

Manual

Two axis inclinometer TILT001-2DO-USB

Features

- Two-axis inclination measurement.
- USB interface (HID class device).
- USB powered or external supply.
- Two isolated alarm outputs.
- Two diagnostic LEDs.
- Alarm conditions configurable.
- Standalone operation.
- Desktop software (calibration, configuration, test).

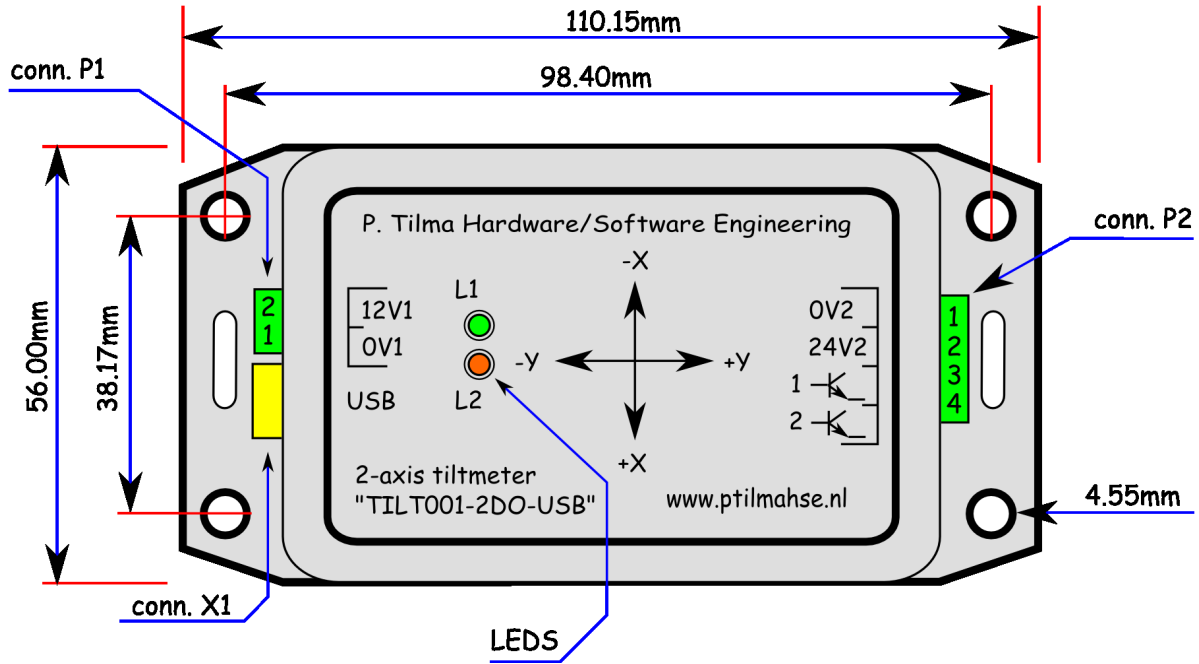
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Section 2 - **General description**

The TILT001-2DO-USB is a two axis intelligent inclinometer. The device can be powered by USB or by an external supply (automatic switchover). Sensor and electronics are housed in an enclosure which can be easily mounted. Communication with the device is possible by means of the USB interface. Commands are implemented to perform calibration, change operational mode or request measurements for inclination and acceleration. Desktop software is included for configuration and testing. The module is equipped with two configurable optoisolated digital outputs.

Section 3 - Dimensions and connections



Connector X1 - USB B	Signal name	Description
Pin 1	VCC	+5V
Pin 2	D-	Data -
Pin 3	D+	Data +
Pin 4	GND	Ground

Connector P1	Signal name	Description
Pin 1	OV1	Power supply return
Pin 2	12V1	Power supply 12V

Connector P2	Signal name	Description
Pin 1	OV2	Output supply return
Pin 2	24V2	Output supply
Pin 3	Output 1	High side power switch
Pin 4	Output 2	High side power switch

Section 4 - Technical specifications

Electrical	Operating conditions	Max. ratings
Supply voltage	5..13V	
Supply current	25mA @ 5V	
Digital outputs (2)	24V	200mA

