Manual

Dynamic inclination sensors GIM700DR with SAE J1939 interface

Firmware version 1.14.2 and higher

10.22 · 174.02.083/2

Contents **Page**

Disclaimer of liability
The present manual was compiled with utmost care, errors and omissions reserved. For this reason Baumer rejects any liability for the information compiled in the present manual.

Neither Baumer nor the author will accept any liability for direct or indirect damages resulting from the use of the present information.

At any time we should be pleased receiving your comments and proposals for further improvement of the present manual.

Created by:
Baumer Germany GmbH & Co. KG
Bodenseeallee 7
DE-78333 Stockach
www.baumer.com

1 Introduction

1.1 Scope of delivery

Please check the delivery upon completeness prior to commissioning.
Depending on sensor configuration and part number, delivery is including:

- Sensor
- Mounting instruction

Further information is available as download via www.baumer.com

- Manual (sensor interface description)

1.2 Product assignment

Product	Product code	Measuring direction	Device name
GIM700DR	60h	1-dimensional	GIM700DR
GIM700DR	61h	2-dimensional (horizontal installation)	GIM700DR
GIM700DR	61h	2-dimensional (vertical installation)	GIM700DR

2 Safety and operating instructions

Intended use

- The inclination sensor is a precision measuring device to determine angular positions and to supply the downstream device with measured values in the form of electronic output signals. The inclination sensor must not be used for any other purpose.
- Make sure the appropriate safety measures are present to prevent damage to persons, the system or operating facilities in case of sensor error or failure.

Personnel qualification

- The inclination sensor must only be installed by a qualified electronics and precision mechanics.
- Observe the user manual of the machine manufacturer.

Maintenance

- The inclination sensor is maintenance-free and must not be opened or modified in its electronics or mechanical design. Opening the sensor can lead to personal injury.

Disposal

- The inclination sensor contains electronic components. At its disposal, local environmental guidelines must be followed.

Installation

- Avoid mechanical impacts or shocks on the housing.

Electrical commissioning

- Do not perform any electrical modifications at the inclination sensor.
- Do not carry out any wiring work when the inclination sensor is live.
- Do not dock or undock the electrical connection while the inclination sensor is live.
- Ensure that the entire equipment is installed in line with EMC requirements. Ambient conditions and wiring affect the electromagnetic compatibility of the inclination sensor. Install sensor and supply cables separately or far away from lines with high interference emissions (frequency converters, contactors, etc.).
- Provide separate power supply for the inclination sensor where working with consumers that have high interference emissions.
- Completely shield the inclination sensor housing and connecting cables.
- Connect the sensor to protective earth (PE) using shielded cables. The braided shield must be connected to the cable gland or connector. Ideally, aim at a bilateral connection to protective earth (PE), the housing via the mechanical assembly and the cable shield via the downstream devices. In case of earth loop problems, earth on one side only as a minimum requirement.

Supplementary information

- This manual is intended as a supplement to already existing documentation (i.e. catalogue, product information and mounting instruction).

3 CAN bus and SAE J1939 communication

CAN bus (CAN: Controller Area Network) was developed by Bosch and Intel for high-speed, economic data transmission in automotive applications. Today, CAN bus is commercialized for use in industrial automation.

CAN bus is a fieldbus system (standards administered by CAN in Automation, CiA) for communication between appliances, actors and sensors of different brands.

3.1 CAN bus characteristics

- Data rate of 1 MBaud with network expansion up to 40 m
- Network connected on both sides
- The bus medium is a twisted-pair cable
- Real time capability: Defined maximum waiting time for high-priority messages.
- Theoretically 127 users at one bus, but physically only 32 are possible (due to the driver).
- Ensures data consistency across the network. Damaged messages are notified as faulty for all network nodes.
- Message-oriented communication
  The message is identified by a message identifier. All network nodes use the identifier to test whether the message is of relevance for them.
- Broadcasting, multicasting
  All network nodes receive each message simultaneously. Synchronization is therefore possible.
- Multi-master capability
  Each user in the field bus is able to independently transmit and receive data without being dependent upon the priority of the master. Each user is able to start its message when the bus is not occupied. When messages are sent simultaneously, the user with the highest priority prevails.
- Prioritization of messages
  The identifier defines the priority of the message. This ensures that important messages are transmitted quickly via the bus.
- Residual error probability
  Safety procedures in the network reduce the probability of an undiscovered faulty data transmission to below 10^{-11}. In practical terms, it is possible to ensure a 100% reliable transmission.
- Function monitoring
  Localization of faulty / failed stations: The CAN protocol encompasses a network node monitoring function. The function of network nodes which are faulty is restricted, or they are completely uncoupled from the network.
- Data transmission with short error recovery time
  By using several error detection mechanisms, falsified messages are detected to a high degree of probability. If an error is detected, the message transmission is automatically repeated.

