

**CTi-Sensors** 

## TILT – 57A Dynamic Dual-Axis Inclinometer



# TILT - 57A Three-Axis Accelerometer Three-Axis Gyroscope

## Dual-Axis Dynamic Inclinometer Datasheet



#### **CTi Sensors Technical Document**

This is our product specific technical data sheet. The following information is available to assist CTi Sensors customers in product development.

#### **TECHNICAL SUPPORT CONTACT INFO**

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Three-Axis Accelerometer Three-Axis Gyroscope

# Dual-Axis Dynamic Inclinometer Datasheet



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### **TILT – 57A**

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#### 1 Introduction

A **Dynamic Inclinometer** is an instrument for measuring angles of slope (or tilt), elevation or depression of an object with respect to gravity while it is not in stationary condition. As motion, vibration and shocks (external acceleration) will introduce errors in the tilt measurements, dynamic inclinometers (or tilt meters) often benefit from an on-board gyroscope and fusion algorithm which combines gyroscope and accelerometer data to rectify errors introduced by external accelerations.

The **TILT-57A** Dynamic Inclinometer series are high performance, high resolution dual axis dynamic inclinometers that use the latest miniature MEMS sensor technology.

#### 1.1 Features

- High-accuracy, dual-axis dynamic tilt sensor
- ullet Measuring range: Pitch:  $\pm 180^\circ$ , Roll:  $\pm 90^\circ$
- Static accuracy: ≤ 0.03° (Typical)
- High resolution:  $\leq 0.003^{\circ}$
- Ultra-low noise: 0.001°/√Hz
- Very low temperature offset drift: ±0.002°/°C (Typical)
- Highest output data rate: up to 2 kHz
- Three-axis accelerometer and three-axis gyroscope data
- Simple ASCII interface language
- IP 67 compliant connector, cable and housing
- Robust aluminum housing
- Low power consumption: 400 mW (80 mA @ 5 V)

#### 1.2 Applications

- Motion and dynamics measurements
- Dynamic platform alignment and stabilization
- Vehicle control: marine, robotics, automotive
- Inertial navigation and GPS compensation
- Agricultural and industrial vehicle tilt monitoring

