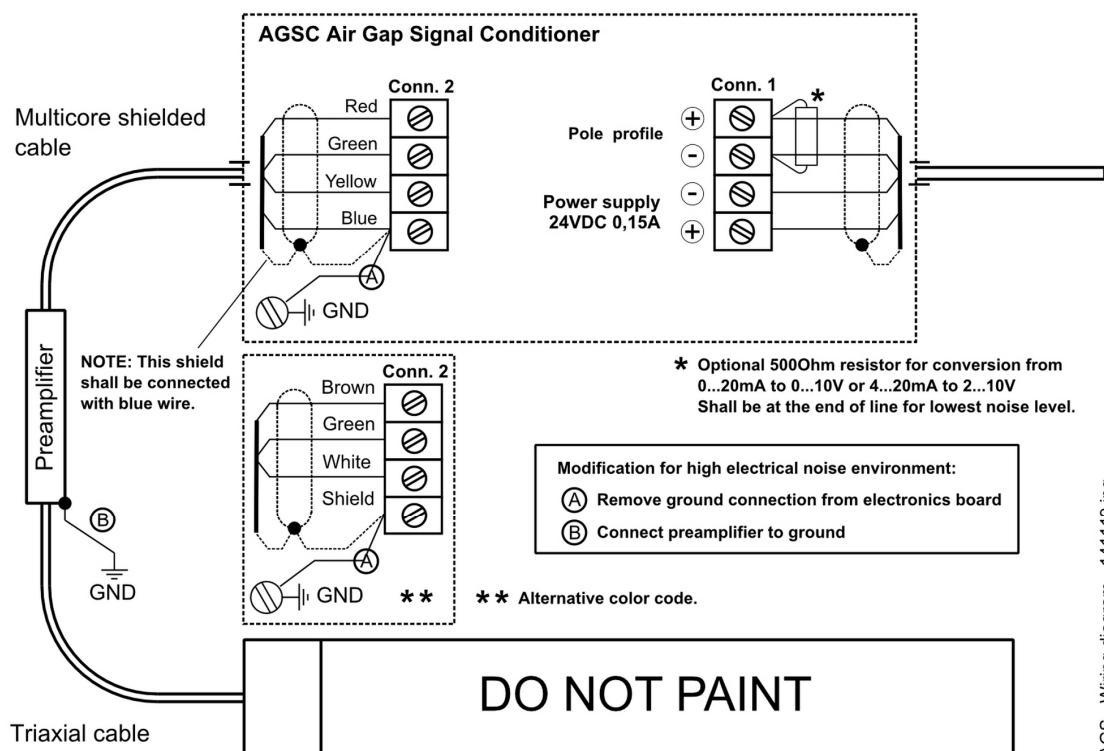


Figure 16. AGS Wiring diagram (before S/N 144701)

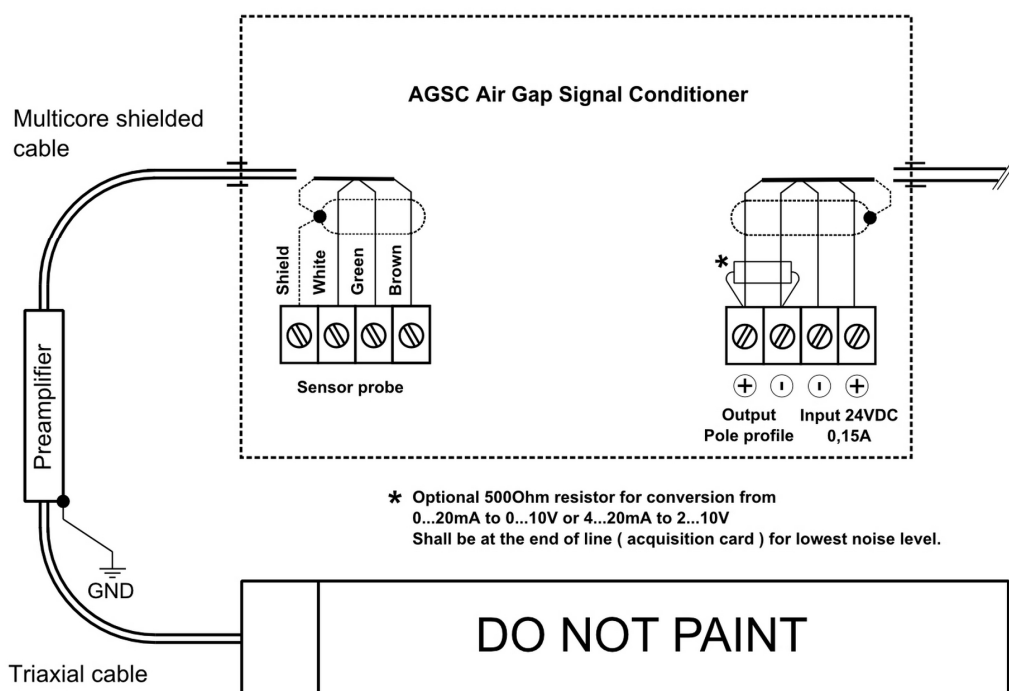


Figure 16b. AGS Wiring diagram (after S/N 144701)

