

# TIPS<sup>®</sup> M603 LARGE ANGLE TILT SENSOR

## INTRINSICALLY SAFE FOR HAZARDOUS MINING ENVIRONMENTS

- Intrinsically safe for Gas and Dust to: Ex I/II M1/GD
- Non-contacting inductive technology to eliminate wear
- Angle set to customer's requirement
- Compact and self-contained
- High durability and reliability
- High accuracy and stability
- Sealing to IP67



As a leading designer and manufacturer of linear, rotary, tilt and intrinsically safe position sensors, Positek<sup>®</sup> has the expertise to supply a sensor to suit a wide variety of applications.

Our M603 TIPS<sup>®</sup> (Tilt Inductive Position Sensor) incorporates electronics system EX07 which is ATEX / IECEx approved for use in potentially explosive gas/vapour, dust atmospheres and mining environments.

The M603 is designed for industrial and scientific feedback applications and is ideal for OEMs seeking good sensor performance for arduous applications in hazardous areas. The M603, like all Positek<sup>®</sup> sensors, is supplied with the output calibrated to the angle required by the customer, between 15 and 160 degrees and with full EMC protection built in. The sensor provides a linear output proportional with the rotation of the sensor. There is a machined registration mark to identify the calibrated mid point.

Overall performance, repeatability and stability are outstanding over a wide temperature range. Electrical connections to the sensor are made via an industrial standard 4-pin M12 connector, with limited rotational capability to facilitate cable routing.

The sensor has a rugged stainless steel body and mounting flange. The flange has two 4.5mm by 30 degree wide slots on a 48mm pitch to simplify mounting and position adjustment. Environmental sealing is to IP67.

### SPECIFICATION

<b>Dimensions</b>	
Body Diameter	35 mm, Flange 60 mm
Body Length (to seal face)	44 mm
For full mechanical details see drawing M603-11	
<b>Power Supply</b>	+5V dc nom. $\pm$ 0.5V, 10mA typ 20mA max
<b>Output Signal</b>	0.5-4.5V dc ratiometric, Load: 5k $\Omega$ min.
<b>Independent Linearity/Hysteresis</b>	
(combined error)	< $\pm$ 0.25° - up to 100°
<b>Temperature Coefficients</b>	< $\pm$ 0.01%/°C Gain & < $\pm$ 0.01%FS/°C Offset
<b>Response Time</b>	250 mS @ 20°C typ.
<b>Resolution</b>	Infinite
<b>Damping Ratio</b>	0.2 : 1 (0.6 nom. @ 25°C)
<b>Noise</b>	< 0.02% FSO
<b>Intrinsic Safety</b>	Ex ia IIC T4 Ga (Ta= -40°C to 80°C) Ex ia IIIC T135°C Da (Ta= -40°C to 80°C) Ex ia I Ma (Ta=-40°C to 80°C)
Approval only applies to the specified ambient temperature range and atmospheric conditions in the range 0.80 to 1.10 Bar, oxygen $\leq$ 21%	
<b>Sensor Input Parameters</b>	Ui: 11.4V, Ii: 0.20A, Pi: 0.51W.
(without cable)	Ci: 1.16 $\mu$ F, Li: 50 $\mu$ H
(with cable)	Ci: 1.36 $\mu$ F, Li: 860 $\mu$ H with 1km max. cable
<b>Environmental Temperature Limits</b>	
Operating	-20°C to +80°C
Storage	-40°C to +125°C
<b>Sealing</b>	IP67
<b>EMC Performance</b>	EN 61000-6-2, EN 61000-6-3
<b>Vibration</b>	IEC 68-2-6: 10 g
<b>Shock</b>	IEC 68-2-29: 40 g
<b>MTBF</b>	350,000 hrs 40°C Gf
<b>Drawing List</b>	
M603-11	Sensor Outline
Drawings, in AutoCAD <sup>®</sup> dwg or dxf format, available on request.	

Do you need a position sensor made to order to suit a particular installation requirement or specification? We'll be happy to modify any of our designs to suit your needs - please contact us with your requirements.



M603-17p

# TIPS<sup>®</sup> M603 LARGE ANGLE TILT SENSOR

## INTRINSICALLY SAFE FOR HAZARDOUS MINING ENVIRONMENTS

Intrinsically safe equipment is defined as "equipment which is incapable of releasing sufficient electrical or thermal energy under normal or abnormal conditions to cause ignition of a specific hazardous atmosphere mixture in its most easily ignited concentration."

