perfect in sensors.

positilt®-PTM
Inclination Sensors

positilt®-PTK
Gyro-compensated Inclination Sensors

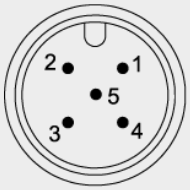
Output specification
CANopen and SAE J1939

positilt® PTM Inclination Sensors
positilt® PTK Gyro-compensated Inclination Sensors
Output specification CANopen

CANOP CANopen 	Communication profile	CANopen CiA 301, Slave
	Encoder profile	CiA 410, Profile „Inclinometer“
	Configuration services	LSS, CiA Draft Standard 305 (Transmission rate, node ID)
	Error Control	Node guarding, Heartbeat, Emergency message
	Node ID	Adjustable via LSS or SDO, default: 127
	PDO	1 TxPDO, 0 RxPDO, no linking, static mapping
	PDO Modes	Event-/Time triggered, Remote-request, Sync cyclic/acyclic
	SDO	1 Server, 0 Client
	Certified	yes
	Transmission rate	125 kBit … 1 Mbit, adjustable via LSS or SDO, default: 125 kBit
	Bus connection	M12 conncector, 5 pin
	Bus, galvanic isolated	no
	Error Control Baudrate	50kBit/s … 1MBit/s configurable
	Transceiver	24V-compliant, not isolated
	Internal termination resistor	120 Ohm configurable

Specifications	Excitation voltage	8 ... 36 V DC
	Excitation current	15 mA typical at 24 V DC 30 mA typical at 12 V DC, 100 mA max.
	Measuring rate	0.5 kHz standard
	Stability (temperature)	± 0,2° (-20 … +40 °C) ± 0,4° (-40 … +85 °C)
	Repeatability	1 LSB
	Operating temperature	-40 … +85 °C
	Protection	Reverse polarity, short circuit
	EMC	DIN EN 61326-1:2013

Signal wiring
Connector M12, 5 pin



View to the sensor connector

Output signals	Connector pin no.
Shield	1
Excitation +	2
GND	3
CAN-H	4
CAN-L	5

Overview Setup, User Configuration

Setup

Before connecting the sensor to the CAN-Bus the devices have to be checked for correct bitrate and unique node-IDs. Both parameters are configurable by Layer-Setting-Service (LSS) or by Service Data Object (SDO).

After power-on the sensor will enter pre-operational state and send a boot-up message being ready for configuration by Service Data Objects. Parameters configured by the user can be stored nonvolatile by SAVE command. On receiving "NMT-Node-Start" the sensor transits to operational state and starts process data transmission. When "Auto-Start" is configured the sensor will automatically transit to operational after boot-up without a need for the Node-Start message.

Node monitoring is supported by Node Guarding and Heartbeat protocol. Node Guarding implements cyclic querying of the node status by the NMT-Master within the guard time window. The Heartbeat protocol provides automatic transmission of the node status (heartbeat message) by the slave within producer heartbeat time window.

By using the CAN example protocols included in this manual the sensor may be used without CANopen master device.

Dual Channel Configuration

Each of the two channels is a logically independent CAN device having a Node-ID on its own. Each channel has to be configured separately. Channel 1 which has the default Node-ID 07Fh accepts odd Node-ID values only while channel 2 which has the default Node-ID 07Eh accepts only even numbers.

⚠ WARNING **Risk of injury by unexpected machine movement!**

- Changing parameters may cause unexpected machine movement.
- Changing parameters may influence dependent parameters e.g. changing the resolution may have influence on position of CAM switches.
- Precautions have to be taken to avoid damage to human and machine parts!
- Change parameters only when machine is in a safe condition!

Configuration Message

Service Data Object (SDO)

Configurable parameters of the sensor are accessible by peer to peer communication. The identifier (COB) of the SDO message is defined by the predefined connection set. Parameters to be uploaded or downloaded are addressed by Index and Subindex.

11-Bit CAN-Id	8 Byte data frame							
SDO COB-Id	**CS**	**Index**		**Sub-Index**	**Data**			
→ Request: Control Unit to Sensor								
600h + Node-Id	Byte	LSB	MSB	Byte	LSB	..	..	MSB
← Response: Sensor to Control Unit								
580h + Node-Id	Byte	LSB	MSB	Byte	LSB	..	..	MSB

SDO - Download Protocol

8 Byte data frame							
CS	**Index**		**Sub-Index**	**Data**			
→ Request: Control Unit to Sensor							
ccs	LSB	MSB	Byte	LSB	..	..	MSB
← Response: Sensor to Control Unit							
scs	LSB	MSB	Byte	Reserved			

