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Introduction

This manual is only valid for sensor embedded firmware v5.x types ("N" series, e.g. QG65N, QG76N)

DIS inclination/acceleration sensor family overview:

- Three housing types: 60x50mm plastic or aluminium (QG65), 70x60 stainless steel (QG76)
- Three inclination types: Inclination 1-axis (vertical plane): 360° (or ±180°)
  Inclination 2-axis (horizontal plane): 2x ±30°
  Inclination 2-axis (horizontal plane): 2x ±90°
- Various CAN settings can be configured conform CANopen standard
- Various Sensor-settings can be configured via CANopen
- EDS files available

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Quick Reference Guide:

- CAN hardware interface: CAN2.0 A and B (complies with ISO11898-1&2)
- CAN communication profile: CANopen CiA301 version 4.2.0 & EN50325-4
- Hexadecimal figures will have suffix "h" in this manual.
- Negative values: two's complement
- Byte-sequence on CAN-bus: little-endian (least significant byte first)
- CAN bus bit rate: 50 kbit/s, 125 kbit/s (default), 250 kbit/s, 500 kbit/s, 1 Mbit/s
- Heartbeat: default on, 2s
- Node-ID: default 01h (possible range 01h – 7Fh, so max. 127 nodes)
- Two modes of PDO transmission:
  - Event mode: default on, event timer default 50ms (range 5ms – 32767ms)
  - Sync mode: default off
- Sensor output:
  - TPDO1(CANID: 180h + node-ID) and TPDO2 (CANID: 280h + node-ID)
  - TPDO mapping available to select sensor-output values
- Vendor ID DIS: 000001BDh (index 1018h sub-index 01h)
- Firmware version available via CAN Object Dictionary (index 1018h sub-index 03h)
- Serial number available via CAN Object Dictionary (index 1018h sub-index 04h)
- Center adjustment available via CAN Object Dictionary (index 300Fh sub-index 00h).
- Center adjustment range limit available via CAN Object Dictionary (index 3012h/3013h sub-index 00h)
- Sample rate g-sensor-chip inclination: 3200Hz(1-axis)/800Hz(2-axis). Averaged by TPDO1 event time.
- Input filter:
  - 1-axis inclination: Fixed 32-tap FIR filter(cut off freq. 120Hz). Always on.
  - 2-axis inclination: Fixed 2nd order Bessel LPF (cut off freq. 10Hz). On/Off by CAN object 3014h.
- Output filter: adjustable 1st order LPF. Controlled by CAN object 300Eh.

Hardware setup

Connection:

Default: 2x 5-pins M12 connector (A-coding), female & male, loop-through.
According to CiA303 V1.8.0

Pin 1:	Shield
Pin 2:	Vcc
Pin 3:	Gnd & CAN_GND
Pin 4:	CAN_H
Pin 5:	CAN_L



Male



Female

Optional: 1x 5-pins M12 connector (A-coding) male only
CAN-Cable with 5-pins M12 connector (A-coding) male
CAN-Cable 5-wire

CAN-bus termination 120Ω

Default: no CAN-bus termination inside
Optional: CAN-bus termination inside

Tip: the last CAN-device in the chain should be terminated. For this purpose you can use the M12 male 5-pin termination resistor' (DIS article number 10217) or the M12 female 5-pin termination resistor' (DIS article number 10194).

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Signal processing: see Appendices 1 and 2 for schematic overview

Sample rate MEMS:
Each axis of the internal G-sensor chip is sampled periodically. The sample rate is fixed.

- Inclination 1-axis: every 0,31ms (3200Hz)
- Inclination 2-axis: every 1,25ms (800Hz)

Input filter:
For inclination the raw values of the g-sensor-chip can be filtered by an input filter. For 1-axis sensor, a 32-tap FIR filter with a cut-off frequency of 120Hz is implemented, while for 2-axis sensor, a 2nd-order Bessel digital low-pass filter with a cut-off frequency of 10Hz is used. This will give a more stable and accurate output value.