Mechanical	
Enclosure dimension (length x width x height)	110mm x 56mm x 25mm
Enclosure material	ABS plastic
Enclosure mounting holes	
Connector USB	Device USB type B
Connector power supply	Phoenix MC1,5/2-G-3,81
Connector digital outputs	Phoenix MC1,5/4-G-3,81

Environmental	
Operating temperature	-20°C .. +20°C
Humidity	
Protection	

Measurement	
Number of axes	2
Range per axis inclination / acceleration	70° / 1000mg
Inclination resolution / accuracy	0.1° / 0.2°
Acceleration resolution/ accuracy	1 mg / 5mg

USB interface	
Interface	USB 2.0 Full speed (12 Mbits/s)
Device class	HID (Human Interface Device)
Connector	Standard USB B

Software	
USB	Full speed
Driver	HID (Human Interface Device)
Desktop application	Windows/x86

Section 5 - HID class device

The TILT001-2DO-USB conforms to the USB HID Class specification version 1.1. After the inclinometer has been connected with your desktop computer (on which an usb-aware operating system is running), the device will automatically be identified as a HID class device. The desktops operating system will then load a HID class device driver. The host now can send and receive data by sending and requesting reports in control or interrupt transfers.

The Windows PC application program makes use of the following functions :

Windows HID API	
API function	Purpose
HidD_GetFeature()	Read a feature report (USB control transfer)
HidD_SetFeature()	Send a feature report (USB control transfer)
ReadFile()	Read an input report (USB interrupt transfer)

Section 6 - Communication protocol

Commands are implemented to request measurements for inclination and acceleration, perform calibration and change operational mode. The supplied PC application program makes use of these different commands.

Test			
USB transfer	Report id	Report size	Description
Control	0x01	0x27	Get software version
Control	0x02	1	Toggle digital output 1
Control	0x03	1	Toggle digital output 2
Control	0x04	1	Toggle led L1
Control	0x05	1	Toggle led L2
Control	0x06	1	Toggle onboard led
Control	0x07	2	Power source (USB or external)
Control	0x09	2	Get number USB interrupts
Control	0x09	2	Get acceleration sensor type
Control	0x0a	2	Get device address

Measurement			
USB transfer	Report id	Report size	Description
Control	0x10	4	Get acceleration values for Xaxis and Y-axis
Control	0x11	4	Get inclination values for Xaxis and Y-axis
Control	0x12	1	Measurement inclination on
Control	0x13	1	Measurement inclination off
Control	0x14	2	Get onboard temperature
Control	0x15	4	Get duty cycle X axis (* 1000)
Control	0x16	4	Get duty cycle Y axis (* 1000)
Control	0x17	2	Get update rate per second
Control	0x18	2	Set filter property
Control	0x19	2	Get filter property
Interrupt	0x20	2	Inclination X-axis
Interrupt	0x21	2	Inclination Y-axis
Interrupt	0x22	2	Acceleration X-axis
Interrupt	0x23	2	Acceleration Y-axis

Initialisation			
USB transfer	Report id	Report size	Description
Control	0x30	1	Set calibration and alarm variables to default
Control	0x31	1	Set calibration variables to default
Control	0x32	1	Set alarm variables to default
Control	0x33	1	Enable sending inclination to USB
Control	0x34	1	Disable sending inclination to USB
Control	0x35	1	Enable sending acceleration to USB
Control	0x36	1	Disable sending acceleration to USB

Calibration			
USB transfer	Report id	Report size	Description
Control	0x40	2	Set calibration value for X-axis horizontal
Control	0x41	2	Set calibration value for X-axis vertical (-1g)
Control	0x42	2	Set calibration value for X-axis vertical (+1g)
Control	0x43	2	Get calibration value for X-axis horizontal
Control	0x44	2	Get calibration value for X-axis vertical (-1g)
Control	0x45	2	Get calibration value for X-axis vertical (+1g)
Control	0x46	2	Set calibration value for Y-axis horizontal
Control	0x47	2	Set calibration value for Y-axis vertical (-1g)
Control	0x48	2	Set calibration value for Y-axis vertical (+1g)
Control	0x49	2	Get calibration value for Y-axis horizontal
Control	0x4a	2	Get calibration value for Y-axis vertical (-1g)
Control	0x4b	2	Get calibration value for Y-axis vertical (+1g)