In the CAN Bus, several network users are connected by means of a bus cable. Each network user is able to transmit and receive messages. The data between network users is serially transmitted.

Examples of network users for CAN bus devices are:
- Automation devices such as PLCs
- PCs
- Input and output modules
- Drive control systems
- Analysis devices, such as a CAN monitor
- Control and input devices as Human Machine Interfaces (HMI)
- Sensors and actuators

3.2 Power-on behavior

1s after power-on process data on the J1939 interface are valid. Device comes up with a NAME function message.

3.3 SAE J1939 interface

SAE J1939 is the vehicle bus standard developed by the Society of Automotive Engineers (SAE) and used for communication and diagnostics among components of cars, heavy duty trucks, utility and specialized vehicles. J1939 is based on the physical layer of CAN bus.

SAE J1939 protocol is used in the commercial vehicle area for communication throughout the vehicle. Several international standards for trucks and trailer rigs, forest and agricultural machines as well as for marine applications are based on SAE J1939. Data transmission method, content and structure of the message as well as data packets are defined by the relevant specification.

J1939: General network description
J1939/0X: General application description
J1939/01: Utility vehicles, trucks and buses
J1939/7X: Application layer
J1939/71: Vehicle application layer vehicle
J1939/73: Application layer diagnostics
J1939/81: Network management
J1939/31: Network layer, bridge, router, gateway, filter
J1939/21: Data link layer
J1939/1X: Physical layer
J1939/11: Physical layer, STP cable, 500 kbits/s
J1939/12: Physical layer, star quad, 500 kbits/s
J1939/13: Off-Board diagnostic connector

SAE J1939 uses the 29-bit extended identifier in the CAN data frame.
The 8-bit address embedded in the identifier is used as source and target address for the SAE-J1939 nodes.

The information is output in the form of electronic signals and compiled in parameter group numbers (PGNs).

The SAE J1939 protocol considers segmentation, flow control, transmission method; message acknowledged yes/no and specifies the message content.

3.3.1 Interpretation of CAN identifier

The CAN identifier of a SAE J1939 message comprises parameter group number (PGN), source address, priority, data page bit, extended data page bit and a target address (peer-to-peer PG only).

Priority	Extended Data Page	Data Page	PDU Format	PDU Specific	Source Address
3 bit	1 bit	1 bit	8 bit	8 bit	8 bit

- In the PDU format < 240 (peer-to-peer), the PDU includes the target address. Global (255) can also be used as target address. In this case, the parameter group is addressed to all devices, and the PGN exists only in the PDU format.

- If PDU format ≥ 240 (broadcast), the PDU format together with the Group Extension in the PDU specific field form the PGN of the transmitted parameter group.

3.3.2 NAME field

The device will transmit its NAME after power on (SAE J1939 NAME field).

J1939/81 specifies a 64-bit NAME – message for the clear identification of each ECU (electronic control unit). The NAME Field comprises 10 entries, 5 are SAE-specific and 5 either represent the network properties or are vendor-specific. For more information please refer to J1939/81.

SAE J1939 NAME Field

Arbitrary Address Capable	Industry Group	Vehicle System Instance	Vehicle System	Re-served	Function	Function Instance	ECU In-stance	Manu-facturer code	Identity Number
1 bit	3 bit	4 bit	7 bit	1 bit	8 bit	5 bit	3 bit	11 bit	21 bit

3.3.3 Process data – PDU Proprietary B message

PDU Proprietary B message is used for transmitting cyclic process data of the sensor. Depending on variant PGNs may be disabled by default (transmission rate = 0).