There is a drawback when using this filter, it adds an extra phase delay, so the response is slower. When the CAN application will do its own filtering or when the fastest output response is needed, the internal filter of the sensor is possible to be disabled.

For 2-axis sensor: this filter can be controlled by CAN object 3014h. See specific part. Disabling this filter will lead to significant more noise on the sensor output and an increased sensitivity for mechanical vibrations.
For 1-axis sensor: this input filter is always on, and cannot be configured by CAN object 3014h.

Averaging :
The filtered values are averaged during the TPDO1 cycle time. A longer TPDO cycle time results is a smaller bandwidth and therefore a more stable output signal (less noise), but also more phase delay. This cycle time is configured by TPDO1 event timer in Object Dictionary Index 1800h, Sub-index 05h.

Calculation to angle:
Every TPDO1 cycle time a new output value is calculated according to a smart algorithm including calibration settings.

Output filter:
The output of the sensor can be filtered with a 1st order low-pass filter. Default this output filter is disabled. Via the CAN object dictionary (index 300Eh) this filter can be controlled, by setting the time-constant in ms, with a maximum of FFFFh = 65536ms.

The time constant t is defined as the time in which the output changes to 70% of the step after a step response. The -3dB frequency can be calculated by the formula $f = 1/2\,\pi t$. This -3dB frequency is independent of a change in TPDO1 event time. But when the output filter time-constant is set < TPDO1 event time the output filter is disabled.

Center/zero adjustment:
To eliminate mechanical offsets, the sensor can be centered/zero-ed by the center/zero adjustment method, which results in a permanent offset on the output of the sensor. The current position will be regarded as the new center/zero position. This can be done repeatedly within the adjustment range limit.

Via CAN object 300Fh (see sensor specific part) the centering/zeroing can be done for each axis separate or for both axis at the same time. Status result of the zero operation is available from object 300Fh. This action will update objects 3010h and 3011h, where the offset value can be read and written.

A center adjustment range limit can be set by object 3012h and 3013h. The value in 3012h and/or 3013h is always positive, but the limited range is always symmetrical around 0.

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Self-test

During sensor start-up the two-axis g-element-chips and the EEPROM in the sensor are submitted to a self-test. The self-test will verify if both axis of the g-element-chip are functional and the main functions are working properly. Additionally the EEPROM for data storage is checked. When an error is detected during the self-test, this is reported on the CAN bus by an emergency message.

When the self-test is passed, an emergency message is sent with all zeroes.
When the self-test fails, an emergency message is sent according to the table below.

The receiving application should ignore the sensor-output when an error is reported.

CAN Connection Object ID: 080h+NODE_ID (emergency message)		
Byte-index	Type	Description
00h to 01h	U16	Error-code: 0000h: No error (self-test OK) 5000h: Device hardware error (self-test FAIL) Error simulation (when switched ON via CAN object 3007h): 6200h: Device software error - user
02h	U8	Error-register: 00h: No error (self-test OK) 81h: Manufacturer specific error (self-test FAIL)
03h to 07h	5*U8	Manufacturer specific data: 00h, 00h, 00h, 00h, 00h: No error 00h, 00h, 00h, 00h, 01h: self-test initialization error 00h, 00h, 00h, 00h, 02h: self-test error X-axis 00h, 00h, 00h, 00h, 04h: self-test error Y-axis 00h, 00h, 00h, 00h, 08h: EEPROM error Multiple errors can be indicated (bitwise ORed) simultaneously.
The receiving application should ignore sensor-output when an error is reported		