Alarm configuration			
USB transfer	Report id	Report size	Description
Control	0x50	2	set inclination alarm low value X axis
Control	0x51	2	set inclination alarm high value X axis
Control	0x52	2	get inclination alarm low value X axis
Control	0x53	2	get inclination alarm high value X axis
Control	0x54	2	set inclination alarm low value Y axis
Control	0x55	2	set inclination alarm high value Y axis
Control	0x56	2	get inclination alarm low value Y axis
Control	0x57	2	get inclination alarm high value Y axis
Control	0x58	2	set max. acceleration change value X axis
Control	0x59	2	get max. acceleration change value X axis
Control	0x5a	2	set max. acceleration change value Y axis
Control	0x5b	2	get max. acceleration change value Y axis
Control	0x5c	4	set assignment of alarms to outputs
Control	0x5d	4	get assignment of alarms to outputs
Control	0x5e	2	set hysteresis inclination alarm
Control	0x5f	2	get hysteresis inclination alarm
Control	0x60	2	set output behaviour
Control	0x61	2	get output behaviour
Interrupt	0x70	2	Vibration alarm X-axis
Interrupt	0x71	2	Vibration alarm Y-axis
Interrupt	0x72	2	Inclination alarm X-axis
Interrupt	0x73	2	Inclination alarm Y-axis

Bit assignment command "setAlarmAss".

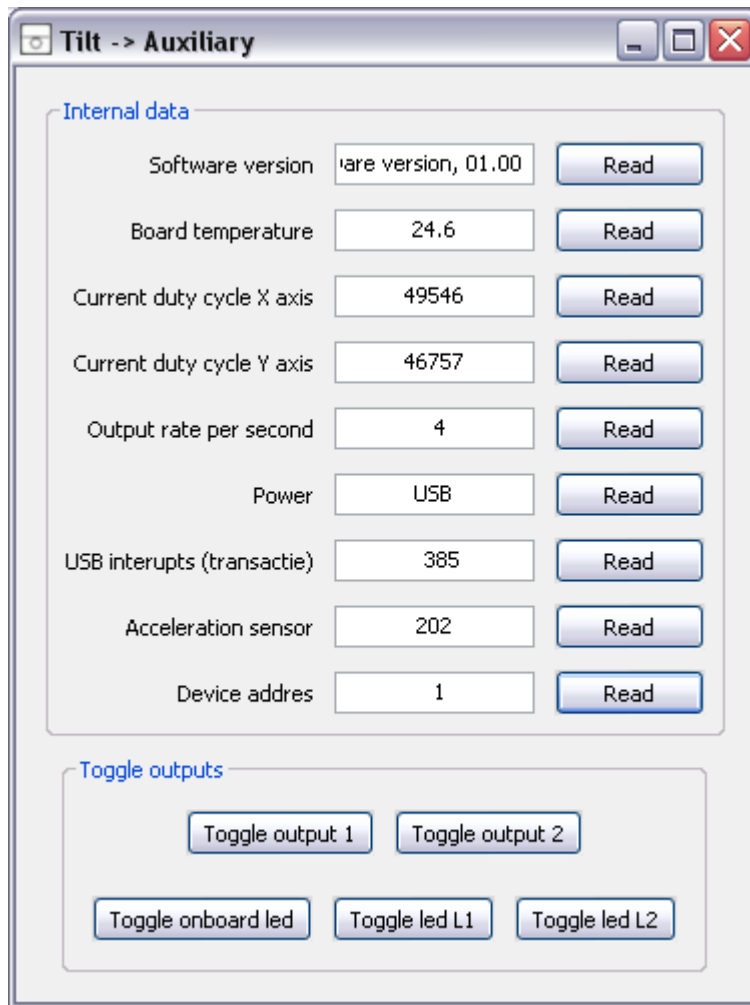
	Output 1	Output 2	L1 (led)	L2 (led)	USB
Vibration X axis	bit 31	bit 30	bit 29	bit 28	bit 27
Vibration Y axis	bit 23	bit 22	bit 21	bit 20	bit 19
Inclination X-axis	bit 15	bit 14	bit 13	bit 12	bit 11
Inclination Y-axis	bit 7	bit 6	bit 5	bit 4	bit 3