Bit structure of command specifier CS:

b7	b6	b5	b4	b3	b2	b1	b0
→ Request: Control Unit to Sensor							
ccs			X	n		e	s
← Response: Sensor to Control Unit							
scs			X				

ccs: control unit command specifier, ccs = 1 (=> CS_8 = 2Fh, CS_{16} = 2Bh, CS_{32} = 23h)
scs: sensor command specifier, scs = 3 (=> CS = 60h)
X: reserved
e: expedited transfer e = 1
s: data set size = 1
n: number of bytes which do not contain data

SDO - Upload Protocol

8 Byte data frame							
CS	**Index**		**Sub-Index**	**Data**			
→ **Request: Control Unit to Sensor**							
scs	LSB	MSB	Byte	Reserved			
← **Response: Sensor to Control Unit**							
ccs	LSB	MSB	Byte	LSB	..	..	MSB

Bit structure of command specifier CS:

b7	**b6**	**b5**	**b4**	**b3**	**b2**	**b1**	**b0**
→ **Request: Control Unit to Sensor**							
scs			X				
← **Response: Sensor to Control Unit**							
ccs			X	n		e	s

ccs: control unit command specifier, ccs = 2 (=> CS = 40h)
scs: sensor command specifier, scs = 2 (=> CS_8 = 4Fh, CS_{16} = 4Bh, CS_{32} = 43h)
X: reserved
e: expedited transfer e = 1
s: data set size = 1
n: number of bytes which do not contain data

SDO - Abort Peer-to-Peer-Protocol

8 Byte data frame			
CS	**Index**	**Sub-Index**	**Data**

→ **Response: Control Unit or Sensor**

cs	LSB	MSB	Byte	Abort Code

Bit structure of command specifier CS for Abort Protocol:

b7	**b6**	**b5**	**b4**	**b3**	**b2**	**b1**	**b0**

→ **Request: Control Unit to Sensor**

cs	X

cs: control unit / sensor command specifier, cs = 4, (=> CS = 8h)
X: reserved

SDO - Abort Code Description

Abort Code	Description
0601 0001h	Attempt to read a write only object.
0601 0002h	Attempt to write a read only object.
0602 0000h	Object does not exist in the object dictionary.
0604 0043h	General parameter incompatibility
0607 0012h	Data type does not match, length of service parameter too high
0607 0013h	Data type does not match, length of service parameter too low
0609 0030h	Value range of parameter exceeded (only for write access).

Process Data Message (TPDO)

Process data messages are broadcast messages. The structure of the 8 Byte data frame is product specific.

11-Bit CAN-Id	8 Byte data frame
PDO COB-Id	Process Data

← Sensor to Control Unit

180h + Node-Id	LSB	…					..	MSB

Format of Process Data Field

B0	B1	B2	B3	B4	B5	B6	B7
Inclination value							Error
LSB_X	MSB_X	LSB_Y	MSB_Y	reserved	reserved	reserved	Status

Bit structure of object 1001, Error Register

b7	b6	b5	b4	b3	b2	b1	b0
							Generic

b0 Generic Error
0: No Error
1: Internal Error or Communication Error

TPDO Transmit-PDO Transmission Type

Transmission type of TPDO-1, -2 is configurable by object PDO Communication Parameter 1800, 1801 sub-indices -1, -2, -3 and -5.

Transmission type example for TPDO-1	COB-Id 1800-1	Transmission Type 1800-2	Inhibit Time 1800-3	Event Timer [ms] 1800-5
Event Timer Driven	1FFh	FEh	0 ... FFFFh	0 ... FFFFh
Cyclic Synchronous	1FFh	N = 1 ... F0h		-
TPDO Disable	80 00 xx xx	-		-
TPDO Enable	00 00 xx xx	-		-

Transmission type "Event Timer Driven" triggers TPDO-transmission periodically with a time period defined by the event timer. In "Cyclic Synchronous" a TPDO is transmitted on reception of a number of one or multiple SYNC commands. Enable or disable a TPDO by setting Bit 31 of the COB-Id '0' resp. '1' (Default: "0" Enabled).