CAN Predefined Connection Object ID's

Standard CAN Connection Object ID's (Most used)		
CAN-ID	Data	Description (client = CAN master, server = sensor)
000h		NMT Network Management
080h		Sync command to sensor
080h + node-ID		Emergency message from sensor
180h + node-ID		TPDO1 message from sensor
280h + node-ID		TPDO2 message from sensor
580h + node-ID		SDO Download Request: Feedback from sensor (server to client)
600h + node-ID		SDO Upload Request: Write to sensor (client to server)
700h + node-ID	00h 04h 05h 7Fh	Heartbeat from sensor, bootup-mode Heartbeat from sensor, stopped mode Heartbeat from sensor, operational mode Heartbeat from sensor, pre-operational mode

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CAN Object Dictionary Entries (Communication Profile section)

Object Dictionary Communication Profile (Most used)					
Index	Sub-index	Data	Type	Read/ Write	Description
1000h	00h		U32	R	Device Type
1001h	00h		U8	R	Error Register
1010h	01h	"save" in ASCII Or "65766173h"	U32	W	Save All parameters in EEPROM
	02h				Save Communication parameters in EEPROM
	03h				Save Application Parameters in EEPROM
1017h	00h	Time in ms (hex) e.g. 07D0h e.g. 0000h	U16	R+W	time for heartbeat e.g. 2000ms (default) e.g. 0ms (heartbeat switched off)
1018h	01h		U32	R	Vendor ID (000001BDh)
	02h	03000001h 03000002h 03000003h	U32	R	Product Code (xx------h) xx = 03 Type C (CAN version v5) Inclination 1-axis (vertical plane): 360° Inclination 2-axis (horizontal plane): 2x ±90° Inclination 2-axis (horizontal plane): 2x ±30°
	03h	e.g. 00050001h	U32	R	Firmware Version from sensor (000x000yh=Vx.y) e.g. v5.1
	04h	00000000h ~ FFFFFFFFh	U32	R	Serial Number of the sensor in 32 bit, unique.
1800h	01h	C0000180h+Node-ID 40000180h+Node-ID	U32	R+W	COB-ID used by TPDO1 Disable TPDO1 Enable TPDO1 (default)
	02h	01h FFh	U8	R+W	Transmission type Sync mode Event mode(default)
	05h	Time in ms (hex) e.g. 0032h e.g. 0000h	U16	R+W	Event timer for TPDO1(range 5ms -32767ms) e.g. 50ms (default) e.g. 0ms (disable TPDO2)
1801h	01h	C0000280h+Node-ID 40000280h+Node-ID	U32	R+W	COB-ID used by TPDO2 Disable TPDO2 Enable TPDO2 (default)
	02h	01h FFh	U8	R+W	Transmission type Sync mode Event mode(default)
	05h	Time in ms (hex) e.g. 0032h e.g. 0000h	U16	R+W	Event timer for TPDO2(range 5ms -32767ms) e.g. 50ms (default) e.g. 0ms (disable TPDO2)
1F80h	00h	00000000h 00000004h	U32	R+W	NMT start-up: Boot-up in Operational state (default) (= self-starting device) Boot-up in Pre-operational state, waiting . . . .

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CAN Object Dictionary Entries (Manufacturer Specific Profile section)

Manufacturer specific parameters					
Index	Subindex	Data	Type	Read/Write	Description
3000h	00h	01h ~ 7Fh	U8	R+W	Set node-ID 01h (default) ~ 7Fh *(changes are being affected after a power cycle only)*
3001h	00h	06 04 03 02 00	U8	R+W	Set CAN Bus bit rate 50 kbit/s 125 kbit/s (default) 250 kbit/s 500 kbit/s 1 Mbit/s *(changes are being affected after a power cycle only)*
3007h	00h	00h FFh	U8	R+W	Simulate Error: 00h: No error (or error reset) FFh: Simulate a device error (error-code = 6200h: device software error - user)
300Eh	00h	Time in ms (hex) e.g. 0000h e.g. 0064h e.g. 03E8h	U16	R+W	Output Filter: disabled (default) time constant 100ms time constant 1000ms

To store manufacturer specific parameters permanent into the EEPROM of the sensor, CAN Object 1010h should be used, otherwise the changes will be lost after a power cycle.
All not-specified objects are reserved for factory use only.