Bit assignment command "setOutputConf"

	Polarity	Freeze	Pattern
Output 1	bit 15	bit 14	bit 13
Output 2	bit 11	bit 10	bit 9
L1 (led)	bit 7	bit 6	bit 5
L2 (led)	bit 3	bit 2	bit 1

Section 7 - Temperature compensation

The output of the tilt sensing element inside the TILT001-2DO-USB is not entirely independant of temperature. Especially in the case of large temperature differences this effect might influence accuracy. Thats why hardware and software have been implemented to compensate for this effect.



Read current board temperature

Section 8 - Calibration

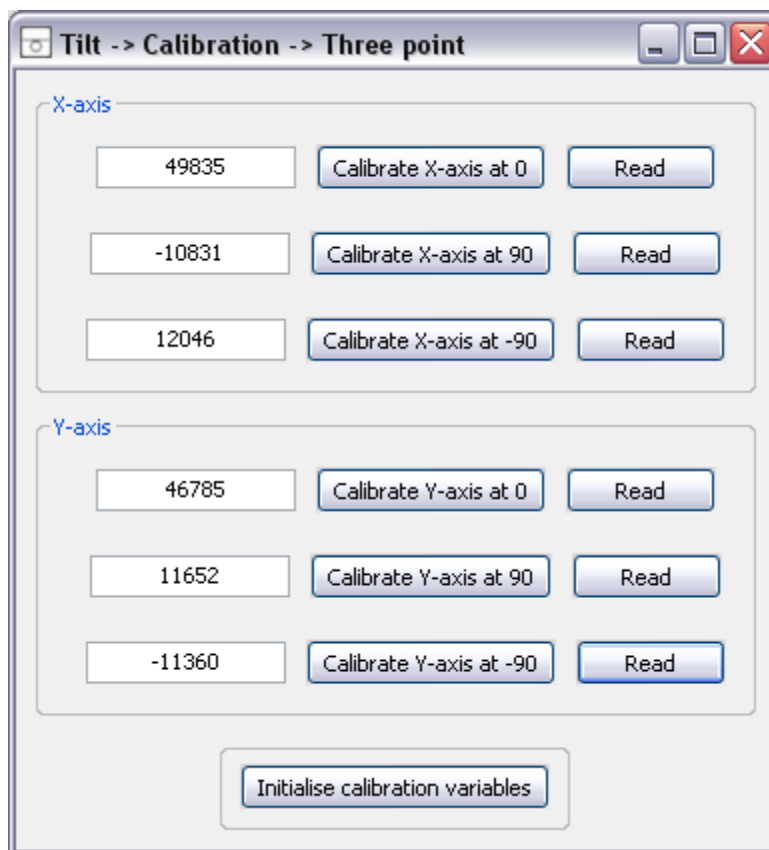
In menu "Tilt-> Calibration->Three point" you can calibrate the TILT001-2DO-USB. The procedure is as follows :

Locate the sensor in such a way that the X-axis is parallel to the earth's surface. Press button "Calibrate X-axis at 0".

Locate the sensor in such a way that the X-axis is perpendicular to the earth's surface. Press button "Calibrate X-axis at 90".

Rotate the sensor 180 so that the X-axis is again perpendicular to the earth's surface. Then press button "Calibrate X-axis at -90".

The calibration procedure for the y-axis goes in exactly the same way.



Calibration

Section 9 - Alarm conditions

In menu "Tilt->Alarm->Conditions" inclination limits for the X-axis and Y-axis can be set. If the current X-axis or Y-axis inclination exceeds these limitvalues an inclination alarm will be generated.