Communication Profile CiA 301

Object	Index [hex]	Sub-idx	Access	Type	Default	Value Range / Note [time spec in ms]
Device type	1000	0	ro	U32	0002019Ah	Inclinometer
Error register	1001	0	ro	U8	0	Error status
Pre-defined Error Field, N	1003	0	rw	U8	0	Number of Errors
Pre-defined Error Field, Error List	1003	1 .. 8	ro	U32	0	Emergency Error Code
COB-ID-Sync	1005	0	rw	U32	80h	
Manufacturer device name	1008	0	ro	String	)[1]	
Manufacturer hardw version	1009	0	ro	String	)[1]	
Manufacturer softw version	100A	0	ro	String	)[1]	
Guard time	100C	0	rw	U16	0	0 .. FFFFh
Life time factor	100D	0	rw	U8	0	0 .. FFh
Save Settings	1010	1	w	U32	-	„save“ (65766173h)
Load Manufacturer Settings	1011	1	w	U32	-	„load“ (64616F6Ch)
COB-ID-EMCY	1014	0	rw	U32	FFh	Node-Id+0x80
Producer heartbeat time	1017	0	rw	U16	0	0 .. FFFFh
Identity Object VendorID	1018	1	ro	U32	00000252h	
Identity Object Product Code		2	ro	U32	)[1]	A-Nummer
Identity Object Revision number		3	ro	U32	)[1]	
Identity Object Serial number		4	ro	U32	)[1]	
COB-ID Server->Client	1200	1	ro	U32	67Fh	Node-Id+0x600
COB-ID Client-> Sever	1200	2	ro	U32	5FFh	Node-Id+0x580
TPDO1 COB-ID	1800	1	rw	U32	1FFh	Node-Id+0x180)[2]
TPDO1 Transmission-Type		2	rw	U8	FEh	0 .. FFh)[2],)[3]
TPDO1 Inhibit time		3	rw	U16	0	0 .. FFFFh)[2]
TPDO1 Event timer		5	rw	U16	64h	0 .. FFFFh
TPDO2 COB-ID	1801	1	rw	U32	2FFh	Node-Id+0x280)[2]
TPDO2 Transmission-Type		2	rw	U8	1	0 .. FFh)[2],)[3]
TPDO2 Inhibit time		3	rw	U16	0	0 .. FFFFh)[2]
TPDO2 Event timer		5	rw	U16	0	0 .. FFFFh
TPDO1 No of mapped Obj	1A00	0	ro	U8	5	
TPDO1-Mapped Object		1	ro	U32	60100010h	Slope long16 x axis
TPDO1-Mapped Object		2	ro	U32	60200010h	Slope long16 y axis
TPDO1-Mapped Object		3,4	ro		-	Dummy
TPDO1-Mapped Object		5	ro	U8	10010008h	Error Register
TPDO2 No of mapped Obj	1A01	0	ro	U8	5	
TPDO2-Mapped Object		1	ro	U32	60100010h	Slope long16 x axis
TPDO2-Mapped Object		2	ro	U32	60200010h	Slope long16 y axis
TPDO2-Mapped Object		3,4	ro		-	Dummy
TPDO2-Mapped Object		5	ro	U8	10010008h	Error Register
NMT-Startup	1F80	0	rw	U32	4	0: Self Start ON 4: Self Start OFF

)[1] Product specific
)[2] enable write access for objects "COB-ID", "Transmission-Type" or "Inhibit time" by setting COB-ID-bit31 to "1"
)[3] Valid Transmission Types: 1 ... F0h, FEh

Configurable Parameters

Parameter	Index [hex]	Sub-Index [hex]	Read / Write	Type	Default	Range / Selection [Unit]
Control						
Store parameters	1010	1	wo)[2]	U32	-	“save”
Reload factory defaults	1011	1	wo)[2]	U32	-	“load”
Node-Id	2000	0	rw)[1]	U8	7Fh	1 .. 7Fh
Bit Rate	2010	0	rw)[1]	U8	4	125 … 1000 kBit/s
Termination Resistor	2050	0	rw	U8	0	0=OFF, 1=ON
Low Pass Output Filter	2103	0	rw	U16	100	0 ... 65535
Mounting Option)[5]	2110	0	rw	U8	1	1=2A, 2=2B, 3=2C
Dynamic Compensation)[6]	2111	0	rw	U16	1	0=OFF, 1=ON
Measurement						
Resolution (in steps of 0.001°)	6000	0	rw	U16	10	10, 100, 1000
Slope long16 inclination angle round x axis	6010	0	ro	I16	no	-180 .. +180 [°]
Operating parameters slope long16)[4]	6011	0	ro / rw)[3]	U8	0	
Slope long16 preset value	6012	0	rw	I16	0	-180 .. +180 [°]
Slope lat16 inclination angle round y axis	6020	0	ro	I16	no	-180 .. +180 [°]
Operating parameters slope lat16)[4]	6021	0	ro / rw)[3]	U8	0	
Slope lat16 preset value	6022	0	rw	I16	0	-180 .. +180 [°]

)[1] Effective after "store parameters" and next power-up
)[2] “save”: LSB...MSB: 73h 61h 76h 65h
“load”: LSB...MSB: 6Ch 6Fh 61h 64h
Reload factory defaults does not affect Node-Id and Bit Rate
)[3] Write access to objects 6012, 6022 only when scaling function enabled (Object 6011, 6021)
)[4] See Table below
)[5] Set preset to 0 for both axes while the sensor is in the new zero-position
)[6] PTK sensors only