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EDS files

The "Electronic Data Sheet" (EDS file) is a file format that describes the communication behavior and the object dictionary entries of a device. In fact it's a template. This allows tools such as CAN configuration tools to handle the device properly. The file format is described in CiA306 V1.3.0

The EDS-file contains all possible settings and functions for the device by describing the CAN object dictionary for the device to be set by CAN commands.

The EDS-file does not contain a customer specific configuration description (the values of the object dictionary, like i.e. the chosen baudrate, TPDO1 event time, Node ID etc). For this purpose the customer can generate a so called DCF-file (Device Configuration File) with all customer specific settings out of the EDS-file. The DCF file is in fact the incarnation of the EDS-file.
After loading the DCF-file into the device you have to store the settings into EEPROM by index2300h subindex 00h to store permanently, see "CAN Object Dictionary Entries".

The EDS-files available for sensors with embedded firmware version v5.x described in this document should have a version number v5.x also.

The next EDS-files are available at www.dis-sensors.com under 'downloads':

- QG_Ctype_1_axis_360v_v5.x
- QG_Ctype_2_axis_90h_v5.x
- QG_Ctype_2_axis_30h_v5.x

Document revision control

v5.01:	New document based on Rev. v4B.01, For "N" series only (e.g. QG65N, QG76N) Sensor Temperature functionality removed	
V5.02:	Event time down to 5ms, TPDO2 time disable, mechanical vibrations vs filtering EN50325-4 added, Raw counts ±30° & ±90° device changed	
V5.03:	Centering Result Read command needs to be > 1 second after centering write command Restore command 1011h removed, Store with Index 2300h removed, 360° device default ±180° output	
V5.04	Change EDS names to DIS standard	
V5.5	20190605	Correct a few errors. Acceleration sensor is not provided with firmware v5.x, thus acceleration part is removed. 32-tap FIR filter is implemented in 1-axis sensor. 2-axis sensor remains the same.

Definition:

U8	Unsigned 8-bits number (0 - 255)
U16	Unsigned 16-bit number (0 - 65535)
U32	Unsigned 32-bit number (0 - 4294967295)
S8	Signed 8-bits number (-128 - +127) (also known as 'Integer 8')
S16	Signed 16-bits number (-32768 - +32767) (also known as 'Integer 16')
S32	Signed 32-bits number (-2147483648 - +2147483647) (also known as 'Integer 32')
LPF	Low Pass Filter
FIR	Finite Impulse Response
EDS	Electronic Data Sheet
CiA	CAN in Automation

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Sensor-Specific: Inclination 1-axis (vertical plane): ±180° (or 360°)

Sensor output data available for TPDO-mapping:

Index 6401h		**Sensor output data Inclination 1-axis (vertical plane) ±180° (or 360°)**
Sub-index	Type	Description
00h	U8	Number of parameters in this object (9)
01h	U16	Angle normal (0 to +35999)
02h	U16	Angle reversed (+35999 to 0)
03h	S16	Angle normal (-17999 to +18000)
04h	S16	Angle reversed (+17999 to -18000)
05h	U16	Raw counts X-sensor (-512 to +512) (*)
06h	U16	Raw counts Y-sensor (-512 to +512) (*)
07h	S16	0h (reserved for future use)
08h	S16	0h (reserved for future use)
09h	U16	Reserved for future use

TPDO1-mapping:

Index 1A00h		**Default TPDO1-mapping**
Sub-index	Type	Description
00h	U8	Number of parameters in this object (2)
01h	U32	64010310h (Index: 6401h, sub-index: 03h, length in bits:10h) e.g. default = Angle normal (-17999 to +18000))
02h	U32	64010710h (Index: 6401h, sub-index: 07h, length in bits:10h) e.g. default = 0h (reserved for future use)

TPDO2-mapping:

Index 1A01h		**Default TPDO2-mapping**
Sub-index	Type	Description
00h	U8	Number of parameters in this object (2)
01h	U32	64010510h (Index: 6401h, sub-index: 05h, length in bits:10h) e.g. default = Raw counts X-sensor (-512 to +512)
02h	U32	64010610h (Index: 6401h, sub-index: 06h, length in bits:10h) e.g. default = Raw counts Y-sensor (-512 to +512)

To store TPDO-mapping permanent into the EEPROM of the sensor CAN-object 1010h should be used. Otherwise the changes will be lost after a power cycle.