Three-Axis Accelerometer Three-Axis Gyroscope

# **Dual-Axis Dynamic Inclinometer Datasheet**



2 Specifications

Pitch: ±180°, Roll: ±90°	2 Specifications	
Static Accuracy   So.03° RMS (Typical)	2.1 Angles	
Jynamic Accuracy         < 0.5° RMS (Typical)	Range	Pitch: ±180°, Roll: ±90°
Angular resolution $$\le 0.003^\circ$$ Noise density $0.001^\circ / \sqrt{\lg}z$ Zero offset error (pitch and roll) $0.001^\circ / \sqrt{\lg}z$ 2. Accelerometer $0.001^\circ / \sqrt{\lg}z$ 2. Accelerometer $0.002^\circ / ^\circ C$ (Typical) $0.025^\circ / ^\circ C$ (Typical) $0.007^\circ / ^\circ / ^\circ C$ (Typical) $0.007^\circ / ^\circ / ^\circ C$ (Typical) $0.007^\circ / ^\circ / ^\circ / ^\circ C$ (Typical) $0.007^\circ / ^\circ /$	Static Accuracy	≤ 0.03° RMS (Typical)
Noise density Zero offset error (pitch and roll) Offset change versus temperature  2.2 Accelerometer Range Range Acceleror temperature  2.2 Acceleror temperature  2.3 Gyroscope Range Range Range Rasonant frequency 2.4 kHz  2.5 $\frac{1}{1}$ km $\frac{1}{1}$	Dynamic Accuracy	< 0.5° RMS (Typical)
Zero offset error (pitch and roll) Offset change versus temperature  2.2 Accelerometer  Range Range Ponlinearity Acro offset error Bias change versus temperature 2.4 b. 5 mg (@20°C) Bias change versus temperature 2.5 mg (@20°C) Bias change versus temperature 3.6 mg (@20°C) Bias change versus temperature 4.0.5 mg (@20°C) Bias change versus temperature 2.6 mg (@20°C) Bias change versus temperature 3.7 mg (@20°C) Bias change versus temperature 3.8 mge Ange Ange Ange Ange Ange Ange And Y: <\0.03 m/Hz (@200Hz)  And Y: <\0.01 m/Fs  And Y: <\0.00 m/Fs (In-run compensated) C: <\0.02 m/Fs (In-run compensated) C: <\0.00 m/Fs (In-run compensated) C: <\0.02 m/Fs (In-run compensated) C: <\0.00 m/Fs (In-run	Angular resolution	≤ 0.003°
Gliset change versus temperature         2.2 Accelerometer         Range       ±2 g/±4 g/±8 g selectable         Nonlinearity       ±0.05% FS         Zero offset error       ≤±0.5 mg (@20°C)         Bias change versus temperature       ±0.03mg/°C (Typical)         Noise density       0.025 mg/√Hz (@200Hz)         Resonant frequency       2.4 kHz         2.3 Gyroscope       ***         Range       ±125/250/500/1000/2000°/s selectable         Nonlinearity       <0.1% FS	Noise density	0.001°/√Hz
2.2 Accelerometer         Range       ±2 g/±4 g/±8 g selectable         Nonlinearity       ±0.05% FS         Zero offset error       <±0.5 mg (@20°C)	Zero offset error (pitch and roll)	< ±0.02° (@20°C)
Range $\pm 2 \text{ g} / \pm 4 \text{ g} / \pm 8 \text{ g selectable}$ Nonlinearity $\pm 0.05\% \text{ FS}$ Zero offset error $<\pm 0.5 \text{ mg} (@20^{\circ}\text{C})$ Bias change versus temperature $\pm 0.03 \text{ mg} / ^{\circ}\text{C} (\text{Typical})$ Noise density $0.025 \text{ mg} / \sqrt{\text{Hz}} (@200 \text{Hz})$ Resonant frequency $2.4 \text{ kHz}$ 2.3 Gyroscope***Range $\pm 125/250/500/1000/2000^{\circ}/\text{s selectable}$ Nonlinearity $<0.1\% \text{ FS}$ Initial bias error $(@\pm 500^{\circ}/\text{s range})$ $\times 125/250/500/1000/2000^{\circ}/\text{s selectable}$ Bias change versus temperature $\times 1.00.5 \text{ s/s/°C}$ $\times 1.00.2 \text{ s/s/°C}$ $\times 1.00.2 \text{ s/s/°C}$ Noise density $\times 1.00.2 \text{ s/s/°C}$ Noise density $\times 1.00.7 \text{ s/s/°C}$ (In-run compensated)2.4 System $\times 1.00.7 \text{ s/s/°C}$ (In-run compensated)Power source $\times 1.00.7 \text{ s/s/°C}$ (In-run compensated)Power consumption $\times 1.00.7 \text{ s/s/°C}$ (In-run compensated)Power consumption $\times 1.00.7 \text{ s/s/°C}$ (In-run compensated)Output data rate $\times 1.00.7 \text{ s/s/°C}$ (In-run compensated) <td< td=""><td>Offset change versus temperature</td><td><math>\pm 0.002</math>°/°C (Typical)</td></td<>	Offset change versus temperature	$\pm 0.002$ °/°C (Typical)
Nonlinearity	2.2 Accelerometer	
Zero offset error       ≤±0.5 mg (@20°C)         Bias change versus temperature       ±0.03mg/°C (Typical)         Noise density       0.025 mg/Hz (@200Hz)         Resonant frequency       2.4 kHz         2.3 Gyroscope       ***125/250/500/1000/2000°/s selectable**         Range       ±125/250/500/1000/2000°/s selectable**         Nonlinearity       **0.1% FS         Initial bias error (@±500°/s range)       X and Y: <±0.05 °/s/°C	Range	$\pm 2$ g/ $\pm 4$ g/ $\pm 8$ g selectable