3.3.3.1 PGN 65363: 1-dimensional device message Z-axis angle

Proprietary B message interpretation of 1-dimensional (1D) inclination sensor variants:

Data length: 8 bytes
Extended Data Page: 0
Data page: 0
PF: 255 (Proprietary B)
PS: 83
Priority: 6
PG Number: 65363 (00FF53h)

Description of data payload:
Byte: 1 Z-axis angle signed word LSB tilt reading (in angular degrees, range 0…360°, resolution 0.01°)
Byte: 2 Z-axis angle signed word MSB tilt reading (in angular degrees, range 0…360°, resolution 0.01°)
Byte: 3, 4 Reserved
Byte: 5 Device temperature signed byte (in degree Celsius, resolution 1 °C)
Byte: 6 Error Module ID
Byte: 7, 8 Error ID

3.3.3.2 PGN 65364: 2-dimensional device message X-/Y-axis and Z-/Y-axis angle

Proprietary B message interpretation of 2-dimensional (2D) inclination sensor variants:

Data length: 8 Bytes
Extended Data Page: 0
Data page: 0
PF: 255 (Proprietary B)
PS: 84
Priority: 6
PG Number: 65364 (00FF54h)

Description of data payload:
Byte: 1 X-axis / Z-axis angle signed word LSB tilt reading (angular degrees, range ±90°, resolution 0.01°)
Byte: 2 X-axis / Z-axis angle signed word MSB tilt reading (angular degrees, range ±90°, resolution 0.01°)
Byte: 3 Y-axis angle signed word LSB tilt reading (angular degrees, range ±90°, resolution 0.01°)
Byte: 4 Y-axis angle signed word MSB tilt reading (angular degrees, range ±90°, resolution 0.01°)
Byte: 5 Device temperature signed byte (in degree Celsius, resolution 1 °C)
Byte: 6 Error Module ID
Byte: 7, 8 Error ID

3.3.4 Warnings / error diagnostics

Depending on variant (1D, 2D) the corresponding PDU supports the error information
Error Module ID and/or **Error ID**
Byte 6: Error Module ID
Byte 7, 8: Error ID

These three bytes Error Module ID and Error ID being other than 00h means a warning or an error occurred. In case of an error, the transmitted inclination information must be considered invalid.

Error Module ID	Error ID	Description
17h	1012h	Angle limit warning. Please check, if angle measurement value in sensor application is near or above specified limit
15h	100Dh 100Fh 1010h	Sensor fusion error. Please check, if acceleration and/or gyroscope rotation rate in sensor application is near or above specified limit
18h	1001h 1004h	Overvoltage voltage error. Please check, if supply voltage in sensor application is near or above specified limit
18h	1005h 1008h	Under voltage error. Please check, if supply voltage in sensor application is near or below specified limit
1Dh	100Eh 1011h	MEMS saturation error. Please check, if acceleration and/or gyroscope rotation rate in sensor application is near or above specified limit

3.3.5 Configuration data PDU Proprietary-A (PDU-1 peer-to-peer)

Acyclic communication such as device configuration can be done by using PDU Proprietary-A messages. The message structure looks similar to a CANopen SDO communication.