(*) Raw counts are uncalibrated sensor-chip values direct proportional to the g-force (no offset/gain compensation, no temperature compensation and no non-linearity calibration).

CAN Object Dictionary Entries (Manufacturer Specific Profile section):

Manufacturer specific parameters Inclination 1-axis (vertical plane) ±180° (or 360°)					
Index	Sub-index	Data	Type	Read/Write	Description
300Fh	00h	01h 00h FFh	U8	W R R	Start center adjustment, allow 1 second before read Center adjustment successful. Center adjustment failed
3010h	00h	 e.g. 0063h	U16	R+W	Offset after center adjustment (1LSB=0.01°) e.g. offset = 0.99°

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Sensor-Specific: Inclination 2-axis (horizontal plane): 2x ±30°

Sensor output data available for TPDO-mapping:

Index 6401h		**Sensor output data Inclination 2-axis (horizontal plane) ±30°**
Sub-index	Type	Description
00h	U8	Number of parameters in this object (6)
01h	S16	X-angle normal (-3000 to +3000)
02h	S16	Y-angle normal (-3000 to +3000)
03h	S16	X-angle reversed (+3000 to -3000)
04h	S16	Y-angle reversed (+3000 to -3000)
05h	U16	Raw counts X-sensor (-512 to +512) (*)
06h	U16	Raw counts Y-sensor (-512 to +512) (*)

TPDO1-mapping:

Index 1A00h		**Default TPDO1-mapping**
Sub-index	Type	Description
00h	U8	Number of parameters in this object (2)
01h	U32	64010110h (Index: 6401h, sub-index: 01h, length in bits:10h) e.g. default = X-angle normal (-3000 to +3000)
02h	U32	64010210h (Index: 6401h, sub-index: 02h, length in bits:10h) e.g. default = Y-angle normal (-3000 to +3000)

TPDO2-mapping:

Index 1A01h		**Default TPDO2-mapping**
Sub-index	Type	Description
00h	U8	Number of parameters in this object (2)
01h	U32	64010510h (Index: 6401h, sub-index: 05h, length in bits:10h) e.g. default = Raw counts X-sensor (-512 to +512)
02h	U32	64010610h (Index: 6401h, sub-index: 06h, length in bits:10h) e.g. default = Raw counts Y-sensor (-512 to +512)

To store TPDO-mapping permanent into the EEPROM of the sensor CAN-object 1010h should be used. Otherwise the changes will be lost after a power cycle.

(*) Raw counts are uncalibrated sensor-chip values direct proportional to the g-force (no offset/gain compensation, no temperature compensation and no non-linearity calibration).

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CAN Object Dictionary Entries (Manufacturer Specific Profile section):

Manufacturer specific parameters Inclination 2-axis (horizontal plane) ±30°					
Index	Sub-index	Data	Type	Read/Write	Description
300Fh	00h		S8		Center adjustment
		01h		W	Start center adjustment X-axis
		02h		W	Start center adjustment Y-axis
		03h		W	Start center adjustment X- AND Y-axis
					Center adjustment response *(allow 1 second before read)*
		00h		R	Center adjustment successful.
		FFh		R	Center adjustment X-axis failed
		FEh		R	Center adjustment Y-axis failed
		FDh		R	Center adjustment X- AND Y-axis failed
3010h	00h	e.g. 0063h	S16	R+W	Offset X-axis after center adjustment (1LSB=0.01°) e.g. offset = 0.99°
3011h	00h	e.g. FF9Dh	S16	R+W	Offset Y-axis after center adjustment (1LSB=0.01°) e.g. offset = -0.99°
3012h	00h	e.g. 01F4h	U16	R+W	Center adjustment range limit X-axis (valid centering range -5° to +5°) 5°(default)
3013h	00h	e.g. 01F4h	U16	R+W	Center adjustment range limit Y-axis (valid centering range -5° to +5°) 5°(default)
3014h	00h	00h 01h	U8	R+W	Input filter: Disabled Enabled (default)