Bit structure of object 6011, 6021, Operating Parameters:

b7	b6	b5	b4	b3	b2	b1	b0
ms			r			s	i

i Slope Inversion
0: slope inversion disabled
1: slope inversion enabled
s Scaling Enable
0: scaling disabled
1: scaling enabled
r reserved
ms Manufacturer specific

Bit structure of object 1001, Error Register

b7	b6	b5	b4	b3	b2	b1	b0
							Generic

b0 Generic Error
0: No Error
1: Internal Error or Communication Error

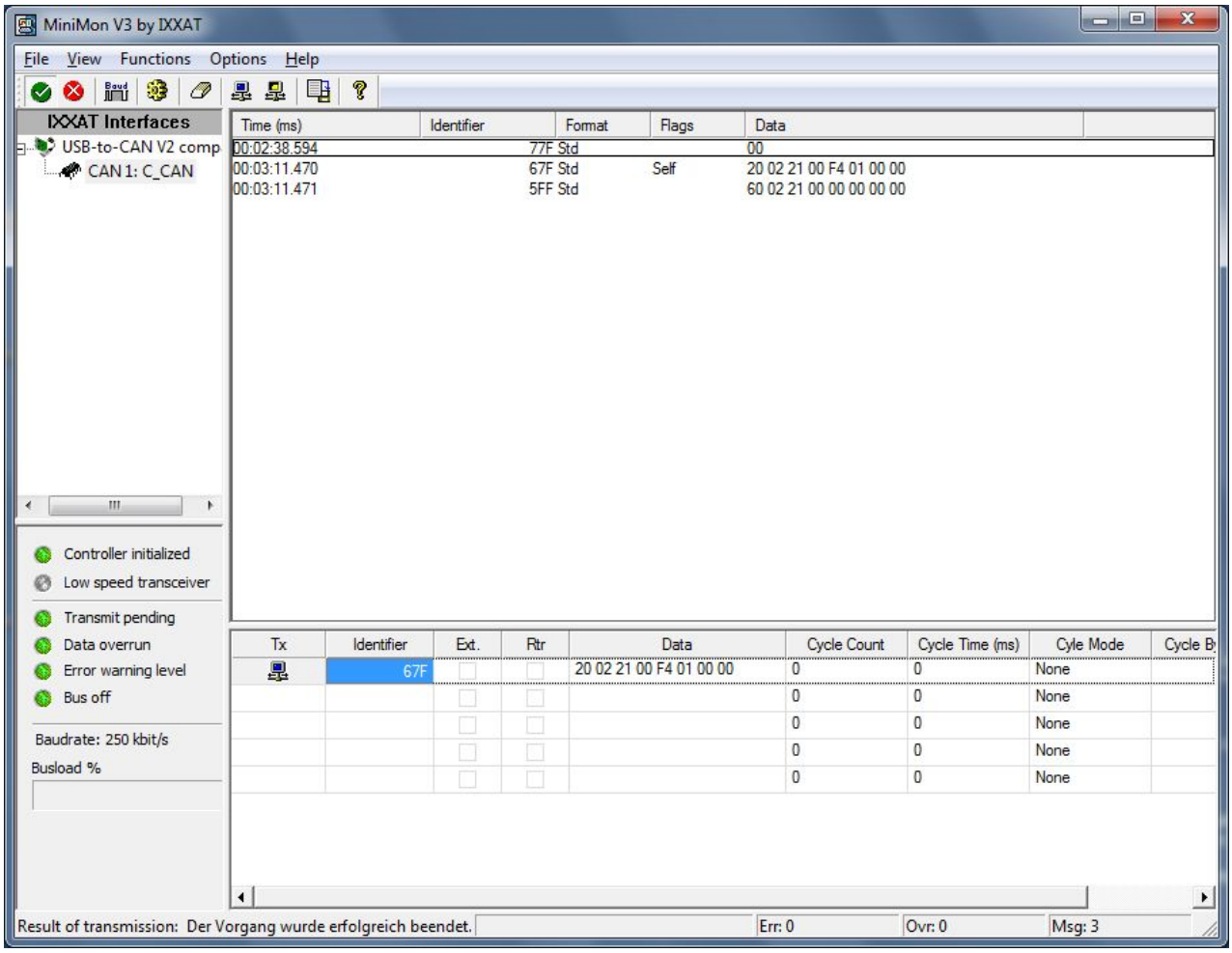
Baud Rate (Object 2010)

Baud Rate Index	Baud Rate [kbit/s]
0	1000
1	800
2	500
3	250
4	125

CANopen example protocols

The example protocols are prepared using the USB-to-CAN Interface with CAN-Monitor „IXXAT“ (HMS Industrial Networks AB). The examples enable the user to configure and run the CANopen sensor from a host PC without using a CANopen master ECU.