ATEX / IECEx approved to;

- Ex I/II M1/GD
- Ex ia IIC T4 Ga (Ta= -40°C to 80°C)
- Ex ia IIIC T135°C Da (Ta= -40°C to 80°C)
- Ex ia I Ma (Ta=-40°C to 80°C)

Designates the sensor as belonging to; Groups I and II: suitable for all areas (including mining), Category M1/1 GD: can be used in areas with continuous, long or frequent periods of exposure to hazardous gas (Zones 2 to 0) and dust (Zone 20), equipment remains energised.

Gas:

Protection class ia, denotes intrinsically safe for all zones Apparatus group IIC: suitable for IIA, IIB and IIC explosive gases.

Temperature class T4: maximum surface temperature under fault conditions 135°C.

Dust:

T135°C: maximum surface temperature under fault conditions 135°C.

Ambient temperature range extended to -40°C to +80°C.

It is imperative Positek<sup>®</sup> intrinsically safe sensors be used in conjunction with a galvanic barrier to meet the requirements of the product certification. The Positek X005 Galvanic Isolation Amplifier is purpose made for Positek IS sensors making it the perfect choice. Refer to the X005 datasheet for product specification and output configuration options.

**Safety Parameters:-**

- Ui: 11.4V, Ii: 0.20A, Pi: 0.51W
- Ci = 1.36µF\*      Li = 860µH\* (cable option/s)
- Ci = 1.16µF      Li = 50µH (connector option/s)

\*Figures for 1km cable where: Ci = 200pF/m & Li = 810nH/m

Sensors can be installed with a maximum of 1000m of cable.

Cable characteristics must not exceed:-

- Capacitance: ≤ 200 pF/m for max. total of: 200 nF.
- Inductance: ≤ 810 nH/m for max. total of: 810 µH

For cable lengths exceeding 10 metres a five wire connection is recommended to eliminate errors introduced by cable resistance and associated temperature coefficients.

ATEX / IECEx approved sensors suitable for gas (X series) and dust (E series) applications, are also available from Positek.

### TABLE OF OPTIONS

**CALIBRATED TRAVEL:** Factory-set to any angle from ±7.5° to ±80° in increments of 1°.  
 Full 360° Mechanical rotation.

#### ELECTRICAL INTERFACE OPTIONS

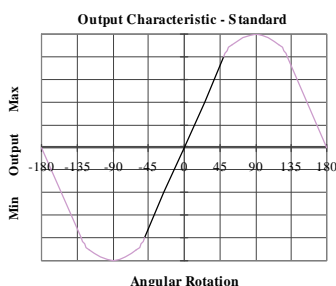
The Positek<sup>®</sup> X005 Galvanic Isolation Amplifier is available with the following output options;

- Standard: 0.5 - 9.5V or 4 - 20mA.
- Reverse: 9.5 - 0.5V or 20 - 4mA.

#### CONNECTOR

Connector - Binder 713 series IP67

We recommend all customers refer to the 3 or 5-Wire Mode Connection page.



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# Three or Five-Wire Mode Connection FOR INTRINSICALLY SAFE SENSORS IN HAZARDOUS ATMOSPHERES

The aim of this document is to help readers who do not understand what is meant by three or five wire modes of connection between the galvanic isolation amplifier and sensor, and the factors behind them. It is by no means an in-depth technical analysis of the subject.

Whether opting for a pre-wired Positek® Intrinsicly Safe sensor or one with a connector, choosing the right mode of connection and cable to suit the application requires careful consideration.

Interconnecting cables are not perfect conductors and offer resistance to current flow, the magnitude of resistance<sup>†</sup> depends on conductors resistivity, which changes with temperature, cross sectional area<sup>‡</sup> and length. If the voltage were to be measured at both ends of a length of wire it would be found they are different, this is known as volts drop. Volts drop changes with current flow and can be calculated using Ohm's law, it should be noted that volts drop occurs in both positive and negative conductors. The effects of volts drop can be reduced by increasing the conductors cross sectional area, this does not however eliminate the effects due to temperature variation. There are instances where large cross-section cables are not practical; for example most standard industrial connectors of the type used for sensors have a maximum conductor capacity of 0.75mm<sup>2</sup>, copper prices and ease of installation are other considerations.