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Sensor-Specific: Inclination 2-axis (horizontal plane): 2x ±90°

Sensor output data available for TPDO-mapping:

Index 6401h		**Sensor output data Inclination 2-axis (horizontal plane) ±90°**
Sub-index	Type	Description
00h	U8	Number of parameters in this object (6)
01h	S16	X-angle normal (-9000 to +9000)
02h	S16	Y-angle normal (-9000 to +9000)
03h	S16	X-angle reversed (+9000 to -9000)
04h	S16	Y-angle reversed (+9000 to -9000)
05h	U16	Raw counts X-sensor (-512 to +512) (*)
06h	U16	Raw counts Y-sensor (-512 to +512) (*)

TPDO1-mapping:

Index 1A00h		**Default TPDO1-mapping**
Sub-index	Type	Description
00h	U8	Number of parameters in this object (2)
01h	U32	64010110h (Index: 6401h, Sub-index: 01h, length in bits:10h) e.g. default = X-angle normal (-9000 to +9000)
02h	U32	64010210h (Index: 6401h, Sub-index: 02h, length in bits:10h) e.g. default = Y-angle normal (-9000 to +9000)

TPDO2-mapping:

Index 1A01h		**Default TPDO2-mapping**
Sub-index	Type	Description
00h	U8	Number of parameters in this object (2)
01h	U32	64010510h (Index: 6401h, Sub-index: 05h, length in bits:10h) e.g. default = Raw counts X-sensor (-512 to +512)
02h	U32	64010610h (Index: 6401h, Sub-index: 06h, length in bits:10h) e.g. default = Raw counts Y-sensor (-512 to +512)

To store TPDO-mapping permanent into the EEPROM of the sensor CAN-object 1010h should be used. Otherwise the changes will be lost after a power cycle.

(*) Raw counts are uncalibrated sensor-chip values direct proportional to the g-force (no offset/gain compensation, no temperature compensation and no non-linearity calibration).

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CAN Object Dictionary Entries (Manufacturer Specific Profile section):

Manufacturer specific parameters Inclination 2-axis (horizontal plane) ±90°					
Index	Sub-index	Data	Type	Read/Write	Description
300Fh	00h		S8		Center adjustment
		01h		W	Start center adjustment X-axis
		02h		W	Start center adjustment Y-axis
		03h		W	Start center adjustment X- AND Y-axis
					Center adjustment response *(allow 1 second before read)*
		00h		R	Center adjustment successful.
		FFh		R	Center adjustment X-axis failed
		FEh		R	Center adjustment Y-axis failed
		FDh		R	Center adjustment X- AND Y-axis failed
3010h	00h	e.g. 0063h	S16	R+W	Offset X-axis after center adjustment (1LSB=0.01°) e.g. offset = 0.99°
3011h	00h	e.g. FF9Dh	S16	R+W	Offset Y-axis after center adjustment (1LSB=0.01°) e.g. offset = -0.99°
3012h	00h	e.g. 01F4h	U16	R+W	Center adjustment range limit X-axis (valid centering range -5° to +5°) 5°(default)
3013h	00h	e.g. 01F4h	U16	R+W	Center adjustment range limit Y-axis (valid centering range -5° to +5°) 5° (default)
3014h	00h	00h 01h	U8	R+W	Input filter Disabled Enabled (default)