Bias change versus temperature  Noise density  Resonant frequency 2.3 Gyroscope  Range  Nonlinearity  Initial bias error (@±500°/s range)  Bias change versus temperature (Typical)  Noise density  2.4 System  Power source  Power consumption  Dutput data rate GUI software  GuI software  Serial interface options  Perotection  Dimension  Material (cable is optional as a third party product)  Temperature range  Cable gland connector M8, 6-contact (female)  2.4 KHz  2.4 System  4.1-38 VDC  4.00 mW (80 mA @ 5 V)  ASCII  Dimension  Dimension  Dimension  Dimension  Dimension  ASCII  Be of (housing, connector and cable)  Cable carrier: TPU or nylon Conductor insulation: PVC  -40°C to +85°C (-40°F to +185°F)  Cable gland connector M8, 6-contact (female)  2.6 Connector and Cable	Nonlinearity	
Bias change versus temperature  Noise density  Resonant frequency  2.3 Gyroscope  Range  Nonlinearity  Initial bias error (@±500°/s range)  Bias change versus temperature (Typical)  Noise density  2.4 System  Power source  Power consumption  Dittal data rate GUI software  GuI software  Serial interface options  Perotection  Dimension  Material (cable is optional as a third party product)  Connection*  Temperature range  Cable gland connector M8, 6-contact (female)  2.4 Sysc (Typical)  2.4 System  4.1-38 VDC  4.00 mW (80 mA @ 5 V)  ASCII  1.64" x 2.14" x 0.85"  Enclosure: anodized aluminum  Conductor insulation: PVC  Cable gland connector M8, 6-contact (female)  2.6 Connector and Cable  2.4 System  4.1-38 VDC  4.1-38 VDC  4.1-38 VDC  4.00 mW (80 mA @ 5 V)  4.00 mW (80 mA	Zero offset error	$<\pm 0.5 \text{ mg} (@20^{\circ}\text{C})$
Noise density       0.025 mg/√Hz (@200Hz)         Resonant frequency       2.4 kHz         2.3 Gyroscope       ****         Range       ±125/250/500/1000/2000°/s selectable         Nonlinearity       <0.1% FS	Bias change versus temperature	
Resonant frequency 2.3 Gyroscope Range ±125/250/500/1000/2000°/s selectable Nonlinearity  ±125/250/500/1000/2000°/s selectable    Initial bias error (@±500°/s range) X and Y: <±0.05 °/s/°C Z: <±0.2°/s/°C Z: <±0.025°/s/°C Noise density	•	
2.3 Gyroscope±125/250/500/1000/2000°/s selectableRange±125/250/500/1000/2000°/s selectableNonlinearity<0.1% FS		Si V
Range±125/250/500/1000/2000°/s selectableNonlinearity<0.1% FS		
Nonlinearity       <0.1% FS		±125/250/500/1000/2000°/s selectable
Initial bias error (@±500°/s range)  Bias change versus temperature (Typical)  Noise density  2.4 System  Power source  Power consumption  Data format  Output data rate  GUI software  Serial interface options  Temperature sensor resolution  Dimension  Material (cable is optional as a third party product)  Temperature range  Connection⁺  Temperature range  Connection⁺  Temperature range  Connection⁺  Cable gland connector M8, 6-contact (female)  X and Y: <±0.05 °/s/°C  Z: <±0.02 °/s/°C (In-run compensated)  Z: <±0.025 °/s/°C (In-run compensated)  Zi <\text{4.38 VDC}  Zi <0.001 × (Ø10 NH)  Zi <2.14 ° x <2.14 ° x <2.85 ° x <2.8485, USB, UART, RS485 w/ multi-drop networking  Dimension  IP 67 (housing, connector and cable)  IP 67 (housing, connector and cable)  Cable data rate  Cable and Y: <±0.025 ° x <2.44 ° x <2.85 ° x <2.44 ° x <2.85 ° x <2.44 ° x <2.85 ° x <2.44 ° x <2.45		
Bias change versus temperature (Typical)  Noise density  2. < ±0.02 °/s/°C  Noise density  2. 4 System  Power source  Power consumption  Data format  Output data rate  GUI software  Serial interface options  Temperature sensor resolution  Dimension  Material (cable is optional as a third party product)  Temperature range  Cable gland connector M8, 6-contact (female)  Z: < ±0.2 °/s/°C  X and Y: < ±0.01 °/s/°C (In-run compensated)  Z: < ±0.02 °/s/°C  X and Y: < ±0.01 °/s/°C (In-run compensated)  Z: < ±0.02 °/s/°C  X and Y: < ±0.01 °/s/°C (In-run compensated)  Z: < ±0.02 °/s/°C  (In-run compensated)  Z: < ±0.02 °/s/°C  (In-run compensated)  Z: < ±0.02 °/s/°C  (In-run compensated)  Z: < ±0.02 °/s/°C  (In-run compensated)  Z: < ±0.02 °/s/°C  (In-run compensated)  Z: < ±0.02 °/s/°C  (In-run compensated)  Z: < ±0.02 °/s/°C (In-run compensated)  Z-10 °/s/°C  Z-10 mW (80 mA Ø 5 V)  Alon mW (80 mA Ø 5 V)  Alo	-	X and Y: $<\pm0.05$ °/s/°C
Bias change versus temperature (Typical)  Noise density  2.4 System  Power source Power consumption Data format Output data rate GUI software  Serial interface options Temperature sensor resolution Dimension  Material (cable is optional as a third party product)  Temperature range Connection  Temperature range Connection  Temperature range Cable gland connector M8, 6-contact (female)  Z. *A and Y: <±0.01 °/s/°C (In-run compensated) Z: <±0.01 °/s/°C (In-run compensated) Z: <±0.01 °/s/°C (In-run compensated) Z: <±0.02 °/s/°C  0.007 dps/√Hz (@10Hz)  4.1-38 VDC 4.00 mW (80 mA @ 5 V) 4.00 mW	Initial bias error (@ $\pm$ 500°/s range)	