CAN Monitor Screen



Example: boot up and change parameter

Time (ms)	Identifier	Format	Flags	Data
00:02:38.594	77F	Std		00
00:03:11.470	67F	Std	Self	20 02 21 00 F4 01 00 00
00:03:11.471	5FF	Std		60 02 21 00 00 00 00 00

After boot up (line 1) the filter (Object 2102-00) will be changed to 1F4h by an SDO message (line 2). The sensor sends a response message (line 3),

Example: change Node-ID

Time (ms)	Identifier	Format	Flags	Data
00:14:34.540	77F	Std		00
00:14:36.969	67F	Std	Self	2F 00 20 00 7E 00 00 00
00:14:36.970	5FF	Std		60 00 20 00 00 00 00 00
00:14:38.633	67F	Std	Self	23 10 10 01 73 61 76 65
00:14:38.637	5FF	Std		60 10 10 01 00 00 00 00
00:14:41.486	77E	Std		00

After boot up (line 1) the node-ID (2000h) will be changed from 7F to 7Eh by SDO (line 2, 3). The changed setting is stored nonvolatile by SDO "SAVE" (line 4). The sensor node-ID stays unchanged (Line5, 6) and will become valid on next power down - boot up cycle (line 6). Note: While the configurable parameters will become valid immediatly node-ID and baud rate stay unchanged until the next power cycle.

Example: switch to operational

Time (ms)	Identifier	Format	Flags	Data
00:00:41.658	77F	Std		00
00:00:46.441	0	Std	Self	01 00
00:00:46.441	1FF	Std		2F 1A 00 00
00:00:46.542	1FF	Std		2F 1A 00 00
00:00:46.643	1FF	Std		2F 1A 00 00
00:00:46.743	1FF	Std		2F 1A 00 00
00:00:46.843	1FF	Std		2F 1A 00 00

After boot up (line 1) a "Start all Nodes" NMT message (line 2) will switch the sensor from pre-operational to operational starting transmission of the process data objects (lines 3...).

Example: change COB-ID of a TPDO

Time (ms)	Identi...	Format	Flags	Data
00:50:43.447	77F	Std		00
00:50:43.447	77E	Std		00
00:51:54.461	67F	Std	Self	23 00 18 01 00 00 00 80
00:51:54.463	5FF	Std		60 00 18 01 00 00 00 00
00:51:59.317	67F	Std	Self	23 00 18 01 81 01 00 00
00:51:59.319	5FF	Std		60 00 18 01 00 00 00 00

The example sequence shows boot up of node 7Fh in line 1. Write access is enabled be writing 80000000h to COB-ID object, Index 1800-1 (lines 3, 4). Next frame writes a new COB-ID 181h to Index 1800-1 (lines 5, 6).

Example: change transmission type of a TPDO

Time (ms)	Identi...	Format	Flags	Data
00:03:41.266	77F	Std		00
00:03:41.266	77E	Std		00
00:03:47.981	67F	Std	Self	23 00 18 01 00 00 00 80
00:03:47.983	5FF	Std		60 00 18 01 00 00 00 00
00:03:55.413	67F	Std	Self	2F 00 18 02 01 00 00 00
00:03:55.414	5FF	Std		60 00 18 02 00 00 00 00
00:04:02.309	67F	Std	Self	23 00 18 01 FF 01 00 00
00:04:02.311	5FF	Std		60 00 18 01 00 00 00 00

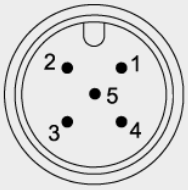
The example sequence shows boot up of node 7Fh in line 1. Write access is enabled be writing 80000000h to COB-ID object, Index 1800-1 (lines 3, 4). Next two frames write a new Transmission Type 1h to Index 1800-2 (lines 5, 6) and restore the COB-ID object, Index 1800-1 to its original value 1FFh (lines 7, 8).

CANJ1939 SAE J1939 	CAN Specification	ISO 11898, Basic and Full CAN 2.0 B extended message format with 29-bit identifier
	Transceiver	24V-compliant, not isolated
	Communication profile	SAE J1939, 29-bit identifier
	Transmission rate	250 kBit/s
	Internal termination resistor	120 Ω
	Address	Default 247d, configurable

NAME - Unique device identifier	**Name Fields**	**Remark**	**Field value**	**Size [Bit]**	**Byte order**	**Byte value**
	Arbitrary Address Capable	No	0	1	Byte 8 (MSB)	00h
	Industry Group	Global	0	3		
	Vehicle System instance		0	4		
	Vehicle System	Non specific	7Fh	7	Byte 7	FEh
	Reserved		0	1		
	Function	Non specific	FFh	8	Byte 6	FFh
	Function Instance		0	5	Byte 5	00
	ECU Instance		0	3		
	Manufacturer	Manufacturer Code	145h	11	Byte 4	28h
					Byte 3	A0h+nn
		Identity Number	n..nh	21		
					Byte 2	nnh
					Byte 1	nnh