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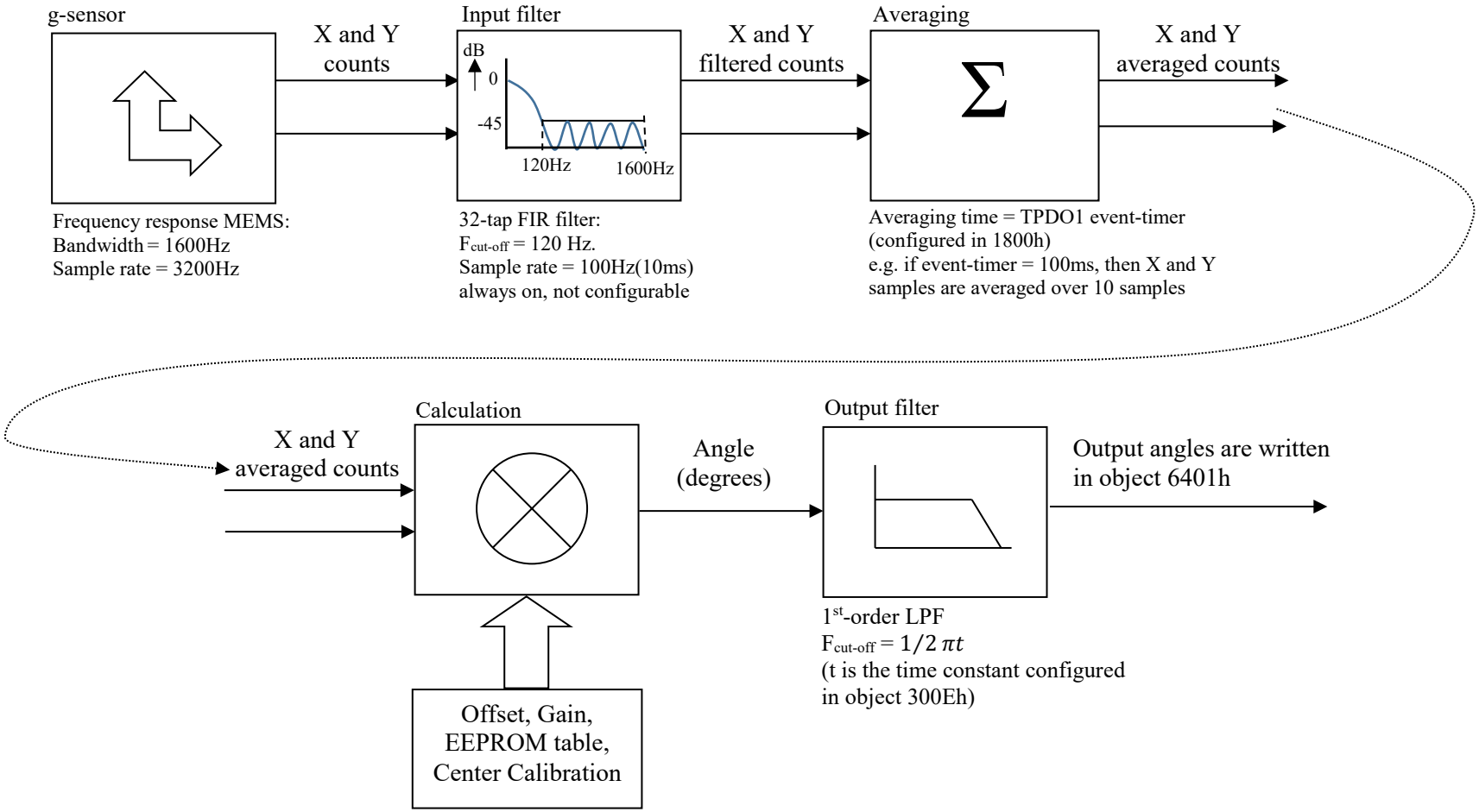
APPENDIX 1: Schematic overview inclination(1-axis) measurement