(Typical)Z: <±0.025 °/s/°CNoise density0.007 dps/√Hz (@10Hz)2.4 System4.1-38 VDCPower source4.1-38 VDCPower consumption400 mW (80 mA @ 5 V)Data formatASCIIOutput data rate1 Hz to 2 kHz selectableGUI softwareWinCTi-Tilt-57®Serial interface optionsRS232, RS422, RS485, USB, UART, RS485 w/ multi-drop networkingTemperature sensor resolution1P 67 (housing, connector and cable)2.5 MechanicsIP 67 (housing, connector and cable)ProtectionIP 67 (housing connector and cable)Material (cable is optional as a third party product)Enclosure: anodized aluminum Connector: brass / nickelCable molded head: TPU Cable carrier: TPU or nylon Conductor insulation: PVCTemperature range-40°C to +85°C (-40°F to +185°F)Connection†Cable gland connector M8, 6-contact (female)2.6 Connector and Cable	Bias change versus temperature	
Power source 4.1-38 VDC  Power consumption 400 mW (80 mA @ 5 V)  Data format ASCII  Output data rate 1 Hz to 2 kHz selectable  GUI software WinCTi-Tilt-57®  Serial interface options RS232, RS422, RS485, USB, UART, RS485 w/ multi-drop networking  Temperature sensor resolution 0.2°C  2.5 Mechanics  Protection IP 67 (housing, connector and cable)  Dimension 1.64" x 2.14" x 0.85"  Enclosure: anodized aluminum  Connector: brass / nickel  (cable is optional as a third party product) Cable carrier: TPU or nylon  Conductor insulation: PVC  Temperature range -40°C to +85°C (-40°F to +185°F)  Connection† Cable gland connector M8, 6-contact (female)	(Typical)	
Power source 4.1-38 VDC  Power consumption 400 mW (80 mA @ 5 V)  Data format ASCII  Output data rate 1 Hz to 2 kHz selectable  GUI software WinCTi-Tilt-57®  Serial interface options RS232, RS422, RS485, USB, UART, RS485 w/ multi-drop networking  Temperature sensor resolution 0.2°C  2.5 Mechanics  Protection IP 67 (housing, connector and cable)  Dimension 1.64" x 2.14" x 0.85"  Enclosure: anodized aluminum  Material (cable is optional as a third party product) Cable molded head: TPU  Cable carrier: TPU or nylon  Conductor insulation: PVC  Temperature range -40°C to +85°C (-40°F to +185°F)  Connection† Cable gland connector M8, 6-contact (female)	Noise density	0.007 dps/\sqrt{Hz (@10Hz)}
Power consumption400 mW (80 mA @ 5 V)Data formatASCIIOutput data rate1 Hz to 2 kHz selectableGUI softwareWinCTi-Tilt-57®Serial interface optionsRS232, RS422, RS485, USB, UART, RS485 w/ multi-drop networkingTemperature sensor resolution0.2°C2.5 MechanicsIP 67 (housing, connector and cable)Dimension1.64" x 2.14" x 0.85"Material (cable is optional as a third party product)Enclosure: anodized aluminum Connector: brass / nickel Cable molded head: TPU Cable carrier: TPU or nylon Conductor insulation: PVCTemperature range-40°C to +85°C (-40°F to +185°F)Connection†Cable gland connector M8, 6-contact (female)	2.4 System	
Data format Output data rate GUI software  Serial interface options Temperature sensor resolution  2.5 Mechanics Protection Dimension  Material (cable is optional as a third party product)  Temperature range Connection  Temperature range Connector and Cable  ASCII  1 Hz to 2 kHz selectable WinCTi-Tilt-57® RS232, RS422, RS485, USB, UART, RS485 w/ multi-drop networking 0.2°C  IP 67 (housing, connector and cable)  IP 67 (housing, connector and cable)  Enclosure: anodized aluminum Connector: brass / nickel Cable molded head: TPU Cable carrier: TPU or nylon Conductor insulation: PVC  Temperature range Cable gland connector M8, 6-contact (female)	Power source	4.1-38 VDC
Data format Output data rate GUI software  Serial interface options Temperature sensor resolution  2.5 Mechanics Protection Dimension  Material (cable is optional as a third party product) Temperature range Connection  Temperature range Connector and Cable  ASCII  1 Hz to 2 kHz selectable WinCTi-Tilt-57® RS232, RS422, RS485, USB, UART, RS485 w/ multi-drop networking 0.2°C  IP 67 (housing, connector and cable)  IP 67 (housing, connector and cable)  Enclosure: anodized aluminum Connector: brass / nickel Cable molded head: TPU Cable carrier: TPU or nylon Conductor insulation: PVC  Temperature range Cable gland connector M8, 6-contact (female)	Power consumption	400 mW (80 mA @ 5 V)
GUI software  Serial interface options Temperature sensor resolution  2.5 Mechanics Protection Dimension  Material (cable is optional as a third party product)  Temperature range Connection  Temperature range Connection  Connector and cable  WinCTi-Tilt-57®  RS232, RS422, RS485, USB, UART, RS485 w/ multi-drop networking 0.2°C  IP 67 (housing, connector and cable)  1.64" x 2.14" x 0.85"  Enclosure: anodized aluminum Connector: brass / nickel Cable molded head: TPU Cable carrier: TPU or nylon Conductor insulation: PVC  Temperature range -40°C to +85°C (-40°F to +185°F) Cable gland connector M8, 6-contact (female)  2.6 Connector and Cable		ASCII