Table of accessible parameters

Index Sub-index	Name	Format	Access	Default	Save[2)]
2102h	SAE J1939 ECU address	U8	rw	F7h	yes[2)]
2103h	SAE J1939 PDU Proprietary B Group Extension [1)]	U8	rw	1D: 53h 2D: 54h 3D: 55h [3)]	yes [2)]
2104h	SAE J1939 PDU Proprietary B transmission rate				
00h	Highest sub-index supported	U8	ro	7h	
01h	Transmission rate according to PGN 65363-1D	U8	rw	C8h	yes [2)]
02h	Transmission rate according to PGN 65364-2D	U8	rw	C8h	yes [2)]
03h	Transmission rate according to PGN 65365-3D [3)]	U8	rw	C8h	yes [2)]
04h	Transmission rate according to PGN 65366-3D [3)]	U8	rw	0	yes [2)]
05h	Transmission rate according to PGN 65367-3D [3)]	U8	rw	0	yes [2)]
06h	Transmission rate according to PGN 65368-3D [3)]	U8	rw	0	yes [2)]
07h	Transmission rate according to PGN 65369-3D [3)]	U8	rw	0	yes [2)]
2576h	Offset tilt position				
00h	Highest sub-index supported	U8	ro	2h	
01h	Offset X-axis tilt position (1D and 2D)	I16	rw	0	yes [2)]
02h	Offset Y-axis tilt position (2D)	I16	rw	0	yes [2)]
2577h	Preset				
00h	Highest sub-index supported	U8	ro	2h	
01h	Preset zero Z-axis / X-axis (1D and 2D)	U8	rw	0	yes [2)]
02h	Preset zero Y-axis (2D)	U8	rw	0	yes [2)]
2578h	Tilt reverse				
00h	Tilt reverse (only available for 1-dimensional variant)	U8	ro	0h	
1010h	Store parameters				
00h	Highest sub-index supported	U8	ro	4h	
01h	Save all parameters	U32	rw		
02h	Communication parameters (not supported)	U32	-		
03h	Application parameters (not supported)	U32	-		
04h	Manufacturer- specific parameters (not supported)	U32	-		
1011h	Restore default parameters				
00h	Highest sub-index supported	U8	ro	4h	
01h	Restore all parameters	U32	rw		
02h	Restore communication parameters (not supported)	U32	-		
03h	Restore application parameters (not supported)	U32	-		
04h	Restore manufacturer specific parameters (not supported)	U32	-		

1) This parameter represents the PDU Proprietary B Group Extension for the first PGN, PGN 65363-1D (2104h, sub-index 01h). The following PGN's (see 2104h, sub-index 02...07h) are assigned each by increasing +1.

2) For non-volatile saving to memory, save command to index 1010h, sub-index 01h is required.

3) 3D / 3-dimensional variant: Not supported.

Example:
To change the ECU address, the device must be properly addressed and the correct data must be transmitted by the master in the format below:

CAN-Identifier	Byte 7	Byte 6	Byte 5	Byte 4	Byte 3	Byte 2	Byte 1	Byte 0
18EFF753h	2Fh	02h	21h	00h	F8h	00h	00h	00h
	Command	Index		Sub-index	Data			

The following configuration options are available:

3.3.6 SAE J1939 ECU address (index 2102h)

Index	Sub-index	Data type	Access	Description	Default	Saved on Access
2102h	0	U8	rw	SAE J1939 ECU address	F7h	no

Example: Change ECU address from F7 to F8h

CAN-Identifier	Direction	RAW data [hex]
18EFF753h	write to device	2F 02 21 00 F8 00 00 00
18EF53F7h	received from device	60 02 21 00 00 00 00 00

The new address is adopted and effective after a save command in object 1010h and a power cycle.

3.3.7 SAE J1939 PDU Proprietary B Group Extension (index 2103h)

Index	Sub-index	Data type	Access	Description	Default	Saved on Access
2103h	0	U8	rw	SAE J1939 PDU Prop. B Group Extension	53h	no

This parameter represents the PDU Proprietary B Group Extension for the first PGN, PGN 65363-1D (2104h, sub-index 1).
The following PGN's (see 2104h, sub-index 2...7) are assigned each by increasing +1.

Example: Change group extension to 22h

CAN-Identifier	Direction	RAW data [hex]
18EFF753h	write to device	2F 03 21 00 22 00 00 00
18EF53F7h	received from device	60 03 21 00 00 00 00 00

22h= 1-dimensional , 23h= 2-dimensional , 24h-28h = 3-dimensional (3D not supported)
The new group extension is adopted and effective after a save command in Index 1010h and a power cycle.

3.3.8 SAE J1939 PDU Proprietary B Transmission Rate (index 2104h)

Index	Sub-index	Data type	Access	Description	Default	Saved on Access
2104h	0	U8	rw	SAE J1939 PDU Prop. B Transmission Rate in milliseconds	C8h	no

Example: Change transmission rate to 50 msec (=32h)

CAN-Identifier	Direction	RAW data [hex]
18EFF753h	write to device	2F 04 21 00 32 00 00 00
18EF53F7h	received from device	60 04 21 00 00 00 00 00

The new transmission rate is adopted and effective after a save command in Index 1010h and a power cycle.