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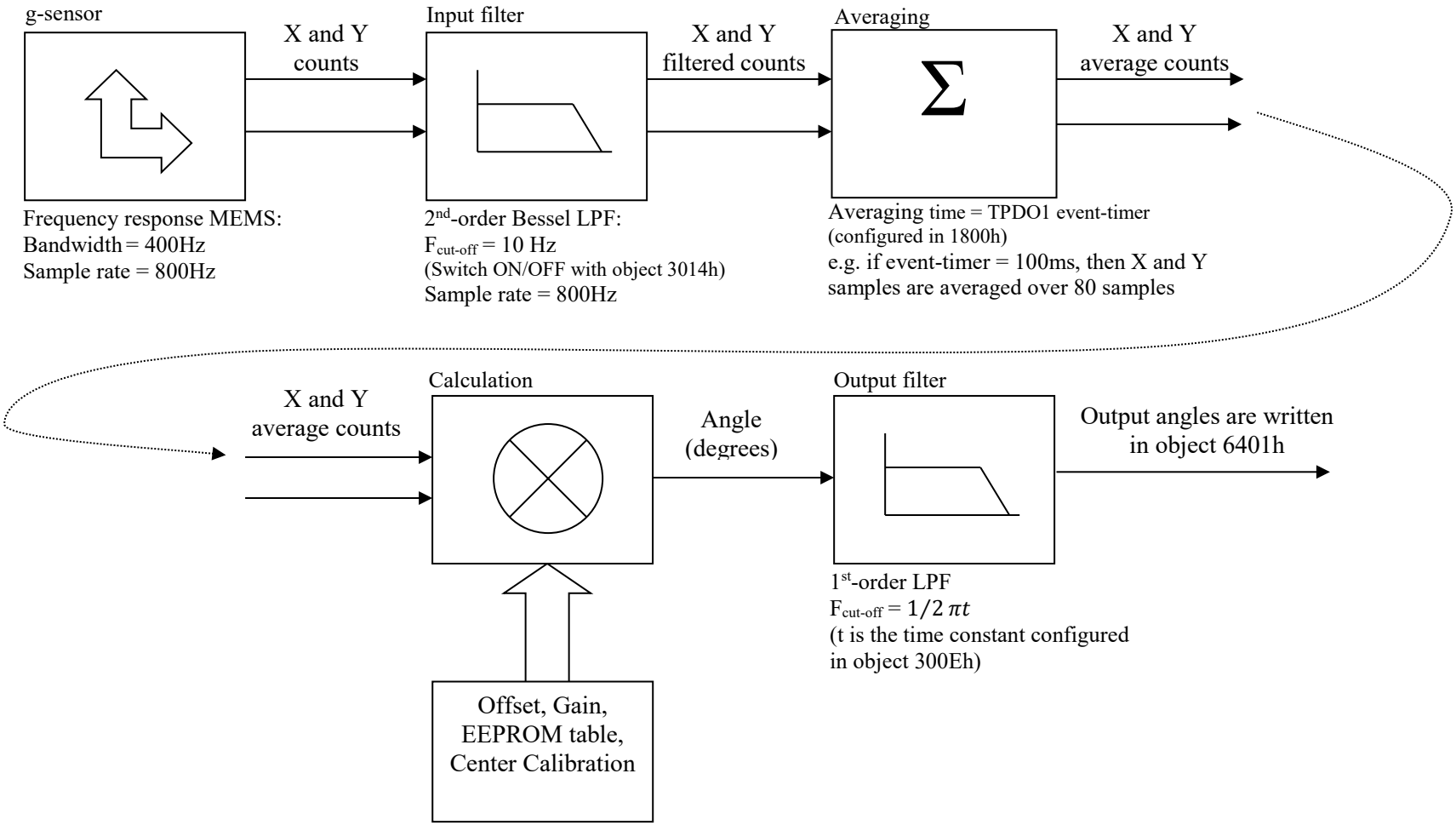
APPENDIX 2: Schematic overview inclination(2 axis) measurement



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