Serial interface optionsRS232, RS422, RS485, USB, UART, RS485 w/ multi-drop networkingTemperature sensor resolution0.2°C2.5 MechanicsIP 67 (housing, connector and cable)Dimension1.64" x 2.14" x 0.85"Material (cable is optional as a third party product)Enclosure: anodized aluminum Connector: brass / nickel Cable molded head: TPU Cable carrier: TPU or nylon Conductor insulation: PVCTemperature range-40°C to +85°C (-40°F to +185°F)Connection†Cable gland connector M8, 6-contact (female)2.6 Connector and CableCable gland connector M8, 6-contact (female)	Output data rate	1 Hz to 2 kHz selectable
Temperature sensor resolution  2.5 Mechanics  Protection  Dimension  Material (cable is optional as a third party product)  Temperature range  Connection†  Connector and cable  0.2°C  IP 67 (housing, connector and cable)  1.64" x 2.14" x 0.85"  Enclosure: anodized aluminum Connector: brass / nickel Cable molded head: TPU Cable carrier: TPU or nylon Conductor insulation: PVC  -40°C to +85°C (-40°F to +185°F)  Cable gland connector M8, 6-contact (female)  2.6 Connector and Cable	GUI software	WinCTi-Tilt-57®
Protection  Dimension  IP 67 (housing, connector and cable)  1.64" x 2.14" x 0.85"  Enclosure: anodized aluminum  Connector: brass / nickel  (cable is optional as a third party product)  Cable molded head: TPU  Cable carrier: TPU or nylon Conductor insulation: PVC  Temperature range  -40°C to +85°C (-40°F to +185°F)  Connection†  Cable gland connector M8, 6-contact (female)	Serial interface options	RS232, RS422, RS485, USB, UART, RS485 w/ multi-drop networking
Protection Dimension  IP 67 (housing, connector and cable)  1.64" x 2.14" x 0.85"  Enclosure: anodized aluminum Connector: brass / nickel (cable is optional as a third party product)  Cable molded head: TPU Cable carrier: TPU or nylon Conductor insulation: PVC  Temperature range  -40°C to +85°C (-40°F to +185°F)  Connection†  Cable gland connector M8, 6-contact (female)	Temperature sensor resolution	0.2°C
Dimension  1.64" x 2.14" x 0.85"  Enclosure: anodized aluminum  Connector: brass / nickel  (cable is optional as a third party product)  Cable molded head: TPU  Cable carrier: TPU or nylon  Conductor insulation: PVC  Temperature range  -40°C to +85°C (-40°F to +185°F)  Connection†  Cable gland connector M8, 6-contact (female)	2.5 Mechanics	
Dimension  1.64" x 2.14" x 0.85"  Enclosure: anodized aluminum  Connector: brass / nickel  (cable is optional as a third party product)  Cable molded head: TPU  Cable carrier: TPU or nylon  Conductor insulation: PVC  Temperature range  -40°C to +85°C (-40°F to +185°F)  Connection†  Cable gland connector M8, 6-contact (female)	Protection	IP 67 (housing, connector and cable)
Material (cable is optional as a third party product)  Temperature range  Connector: brass / nickel Cable molded head: TPU Cable carrier: TPU or nylon Conductor insulation: PVC  Temperature range  -40°C to +85°C (-40°F to +185°F)  Cable gland connector M8, 6-contact (female)	Dimension	
Material (cable is optional as a third party product) Cable molded head: TPU Cable carrier: TPU or nylon Conductor insulation: PVC  Temperature range Connection† Cable gland connector M8, 6-contact (female)  Connector: brass / nickel Cable molded head: TPU Cable carrier: TPU or nylon Conductor insulation: PVC  -40°C to +85°C (-40°F to +185°F)  Cable gland connector M8, 6-contact (female)		
(cable is optional as a third party product)Cable molded head: TPU Cable carrier: TPU or nylon Conductor insulation: PVCTemperature range-40°C to +85°C (-40°F to +185°F)Connection†Cable gland connector M8, 6-contact (female)2.6 Connector and Cable	Material	
Cable carrier: TPU or nylon Conductor insulation: PVC  Temperature range -40°C to +85°C (-40°F to +185°F)  Connection† Cable gland connector M8, 6-contact (female)  2.6 Connector and Cable		
Conductor insulation: PVC  Temperature range -40°C to +85°C (-40°F to +185°F)  Connection† Cable gland connector M8, 6-contact (female)  2.6 Connector and Cable	, , , , , , , , , , , , , , , , , , , ,	Cable carrier: TPU or nylon
Connection† Cable gland connector M8, 6-contact (female)  2.6 Connector and Cable		
Connection† Cable gland connector M8, 6-contact (female)  2.6 Connector and Cable	Temperature range	-40°C to +85°C (-40°F to +185°F)
2.6 Connector and Cable		` ′
		Male cable M8, 6-pin (straight or right angle)