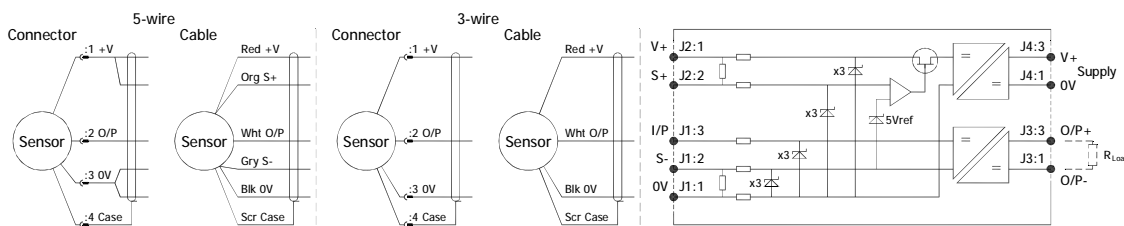
This is important because the effects of volts drop can significantly alter the perceived accuracy of the sensor which is ratiometric i.e. the output signal is directly affected by the voltage across the sensor. Changes in temperature will also be seen as gain variation in the sensor output.

**Three wire mode** connections are common and are suitable in most cases with short or moderate cable runs. Applications that do not require a high degree of accuracy but have cable runs, say in excess of 10m, volts drop can be reduced by introducing a terminal box close to the sensor and using a larger cross-section cable for a majority of the cable run. Sensors supplied with three core cable are calibrated with the cable fitted which largely eliminates errors due to conductor resistance at room temperature however, as mentioned above, small gain errors due to temperature fluctuations should be expected.

**Five wire mode** connections have significant benefits as losses in the positive and negative conductors are compensated for by the galvanic isolation amplifier which can 'sense' the voltage across the sensor and dynamically adjust the output voltage so that the voltage across the sensor is correct. The effects of cable resistance and associated temperature coefficients are eliminated allowing for smaller conductors than a three wire connection for the same cable run. The amplifier can compensate for up to 15Ω per conductor with a current flow of 15mA, which is more than adequate for 150m of 0.25 mm<sup>2</sup> cable, longer lengths will require larger conductors.

For this reason Positek® recommends five wire connections for cable lengths exceeding 10 metres in 0.25 mm<sup>2</sup> cable to preserve the full accuracy of the sensor.

See illustrations below for examples of connecting a sensor to the galvanic isolation amplifier.



Cable Length (metres)	Up to 150	150 - 300	300 - 450	450 - 600	600 - 900	900 - 1000
Cross Section (mm <sup>2</sup> )	0.25	0.5	0.75	1.0	1.5	2.0

The table above shows recommended conductor sizes with respect to cable length for both three and five wire connections, based on copper conductors. Three wire connections will introduce a gain reduction of 5% and a ±1% temperature dependence of gain over the range -40°C to +80°C for the cable temperature. (i.e. about -150 ppm/°C for the maximum lengths shown and less pro rata for shorter lengths.)

It should be noted that the maximum cable length, as specified in the sensor certification, takes precedence and must not be exceeded.

Positek® sensors are supplied with three core 0.25 mm<sup>2</sup> cable as standard, however five core 0.25 mm<sup>2</sup> cable can be supplied on request. The galvanic isolation amplifier is available as;

- G005-\*\*\* for 'G' and 'H' prefix sensors
- X005-\*\*\* for 'E', 'M' and 'X' prefix sensors

<sup>†</sup>  $R = \rho L/A$   $\rho$  is the resistivity of the conductor ( $\Omega m$ )  $L$  is the length of conductor (m)  $A$  is the conductor cross-sectional area (m<sup>2</sup>).

<sup>‡</sup> It is presumed that direct current flow is uniform across the cross-section of the wire, the galvanic isolation amplifier and sensor are a dc system.



# Intrinsically Safe - Mining Environments

## TIPS® SERIES M603 Large Angle Tilt Sensor

	a	b	c	d	e
M603	Displacement	A	Y	J	Z-code

a Displacement (degrees)		Value
Displacement in degrees	e.g. 0 - 54 degrees	54
b Output		
Supply V dc V <sub>s</sub> (tolerance)	Output	Code
+5V (4.5 - 5.5V)	0.5 - 4.5V (ratiometric with supply)	A
c Calibration Adjustments		Code
Sealed		Y
d Connections		Code
Connector	IP67 M12 IEC 60947-5-2	J
e Z-code		Code
Calibration to suit X005 - Default		Z000
Connector with cable option 'J' or 'JO' with length required in cm i.e. J500 specifies connector with 500cm of cable.		Z999

### Note!

All Intrinsically Safe (IS) sensors must have a Z-code suffix.  
IS sensors must be used in conjunction with a Galvanic Isolation Amplifier - See X005 for Output options.