3.3.8.1 Offset X/Y-axis tilt position (index 2576h)

Index	Sub-index	Data type	Access	Description	Default	Saved on Access
2576h	1	I16	rw	Offset X-axis tilt position	0d	no
2576h	2	I16	rw	Offset Y-axis tilt position	0d	no

Example: Change offset X-axis to 500 (= 01F4h)

CAN-Identifier	Direction	RAW data [hex]
18EFF753h	write to device	2B 76 25 01 F4 01 00 00
18EF53F7h	received from device	60 76 25 01 00 00 00 00

Example: Change offset Y-axis to -500 (= FE0Ch)

CAN-Identifier	Direction	RAW data [hex]
18EFF753h	write to device	2B 76 25 02 0C FE 00 00
18EF53F7h	received from device	60 76 25 02 00 00 00 00

3.3.8.2 Preset zero (index 2577h)

Index	Sub-index	Data type	Access	Description	Default	Saved on Access
2577h	1	U8	wo	X-axis Preset position	0d	no
2577h	2	U8	wo	Y-axis preset position (if available)	0d	no

Example: Execute X-axis preset zero

CAN-Identifier	Direction	RAW data [hex]
18EFF753h	write to device	2F 77 25 01 00 00 00 00
18EF53F7h	received from device	60 77 25 01 00 00 00 00

Example: Execute Y-axis preset zero

CAN-Identifier	Direction	RAW data [hex]
18EFF753h	write to device	2F 77 25 02 00 00 00 00
18EF53F7h	received from device	60 77 25 02 00 00 00 00

3.3.8.3 Tilt reverse (index 2578h)

Index	Sub-index	Data type	Access	Description	Default	Saved on Access
2578h	0	U32	rw	Tilt reverse (for 1-dim. variant only)	C8h	no

Example: Enable Tilt reverse

CAN-Identifier	Direction	RAW data [hex]
18EFF753h	write to device	23 78 25 00 01 00 00 00
18EF53F7h	received from device	60 78 25 00 00 00 00 00

Example: Disable Tilt reverse

CAN-Identifier	Direction	RAW data [hex]
18EFF753h	write to device	23 78 25 00 00 00 00 00
18EF53F7h	received from device	60 78 25 00 00 00 00 00

3.3.8.4 Store parameters

Parameters can be saved with ASCII-command "save" in parameter 1010h, sub-index 1 with a specific key (similar to CANopen store command). A store command is important for all parameters which are not saved at access.

Example:

CAN-Identifier	Direction	RAW data [hex]
18EFF753h	write to device	22 10 10 01 73 61 76 65
18EF53F7h	received from device	60 10 10 01 00 00 00 00

3.3.8.5 Restore default parameters (factory settings)

ASCII command "load" in parameter 1011h, sub-index 1 will restore the device default configuration.

Example:

CAN-Identifier	Direction	RAW data [hex]
18EFF753h	write to device	22 11 10 01 6C 6F 61 64
18EF53F7h	received from device	60 11 10 01 00 00 00 00

3.3.9 Address claiming

Two devices with the same address in the same bus network will have the address claiming function executed, meaning the new address is being assigned to the device of higher priority while the second device is being assigned a higher address.

4 Sensor configuration

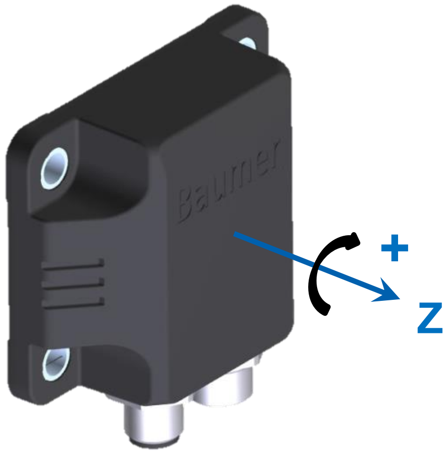
The sensor coordinate system is defined according to ISO 8855.

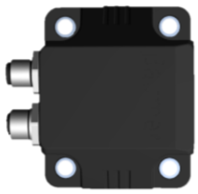
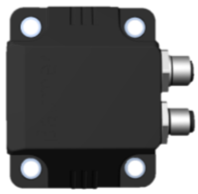
Note: To ensure backward compatibility to previous 1D and 2D versions of GIM500R and GIM140R, for some versions, positive direction of rotation deviates from ISO8855.