 $<sup>^{\</sup>dagger}$  Cable is a third-party product with temperature tolerance from -40°C to +105°C (-40°F to +221°F).

## Dual-Axis Dynamic Inclinometer Datasheet

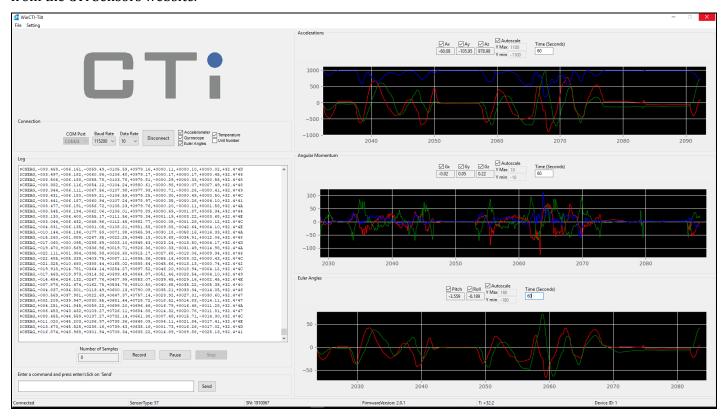


### 3 Terminal Assignment

Connector	RS232/UART/USB#	RS422	RS485	Wire Color
Pin 1	+Vin	+Vin	+Vin	Brown
Pin 2	GND	GND	GND	White
Pin 3	TX	TX+	D+	Blue
Pin 4	_	TX-	D-	Black
Pin 5	RX	RX+	D+	Gray
Pin 6	_	RX-	D-	Pink
1 6 2 5 0 3	Device: M 8 – 6-contact (f	emale)	Cable: M 8 – 6-pin (ma	ale) $3 + \frac{1}{4} + \frac{1}{5}$

### 4 WinCTi-Tilt Software

WinCTi-Tilt is a graphical user interface (GUI) software provided by CTi Sensor Inc. for visualization aid, device configuration, and data logging. WinCTi-Tilt is designed to be intuitive to users. The package can be downloaded from the CTi Sensors website.



 $<sup>^{\</sup>ddagger}$  USB is a third-party produce with temperature tolerance from -40°C to +105°C (-40°F to +221°F).

<sup>&</sup>lt;sup>‡</sup> USB uses UART interface and a UART to USB cable.

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## Dual-Axis Dynamic Inclinometer Datasheet



#### 5 Serial Interface and Data Format

The TILT-57A uses the following ASCII format, very similar to the widely used NMEA 0183 protocol, for data output:

Inclinometer message: \$CSEAG,U,α<sub>X</sub>,α<sub>Y</sub>,A<sub>X</sub>,A<sub>Y</sub>,A<sub>Z</sub>,G<sub>X</sub>,G<sub>Y</sub>,G<sub>Z</sub>,T\*CC<CR><LF>

#### Which:

A<sub>X</sub>,A<sub>Y</sub>,A<sub>Z</sub>: X, Y and Z accelerations in milli g (three-axis accelerometer data)

G<sub>X</sub>, G<sub>Y</sub>, G<sub>Z</sub>: X, Y and Z angular velocities in deg/s (three-axis gyroscope data)

 $\alpha_X$ ,  $\alpha_Y$ : Roll & Pitch angles in degrees

T: Internal temperature in degrees Celsius

U: Device unit number

CC: Checksum (Two ASCII characters)

<CR> <LF>: Carriage return, and line feed characters

#### Example:

\$CSEAG,1,+006.756,-003.813,+0116.53,-0065.42,+0981.42,,+000.21,-000.16,-000.27,+29.7\*68

Within the inclinometer message, the temperature, accelerometer, gyroscope, or angle portion of the message may be turned on or off. See Section 8 for specific commands.

The inclinometer message may run in full at an output data rate of up to 500 Hz. With only 2 of the 3 data message portions turned on (accelerometer, gyroscope or angles), the inclinometer message may be run at an output data rate of up to 1 kHz. With only 1 of the 3 message portions turned on, the inclinometer message may be run at an output data rate of up to 2 kHz. When running at 1kHz and 2kHz, it is recommended that the other message portions (temperature and unit number) be turned off if they are not needed.

Because the updated data rate is always saved into the device's flash memory but the updated baud rate is not, it is possible to create a scenario where the data rate is too high for the baud rate to support. This will not damage the sensor, but it may print gibberish to the screen. To prevent this problem, if selected data rate is greater than 100 Hz, it is recommended to save the baud rate to the flash memory, or change the data rate to lower number before disconnecting the sensor. The baud rate can be saved to the flash memory with the command "[nBFW<cr>" (without the quotes). If one encounters this problem, it can easily be remedied by setting a lower data rate, i.e. "[1D10<cr>" (so long as the baud rate matches that of the sensor, commands will go through).