AGS - Wiring diagram - 141119.jpg

AGS - Wiring diagram - 141121.jpg

Distance (mm)	Iout (mA)	Vout (V) at 500 Ohm
0	0	0
5	4	2
25	20	10

Table 2. AGS-25 0...20mA 0,8mA/mm, Output example

Distance (mm)	Iout (mA)	Vout (V) at 500 Ohm
0	4	2
5	7,2	3,6
25	20	10

Table 3. AGS-25 4...20mA 0,64mA/mm, Output example

5. Troubleshooting

1. Q: Output signal drift with change of temperature/humidity:

A:

For units before S/N 144701:

Although Air Gap Sensor Probe (AGSP) is not temperature sensitive, Air Gap Signal Conditioner (AGSC) contains humidity sensitive components which can cause significant output signal drift if humidity enters AGSC enclosure. Each AGSC unit shall contain a fresh desiccant pack.

Please keep desiccant in tightly sealed zip-bag during installation or, better, replace desiccant every time AGSC enclosure is opened.

Every attempt to adjust **OFFSET** shall be made **only** after fresh pack of dessicant has been installed for at least 12 hours, in order to dry-out inside of AGSC enclosure. Another option is to use **AGSC-x-x-CON** enclosure which has connectors for cable installation and OFFSET adjustment is possible without opening.

For units after S/N 144701:

New enclosure for electronics with protection from humidity.

No desiccant replacement needed.

OFFSET adjustment trimmer shall be sealed with adhesive tape after adjustment.

2. Q: Pole profile Output signal higher/lower than nominal:

A:

1. Check the distance to pole surface is within measuring range.

2. Check Sensor or Triax cable for damages.

3. If replacement sensor probe is connected to already installed "old" Signal Conditioner, slowly turn OFFSET adjustment trimmer potentiometer until reaching desired output.

Please see also 5.1 (Output drift with change of temperature / humidity)

3. Q: 50/100Hz and/or higher frequency noise in pole profile signal:

A.

1. Metallic cable conduits are mandatory for AGS installation.

Most important for generators with newer Switching power regulators in the Exciter circuit (a source of broadband electrical noise) (Figure 15b).

2. **Check grounding scheme. Ground loops shall be avoided** (Figure 15b).

Installations before S/N 144701 will have lower noise level with modification as per Fig.16. Main ground connection shall be removed from AGSC electronics PCB and placed at the Preamplifier body.

Calibration is not affected with this modification.

Pole profile output signal is electrically floating, minus pole shall be grounded at acquisition card input or AGSC enclosure but **not at both** places.

Please **do not allow multiple grounding** ie. at AGSC **and** at acquisition card unit **and** at monitoring PC-power supply, **and** at Ethernet adapter, etc. Use opto-isolated Ethernet adapters if needed.

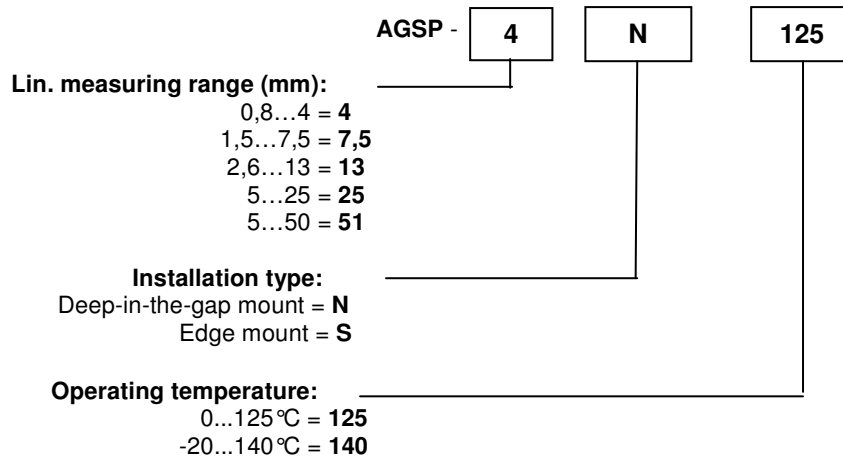
3. **Air Gap Signal Conditioner** unit will tolerate aprox 0,2 Tesla of stray magnetic fields. If stronger fields are present use additional protection-box made from ferromagnetic material or move to other location.

6. Ordering information

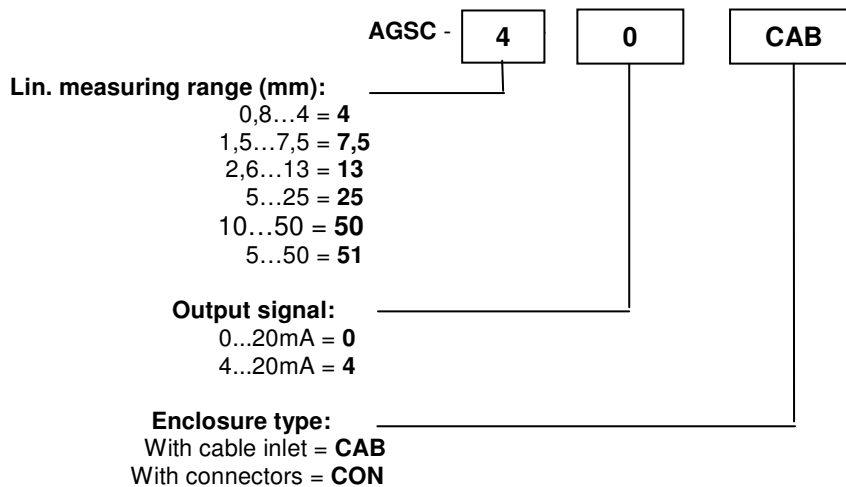
AGS Air Gap Sensor is delivered as factory calibrated sets containing:

- P/N: **AGSP** sensor probe with integrated preamplifier and connection cable,
- P/N: **AGSC** signal conditioner.

When ordering **AGSP** sensor probe please use the following format:



When ordering **AGSC** signal conditioner please use the following format:



7. Manufacturers Test and Calibration Report

Air Gap Sensors are individually calibrated and Manufacturers Test and Calibration Report (MTR) included with each unit as per sample below:

Manufacturer: MIKROTREND d.o.o. 4.Bizek 14, 10000 Zagreb, CROATIA
e-mail: info(at)mikrotrend.com www.mikrotrend.com

Date: 07. March 2014

Ambient: 26 °C

Test performed by: K. Pavlovic

Manufacturers Test and Calibration report No. 141003

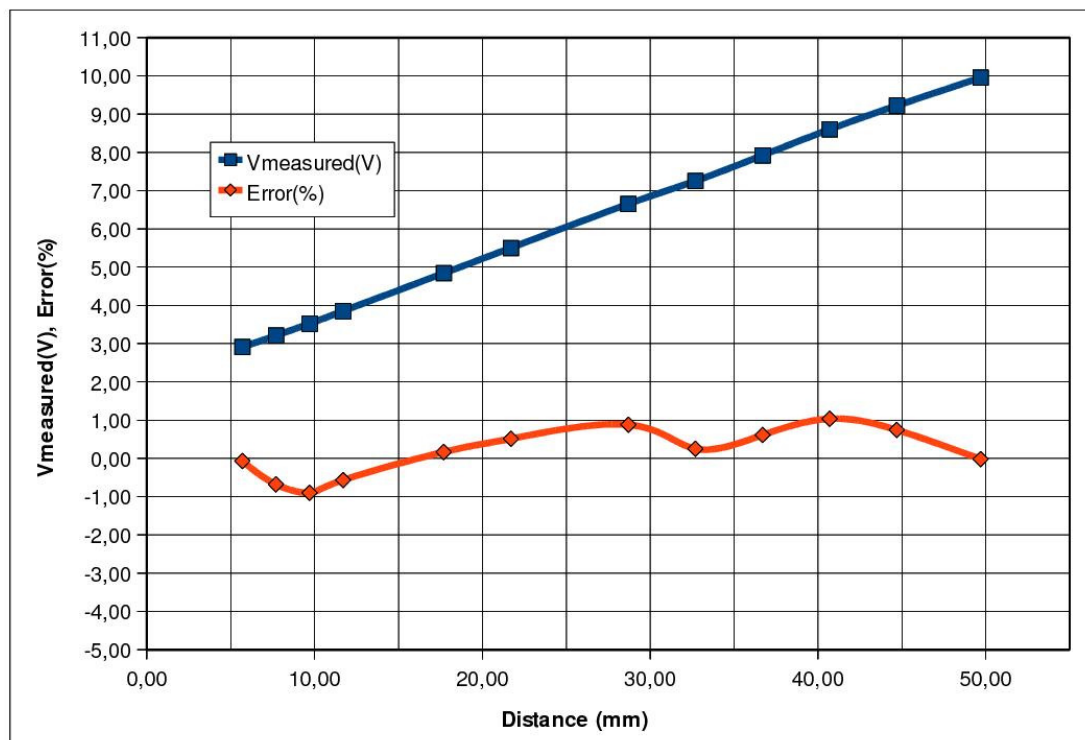
Product name: **Air Gap Sensor Probe** Part No. **AGSP-51-N-125** Ser. No. **P51-141003**

with:

Product name: **Air Gap Signal Conditioner** Part No. **AGSC-51-4-CAB** Ser. No. **C51-141003**

Scope of testing: **tested and recorded is sensor output at specified distance**

Distance d(mm)	Output voltage Videal(V)	Output voltage Vmeasured(V)	Error(%)
5,70	2,91	2,91	-0,07
7,70	3,23	3,21	-0,68
9,70	3,55	3,52	-0,90
11,70	3,87	3,85	-0,57
17,70	4,83	4,84	0,17
21,70	5,47	5,50	0,51
28,70	6,59	6,65	0,88
32,70	7,23	7,25	0,25
36,70	7,87	7,92	0,61
40,70	8,51	8,60	1,03
44,70	9,15	9,22	0,74
49,70	9,95	9,95	-0,02



The product and the factory surveillance system meet all applicable requirements as laid down in the relevant Installation and user manual

8. Important notice

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