Proprietary PGN - Manufacturer specific Parameter Group Numbers	Configuration data	PGN EFddh	Proprietary-A (PDU1 peer-to-peer)
	Process data	PGN FFnnh	Proprietary-B (PDU2 broadcast); nn Group Extension (PS) configurable

Specifications	Excitation voltage	8 ... 36 V DC
	Excitation current	15 mA typical at 24 V DC 30 mA typical at 12 V DC, 100 mA max.
	Measuring rate	0.5 kHz (asynchronous)
	Stability (temperature)	± 0,2° (-20 … +40 °C) ± 0,4° (-40 … +85 °C)
	Repeatability	1 LSB
	Operating temperature	-40 … +85 °C
	Protection	Reverse polarity, short circuit
	EMV	DIN EN 61326-1:2013

Signal wiring **Connector M12, 5 pin**	**Output signals**	**Connector pin no.**
 View to the sensor connector	Shield	1
	Excitation +	2
	GND	3
	CAN-H	4
	CAN-L	5

Overview Boot-Up, User Configuration, Process Data

Address Claiming (Single Address capable device)

On power up the sensor claims a Node Address by sending an *Address Claimed* message which contains the NAME as a unique identifier. Should another device claim the same address the device having the NAME with a lower priority will send *Cannot Claim Address* and stay passive.

User configuration

User accessible parameters are configurable by peer-to-peer proprietary-A message (PGN EF00h). The configuration parameters are accessed by a standard message format. The Node Address is configurable either by *Commanded Address* or by peer-to-peer proprietary-A message. A new address set by peer-to-peer proprietary-A message will be effective not before next power up. A new address set by *Commanded Address* will be effective immediately and an *Address Claimed* message will be sent. On execution of *Store Parameters,* the configuration is saved nonvolatile.

Process Data

Process Data are transmitted cyclic by Broadcast PGN FFnnh on power up after successful address claiming. The cycle time and the Group Extension Byte nn (PS) are user configurable.

Dual Channel Configuration

Each of the two channels is a logically independent CAN device having a Node Address on its own. Each channel has to be configured separately. Channel 1 which has the default Node-ID 0F7h accepts odd node-id values only while channel 2 which has the default node-id 0F6h accepts only even numbers.

⚠ WARNING

Risk of injury by unexpected machine movement!

- Changing parameters may cause unexpected machine movement.
- Changing parameters may influence dependent parameters e.g. changing the resolution may have influence on position of CAM switches.
- Precautions have to be taken to avoid damage to human and machine parts!
- Change parameters only when machine is in a safe condition!

Configuration Message

Configuration message Peer-to-Peer

Configurable parameters of the sensor are accessible by peer to peer communication. The Parameter Group Number (PGN) of this message is EFddh. Parameters to be uploaded or downloaded are addressed by Index and Subindex.

29-Bit CAN-Id						8 Byte data frame			
PR	R	DP	PF	PS	SA	CS	Index	Sub-Index	Data

→ Request: Control Unit to Sensor

Byte	EFh	DA	SA	Byte	LSB	MSB	Byte	LSB	..	..	MSB

← Response: Sensor to Control Unit

Byte	EFh	DA	SA	Byte	LSB	MSB	Byte	LSB	..	..	MSB

PR: 3-Bit-Priority, not configurable, reflects priority of request message
R: 1 Bit Reserved (R = 0)
DP: 1 Bit Data Page (DP = 0)
PF: 1 Byte PDU Format of a Parameter Group Number PGN (= EFh)
PS: 1 Byte PDU Specific: Message destination address DA if PF < F0h (Peer-to-Peer message)
SA: 1 Byte Message Source Address
CS: 1 Byte Command Specifier
Index: 2 Byte Index
SubIndex: 1 Byte Subindex

Configuration Message - Download Protocol

8 Byte data frame							
CS	**Index**		**Sub-Index**	**Data**			
→ **Request: Control Unit to Sensor**							
ccs	LSB	MSB	Byte	LSB	..	..	MSB
← **Response: Sensor to Control Unit**							
scs	LSB	MSB	Byte	Reserved			

Bit structure of command specifier CS:

b7	**b6**	**b5**	**b4**	**b3**	**b2**	**b1**	**b0**
→ **Request: Control Unit to Sensor**							
ccs			X	n		e	s
← **Response: Sensor to Control Unit**							
scs			X				

ccs: control unit command specifier, ccs = 1 (=> CS_8 = 2Fh, CS_{16} = 2Bh, CS_{32} = 23h)
scs: sensor command specifier, scs = 3 (=> CS = 60h)
X: reserved
e: expedited transfer e = 1
s: data set size = 1
n: number of bytes which do not contain data