In the same menu acceleration limits for the X-axis and Y-axis can be set. If the change in X-axis acceleration or Y-axis acceleration exceeds these limitvalues an acceleration alarm will be generated.

To prevent continuously switching at a critical point an hysteresis procedure has been implemented. The hysteresis value can be changed.

The screenshot shows a software window titled "Tilt -> Alarm -> Conditions". It contains three main sections for setting alarm conditions:

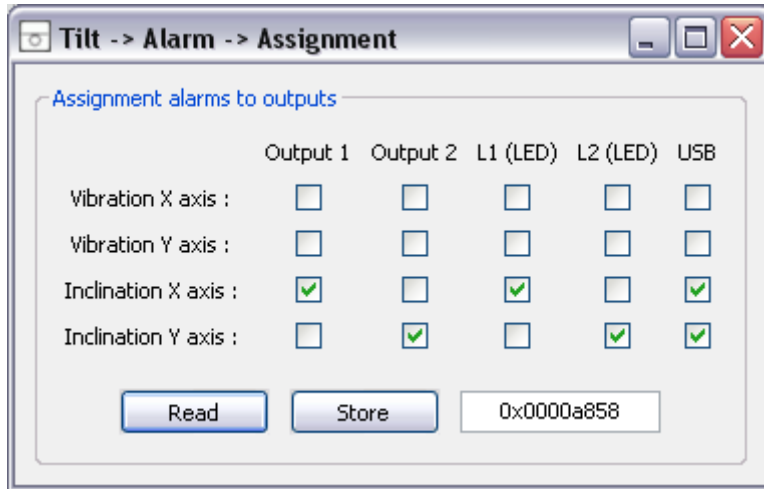
- Inclination alarm conditions [degrees]:**
 - Inclination low X-axis: -5 (with Read and Store buttons)
 - Inclination high X-axis: 5 (with Read and Store buttons)
 - Inclination low Y-axis: -5 (with Read and Store buttons)
 - Inclination high Y-axis: 5 (with Read and Store buttons)
- Inclination hysteresis [1/10th of degrees]:**
 - Hysteresis: 5 (with Read and Store buttons)
- Acceleration alarm conditions [mg]:**
 - Acceleration change X-axis: 2000 (with Read and Store buttons)
 - Acceleration change Y-axis: 2000 (with Read and Store buttons)

At the bottom of the window is a button labeled "Initialise alarm conditions".

Setting alarmconditions

Section 10 - Alarm assignment

Four possible alarm events can be directed to 5 physical outputs. In menu "Tilt->Alarm->Assignment" you can specify how this redirection takes place. Not all possible combinations are allowed.



Assignment alarm events to physical outputs

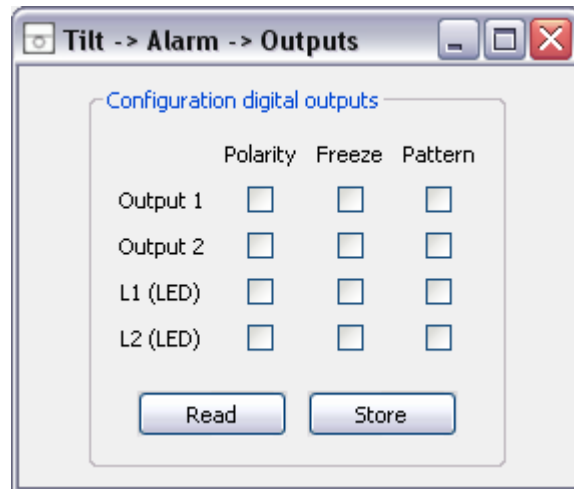
Section 11 - Output configuration

Three properties determine the behaviour of each output.