4.1 1-dimensional sensor / vertical installation (Z-axis angle, PGN 65363)

Install sensor in vertical position with horizontal Z-axis (see illustration). For optimum measuring accuracy, limit misalignment (maximum misalignment ±3°).

- Sensor measures rotation around Z-axis with measuring range 0…360°.
- Sensor output / slope value increases during clockwise rotation.
- Sensor output is zero / 0°, when the connectors are pointing downwards.
- Zero degree position may be configured by preset object (2577h).



			
Z-axis angle = 0°	Z-axis angle = 90°	Z-axis angle = 180°	Z-axis angle = 270°

4.2 2-dimensional sensor / horizontal installation (X-/Y-axis angles, PGN 65364)

Install sensor with horizontal X-axis and Y-axis (see illustration).

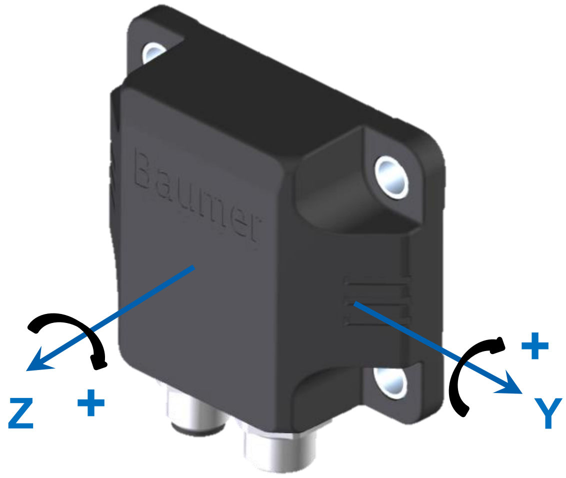
- Sensor measures rotation around X-axis and Y-axis with measuring range ±90°.
- Sensor outputs / slope values increase during clockwise rotation.
- Sensor outputs are zero / 0°, when sensor base plate has horizontal alignment (factory default settings).
- Zero degree position for both axes may be configured by preset object (2577h).

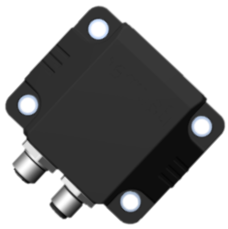
		
X-axis angle = 0° Y-axis angle = 0°	X-axis angle = 45° Y-axis angle = 0°	X-axis angle = 90° Y-axis angle = 0°
		
X-axis angle = 0° Y-axis angle = 0°	X-axis angle = 0° Y-axis angle = -45°	X-axis angle = 0° Y-axis angle = -90°

4.3 2-dimensional sensor / vertical installation (Z-/Y-axis angles, PGN 65364)

Install sensor in vertical position with horizontal Z-axis and Y-axis (see illustration).

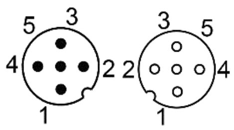
- Sensor measures rotation around Z-axis and Y-axis with measuring range ±90°.
- Sensor outputs / slope values increase during clockwise rotation.
- Sensor outputs are zero / 0°, when Z-axis and Y-axis have horizontal alignment (factory default settings).
- Zero degree position for both axes may be configured by preset object (2577h).



		
Z-axis angle = 0° Y-axis angle = 0°	Z-axis angle = +30° Y-axis angle = 0°	Z-axis angle = +45° Y-axis angle = 0°
		
Z-axis angle = 0° Y-axis angle = 0°	Z-axis angle = 0° Y-axis angle = -30°	Z-axis angle = 0° Y-axis angle = -45°

5 Terminal assignment

5.1 2 x M12 flange connector, 5-pin

Pin	Assignment	Description	M12 (plug / socket)
1	CAN_GND	Ground connection relating to CAN	
2	+Vs	Voltage supply	
3	GND	Ground connection relating to +Vs	
4	CAN_H	CAN Bus signal (dominant High)	
5	CAN_L	CAN Bus signal (dominant Low)	

Terminals with the same designation are connected to each other internally and identical in their functions. Maximum load on the internal clamps Vs-Vs and GND-GND is 0.6 Amps each.