Configuration Message - Upload Protocol

8 Byte data frame			
CS	**Index**	**Sub-Index**	**Data**

→ Request: Control Unit to Sensor

scs	LSB	MSB	Byte	Reserved

← Response: Sensor to Control Unit

ccs	LSB	MSB	Byte	LSB	..	..	MSB

Bit structure of command specifier CS:

b7	**b6**	**b5**	**b4**	**b3**	**b2**	**b1**	**b0**

→ Request: Control Unit to Sensor

scs	X

← Response: Sensor to Control Unit

ccs	X	n	e	s

ccs: control unit command specifier, ccs = 2 (=> CS = 40h)
scs: sensor command specifier, scs = 2 (=> CS_8 = 4Fh, CS_{16} = 4Bh, CS_{32} = 43h)
X: reserved
e: expedited transfer e = 1
s: data set size = 1
n: number of bytes which do not contain data

Configuration Message - Abort Peer-to-Peer-Protocol

8 Byte data frame			
CS	**Index**	**Sub-Index**	**Data**

→ **Response: Control Unit or Sensor**

cs	LSB	MSB	Byte	Abort Code

Bit structure of command specifier CS for Abort Protocol:

b7	b6	b5	b4	b3	b2	b1	b0

→ **Request: Control Unit to Sensor**

cs	X

cs: control unit / sensor command specifier, cs = 4, (=> CS = 8h)
X: reserved

Bit structure of object 1001, Error Register

b7	b6	b5	b4	b3	b2	b1	b0
							Generic

b0 Generic Error
0: No Error
1: Internal Error or Communication Error

Configuration Message - Abort Code Description

Abort Code	Description
0601 0001h	Attempt to read a write only object.
0601 0002h	Attempt to write a read only object.
0602 0000h	Object does not exist in the object dictionary.
0607 0010h	Data type does not match, length of service parameter does not match.
0609 0011h	Sub-index does not exist.
0609 0030h	Value range of parameter exceeded (only for write access).

Process Data Message

Process data messages are broadcast messages. The Parameter Group Number (PGN) of this message type ist FFnnh. GE is a user configurable group extension byte. The structure of the 8 Byte data frame is product specific.

29-Bit CAN-Id						8 Byte data frame
PR	R	DP	PF	PS	SA	Process Data

← Sensor

Byte	FFh	GE	SA	LSB	..	..	..	..	..	..	MSB

PR: 3-Bit-Priority, not configurable PR=7 (lowest priority)
R: 1 Bit Reserved (R = 0)
DP: 1 Bit Data Page (DP = 0)
PF: 1 Byte PDU Format of a Parameter Group Number PGN (= FFh)
PS: 1 Byte PDU Specific: Configurable group extension GE if PF ≥ F0h (Broadcast message)
SA: 1 Byte Message Source Address

Format of Process Data Field

B0	B1	B2	B3	B4	B5	B6	B7
Inclination value							Error
LSB_X	MSB_X	LSB_Y	MSB_Y	reserved	reserved	reserved	Status

Bit structure of object 1001, Error Register

b7	b6	b5	b4	b3	b2	b1	b0
							Generic

b0 Generic Error
0: No Error
1: Internal Error or Communication Error

Format of Process Data Field - Option CRC, Roll-Counter

B0	B1	B2	B3	B4	B5	B6	B7
Inclination value					Roll-Counter	CRC Value	Error
LSB_X	MSB_X	LSB_Y	MSB_Y	reserved	ROLL	CRC8	Status

Bit structure of object 1001, Error Register

b7	b6	b5	b4	b3	b2	b1	b0
							Generic

b0 Generic Error
0: No Error
1: Internal Error or Communication Error

ROLL 8 Bit Roll-Counter
increments with every Process Data Frame transmitted, overflows from 0xFF to 00

CRC8 Check Value for Prozess Data B0, B1, B2, B3, B4, B5, B7
Initial Value = 0x00
Polynomial = 0x97