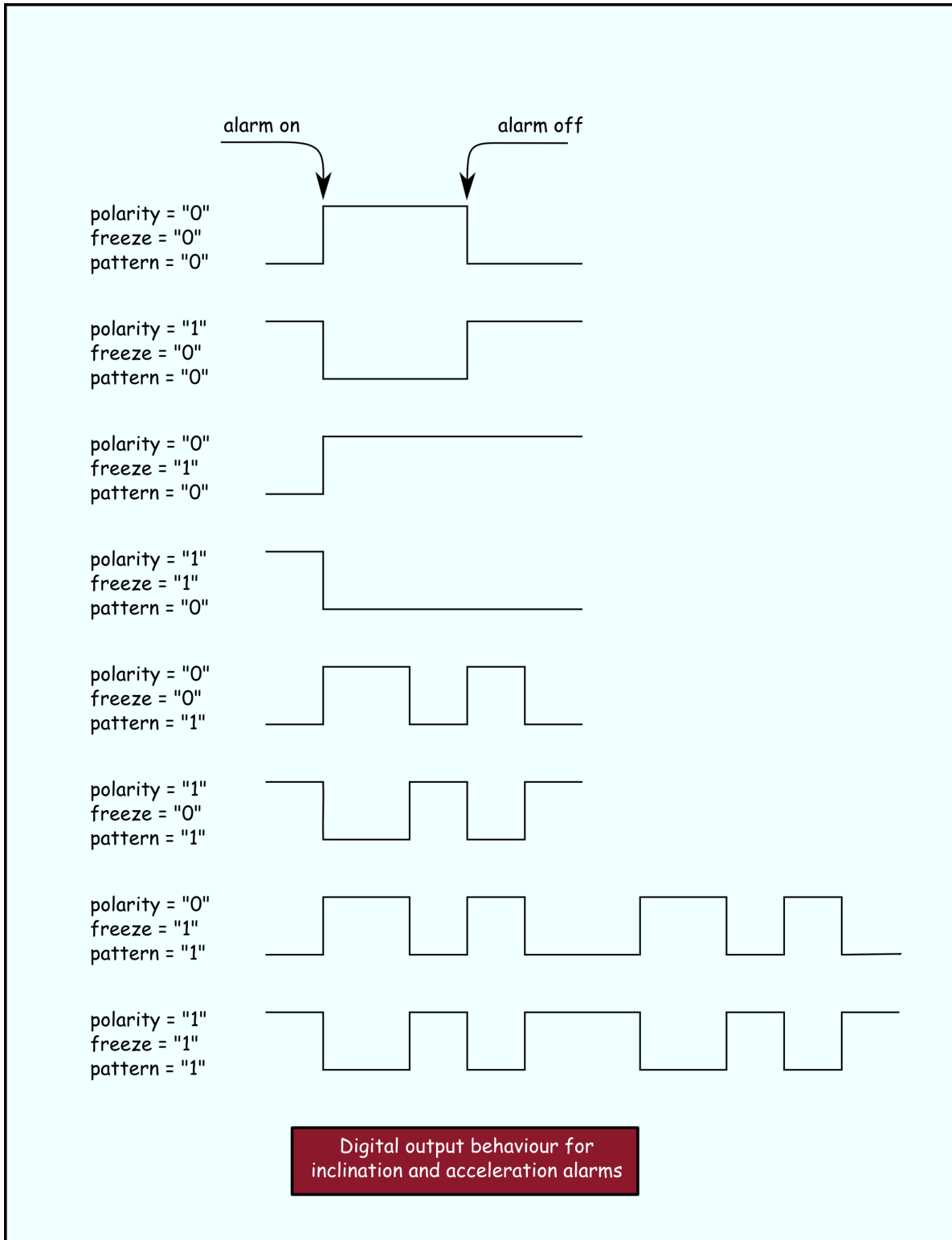
Polarity : voltage level of the output will be inverted.

Freeze : if an alarm event takes place the output will switch, and will stay in that state even if there is no alarm anymore.