#### 6 8-bit Checksum

The checksum is calculated by XORing all characters between \$ and \* (not including the \$ and the \* characters) based on the NMEA standard. It results in two hexadecimal characters, which are sent in ASCII format.

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#### 7 Header

The header of the inclinometer message will change depending on its contents. Portions of the inclinometer message can be turned on and off with commands seen in the Configuration Commands section below.

Header	Angles	Accelerometer	Gyroscope
\$CSEAG	On	On	On
\$CSNAG	Off	On	On
\$CSENG	On	Off	On
\$CSEAN	On	On	Off
\$CSNNG	Off	Off	On
\$CSNAN	Off	On	Off
\$CSENN	On	Off	Off
\$CSNNN	Off	Off	Off

### **8 Configuration Commands**

The TILT-57A uses a simple command format which allows the user to change the device configuration and request specific information or data. All commands start with a '[' character, and end with a carriage return character. All responses end with a carriage return and newline character. The table below shows the list of the interface commands for the TILT-57A series.

In the table below, lowercase 'n' represents the unit number, which is set to 1 by default, and can be set by user to any number from 1 to 9. The lowercase letters 'm', 'x', and 'y' represent variable inputs that can be used to set the properties of the device. The lowercase letter 'd' represents variable outputs. In the commands, uppercase letters and other characters do not change.

Command	Comments	Response	Comments
[n <cr></cr>	Ping unit number n	>!n	Acknowledge ping
[N? <cr></cr>	Request unit number	>Unit Number: n	Returns unit number, default: n=1
[n#m <cr></cr>	Change unit number n to (non-zero) unit number m, $1 \le m \le 9$	>New Unit Number: n	n=old unit number, m=new unit number, default: n=1
[n#FW <cr></cr>	Save unit number into flash memory	>Current Unit Number, n, was written into flash memory as the default Unit Number for this device!	Unit number will be changed permanently, and current unit number will be saved into the flash memory as the default unit number.
[nV <cr></cr>	Firmware Version	>Firmware Version: d.d	Returns firmware version
[nS <cr></cr>	Serial Number	>Device n Serial Number: ddddddd	Returns 7-digit serial number

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[nBxxx <cr></cr>	Baud rate setting:	>Change to new Baud	Selected baud rate should support
	xxx= 2:2400, 4:4800, 9:9600, 19:19200, 38:38400, 57:57600, 115:115200, 230:230400, 460:460800, 921:921600 (bps)	Rate: dddddd	current data rate. Otherwise, baud rate will not be changed.
[nBFW <cr></cr>	Save baud rate into flash memory	>Current Baud Rate, dddddd, was written into flash memory as the default Baud Rate!	Baud rate will be changed permanently, and current baud rate will be saved into the flash memory.
[nDxx <cr></cr>	Data rate setting: xx= 1, 2, 5, 10, 20, 25, 40, 50,100, 200, 500, 1000, and 2000 Hz	>New Output Data Rate: dddd	Default data rate is 2 Hz. New data rate will be saved into the flash memory.
[nARx <cr></cr>	Selecting accelerometer measurement range: x=2, 4, 8	> New Accelerometer Range: +/-d g	New accelerometer range will be saved into the flash memory (Default: ±4 g).
[nGRx <cr></cr>	Selecting gyroscope measurement range: x= 0:2000, 1:1000, 2:500, 3:250 °/s	>New Gyroscope Range: ±dddd°/s	New gyroscope range will be saved into the flash memory (Default: ±500°/s)
[nZA <cr></cr>	Zero g offset correction for X and Y axes	>Accelerometer Zero Offset Adjusted: X Offset: ddd, Y Offset: ddd	Current values of $A_x$ and $A_y$ will be saved into the flash memory as the zero g offset.
[nMIy <cr></cr>	Output message ON/OFF y = S: single message y = C: Continuous message y = X: Message off	>Send one Message Or >Send continuous Message Or >Message OFF	Example for inclinometer data: [1MIS: Sends out one data message [1MIC: Continuously sends out data message [1MIX: Stops sending out data message
[nALPFx <cr></cr>	Accelerometer low pass filter setting: x = 0:1, 1:2, 2,:4, 3:8, 4:16, 5:31, 6:62, 7:125, 8:250, 9:500, 10:1000 Hz	>Accelerometer low pass filter bandwidth: ddd Hz	Default filter is 31 Hz. New low pass filter will be saved into flash memory.
[nALPF? <cr></cr>	Request accelerometer low pass filter setting.	>Accelerometer low pass filter bandwidth: ddd Hz	Default filter is 31 Hz.
[nGLPFx <cr></cr>	Gyroscope low pass filter setting: x = 0:11, 1:21, 2,:40, 3:75, 4:137, 5:255, 6:524, 7:890, Hz	>Gyroscope low pass filter bandwidth: ddd Hz	Default filter is 40 Hz. New low pass filter will be saved into flash memory.

