Control Plus Inclinometer

The Control Plus inclinometer is a microprocessor controlled, dual axis, smart inclinometer. The angle sensing element is based on thermal convection and as such has no moving parts, is highly accurate and immune to electromagnetic noise. The 32bit microprocessor includes advanced Kalman filters to provide a stable signal for your application. The angular signal is available via serial RS232 communication or the 0-10 volt signal.

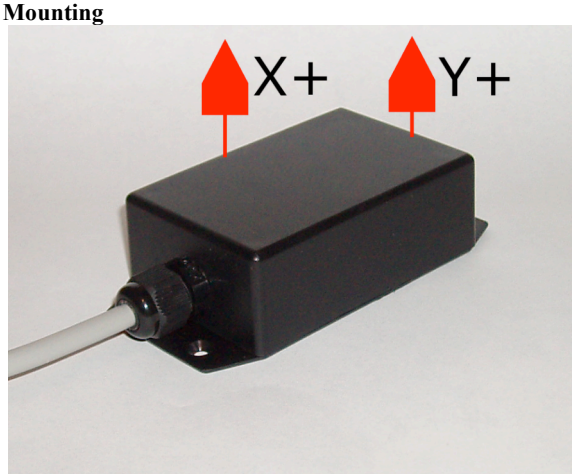
Characteristics

Property	Value
X axis range	-60 to +60 degrees
Y axis range	-60 to +60 degrees
Temperature range	0 to 70 degrees C
Supply voltage	15 volts DC required for analog output. 8 – 15 volts for serial only output.
Analog output	0 to 10 volts -60 to 60 degrees ie 5 volts = 0 degrees
Serial Communications	RS232
Size	83 x 54 x 31mm
Cable length	500mm

Connections

Wire Colour	Description
Red	+15Volts
Black	0 Volt
Green	TX Data
White	RX Data
Blue	X Axis 0-10volt signal
Yellow	Y Axis 0-10volt signal

Mounting



Communications Protocol

To obtain the most accurate reading from the inclinometer it is recommended to use the RS232 serial port. The analog output channels can be subjected to noise and conversion inaccuracies.

The communications protocol is a subset of the protocol used by microstrain.

Communications Properties

Property	Value
Baud	38400
Data Bits	8
Stop Bits	1
Parity	None

Read Current Values

Function	The inclinometer will reply with a packet containing the current values depending on parameter 7
Command	0x0E
Command Data	None
Response	11 bytes
Byte 1	0x0E
Byte 2	Value 1 MSB
Byte 3	Value 1 LSB
Byte 4	Value 2 MSB
Byte 5	Value 2 LSB
Byte 6	Value 3 MSB
Byte 7	Value 3 LSB
Byte 8	Timer Ticks MSB
Byte 9	Timer Ticks LSB
Byte 10	Checksum MSB
Byte 11	Checksum LSB

Data Scaling

Values returned in the "Read Current Values" packet are scaled as follows:-

Angles
-16383 to +16383 = -90 to +90 degrees

Temperature
current temperature inside the sensor in degrees C x 10
ie 312 = 31.2 degrees C

Gravity -16383 to +16383 = -1 to +1 g

Read Single Parameter

Function	The inclinometer will reply with a packet containing parameter data
Command	0x08
Command Data	1 Byte
Byte 1	Parameter number (0 – 16)
Response	2 bytes
Byte 1	Value 1 MSB
Byte 2	Value 1 LSB

Write Single Parameter

Function	Write data to the inclinometer parameter list
Command	0x09
Command Data	5 Bytes
Byte 1	0x71
Byte 2	Parameter number (0 – 16)
Byte 3	Data MSB
Byte 4	Data LSB
Byte 5	0xAA
Response	2 bytes
Byte 1	Data 1 MSB
Byte 2	Data 1 LSB

Read Firmware Version

Function	The inclinometer will reply with a packet containing the current firmware version
Command	0xF0
Command Data	None
Response	5 bytes
Byte 1	0xF0
Byte 2	Firmware MSB
Byte 3	Firmware LSB
Byte 4	Checksum MSB
Byte 5	Checksum LSB

Read Serial Number

Function	The inclinometer will reply with a packet containing the serial number
Command	0xF1
Command Data	None
Response	5 bytes
Byte 1	0xF1
Byte 2	Serial Number MSB
Byte 3	Serial Number LSB
Byte 4	Checksum MSB
Byte 5	Checksum LSB

Parameters

The inclinometer has 16 x 16bit words for the use of parameters

Parameter	Description
0	Flags – each bit turns ON/OFF a function 00 – use kalman filtered signal in the analog output channel for the X axis 01 – use kalman filtered signal in the analog output channel for the Y axis
1	Primary gain for X channel Kalman prediction algorithm (0 - 4095)
2	Process variance X channel
3	Measurement variance X channel
4	Primary gain for Y channel Kalman prediction algorithm (0 - 4095)
5	Process variance Y channel
6	Measurement variance Y channel
7	Values returned in 0x0E command packet 0 XKal, YKal, XRaw - ANGLES 1 XKal, YKal, YRaw - ANGLES 2 XKal, YKal, Temp – ANGLES (Default) 3 XKal, YKal, XRaw - GRAVITY 4 XKal, YKal, YRaw - GRAVITY 5 XKal, YKal, Temp - GRAVITY 6 XRaw, YRaw, Temp - ANGLES 7 XRaw, YRaw, Temp - GRAVITY
8	Spare
9	Spare
10	Spare
11	Spare
12	Spare
13	Spare
14	Spare
15	Spare

Kalman Filter

Kalman filter can be considered as two distinct parts.

1. Prediction from previous data
2. Correction of prediction based on sensor values

The prediction section uses prior information to predict the next value. This prediction is then corrected based on actual measurements from the sensors.

Prediction primary gain is a value 0 – 4095, default value is 3000, 0 disables the prediction function. If this parameter is set too high for your application the output of the filter will oscillate after a change in sensor angle.

The correction algorithm is controlled by 2 parameters.
Process Variance – the amount that the actual process changes between samples. Default value 1
Measurement Variance – the amount that the sensor measurement varies between samples. Default value 100.

It is recommended that for simple applications the process variance is left set to 1 and the value of the measurement variance is increased to increase the effect of the filter.

Update rate of the Kalman filter is 100Hz

Applications

This sensor has been specifically designed for use in longwall mining equipment, in particular longwall shearing machines (shearers). However, due to the high accuracy and high repeatability the sensor could be used in any application that requires inclination sensing.

- Underground mining
- Surface mining
- Automotive
- Shipping
- Aviation

Version	Description
1	Initial draft
2	Revision 2007-08-31