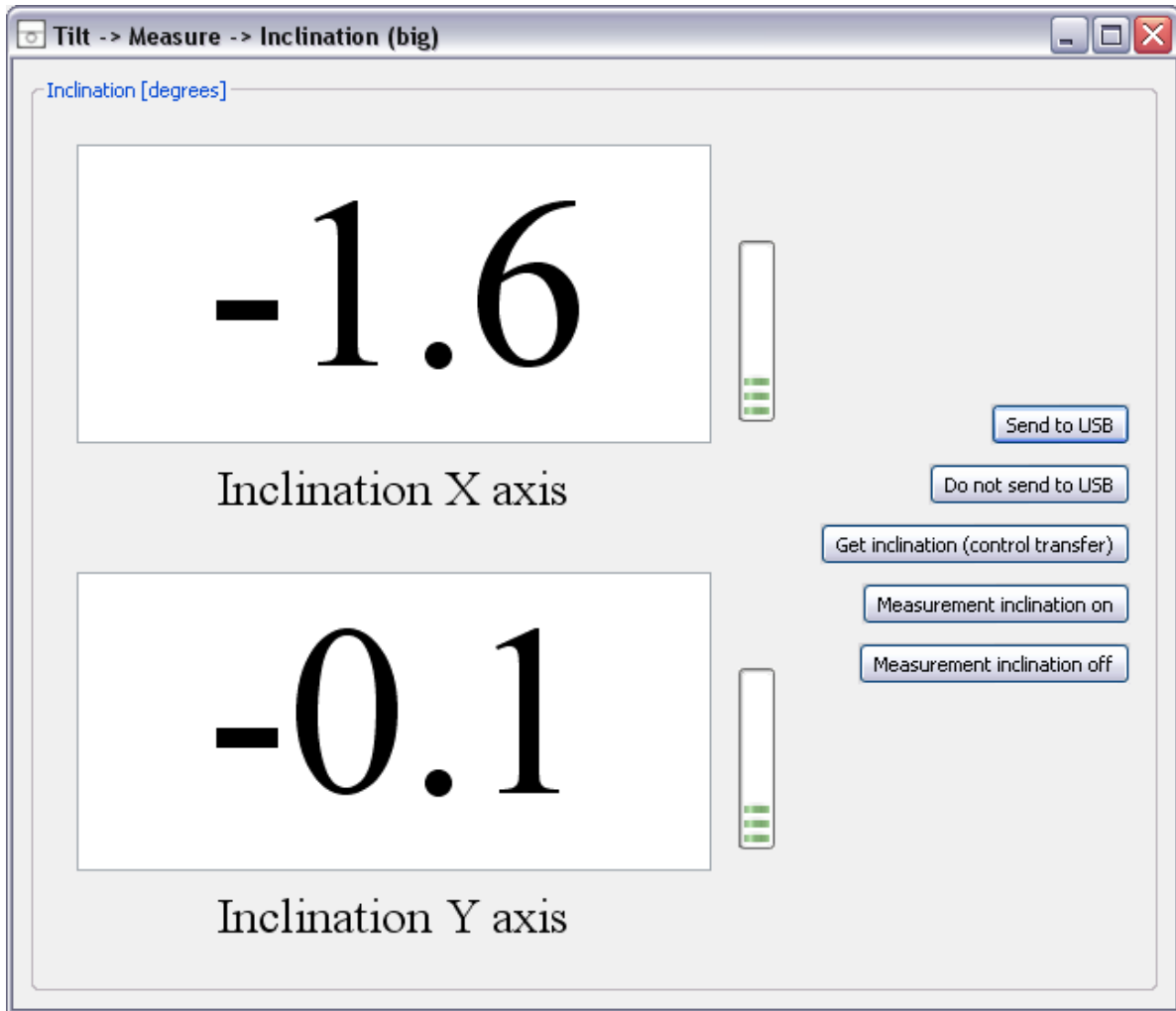
Pattern : an on/off sequence will be send to the output (e.g. buzzer).



Properties physical outputs



Section 12 - More PC application screenshots



Inclination display.

Section 13 - Package contents

Items	Description
1	Box with electronics and sensor
2	USB cable (2m)
3	2 pole plug (phoenix MC1,5/2-ST-3,81)
4	4 pole plug (phoenix MC1,5/4-ST-3,81)

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