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[nGLPF? <cr></cr>	Request gyroscope low pass filter setting.	>Gyroscope low pass filter bandwidth: ddd Hz	Default filter is 40 Hz.
[nANFx <cr></cr>	Accelerometer message portion ON/OFF $x = 0$ : Off $x = 1$ : On	>Accelerometer portion of data turned ON/OFF in message.	Only 1 of 3 data messages can be turned on for sensor to run at 2kHz. Only 2 of 3 messages can be turned on for the sensor to run at 1kHz.
[nGNFx <cr></cr>	Gyroscope message portion ON/OFF $x = 0$ : Off $x = 1$ : On	>Gyroscope portion of data turned ON/OFF in message.	Only 1 of 3 data messages can be turned on for sensor to run at 2kHz. Only 2 of 3 messages can be turned on for the sensor to run at 1kHz.
[nENFx <cr></cr>	Roll/Pitch message portion ON/OFF x = 0: Off x = 1: On	>Euler angles portion of data turned ON/OFF in message.	Only 1 of 3 data messages can be turned on for sensor to run at 2kHz. Only 2 of 3 messages can be turned on for the sensor to run at 1kHz.
[nTNFx <cr></cr>	Temperature message portion ON/OFF $x = 0$ : Off $x = 1$ : On	>Temperature portion of data turned ON/OFF in message.	For optimal performance, should be turned off when the sensor is running at 1kHz or 2kHz.
[nUNFx <cr></cr>	Unit number message portion ON/OFF $x = 0$ : Off $x = 1$ : On	>Unit number portion of data turned ON/OFF in message.	For optimal performance, should be turned off when the sensor is running at 1kHz or 2kHz.
[nMICFW <cr></cr>	Save output message ON/OFF status into flash memory	>Current ON/OFF message status was written into flash memory as the default status!	Current message ON/OFF status will be saved into flash memory.

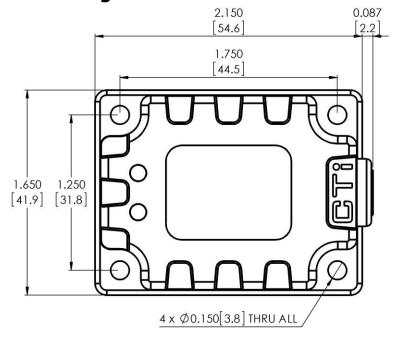
**Three-Axis Gyroscope** 

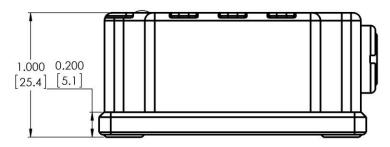
## **Dual-Axis Dynamic Inclinometer**

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## **Dimensional Drawing**



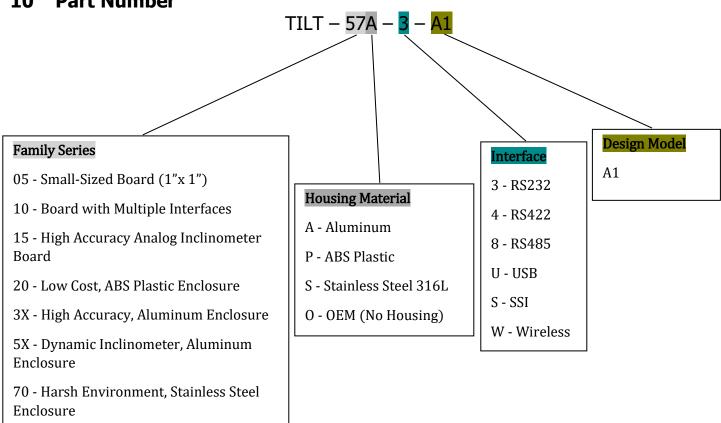


Inch [millimeter]

# Dual-Axis Dynamic Inclinometer Datasheet

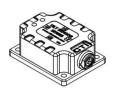






### 11 Horizontal Installation Position

Measuring range: ±90° (two-dimensional)





Default Y=0



 $\begin{array}{c} Inclination \\ Y=+30 \end{array}$ 



Default X=0



Inclination X=+30

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## 12 Revision History

Revision Number	Revision Date	Description of Changes
1.0	10/2018	Created document based on initial specifications
1.1	12/2018	Updated document to reflect new command structure
1.2	2/2019	Updated document to reflect new message structure
1.3	4/2019	Updated the GUI picture and some specifications

<u>WARRANTY</u>: This product has 18 months limited warranty. For more information, please visit: <u>www.CTiSensors.com/warranty</u>

This product is designed and manufactured in the U.S.A.

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All contents of this document are subject to change without notice.