Calculation Example for CRC Check Value

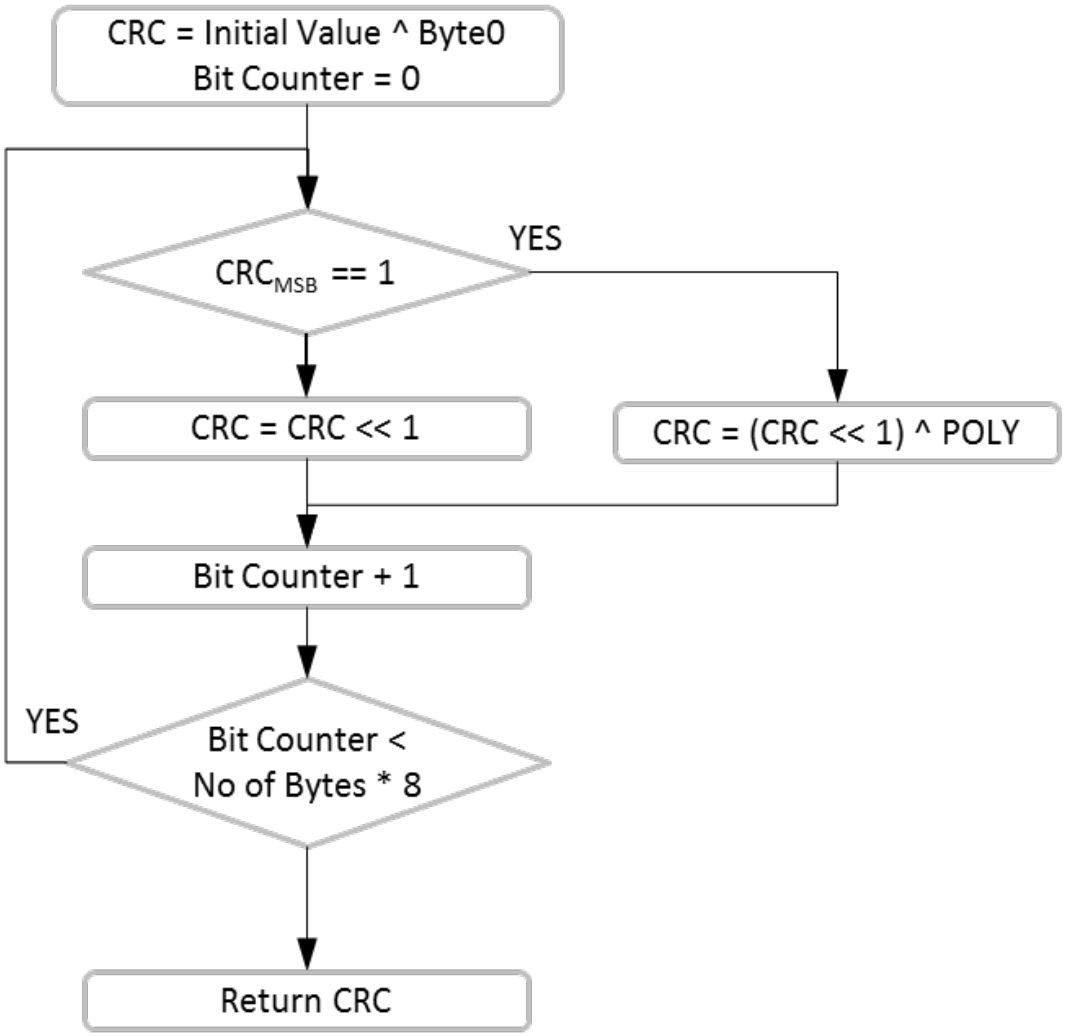
Test Pattern:

Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte7
41	53	4D	47	6D	62	48

Calculation of CRC8 Value - Calculation Table

ShiftCnt		Input Bytes Byte0 – Byte1 – Byte 2 - .. – Byte5 – Byte7																			
		Byte0								Byte1								Byte2 ...			
	Initial Value	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**												
	Polynomial	**1**	**0**	**0**	**1**	**0**	**1**	**1**	**1**												
	Input Data	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**0**	**1**	**1**	**0**	**1**	...
	CRC = Initial Value ^ Byte0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	1	1	0	1	...
1	CRC = (CRC << 1)	1	0	0	0	0	0	1	0	1	0	1	0	0	1	1	0	1	0	...
2	CRC = (CRC << 1) ^ POLY	1	0	0	1	0	0	1	0	0	1	0	0	1	1	0	1	0	0	...
3	CRC = (CRC << 1) ^ POLY	1	0	1	1	0	0	1	1	1	0	0	1	1	0	1	0	0	1	...
4	CRC = (CRC << 1) ^ POLY	1	1	1	1	0	0	0	0	0	0	1	1	0	1	0	0	1	1	...
5	CRC = (CRC << 1) ^ POLY	0	1	1	1	0	1	1	1	0	1	1	0	1	0	0	1	1	0	...
..	CRC = CRC << 1 ...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	...
56	**Result CRC8 Check Value**	**1**	**0**	**1**	**1**	**1**	**1**	**1**	**0**												

Calculation of CRC8 Value – Flow Chart



Stepwise calculation of the CRC8 Value for a sequence of bytes will start by XOR-ing the initial value with the first byte0. Each subsequent step will shift the bits of the byte sequence one bit-position left. If there is a leading bit = 1 shifted out of the most significant bit (MSB) the shift result will be XOR-ed with the CRC-polynomial.

Configurable Parameters

Parameter	Index [hex]	Sub-Index [hex]	Read / Write	Type	Default	Range / Selection [Unit]
Control						
Store parameters	1010	1	wo)[2]	U32	-	“save”
Reload factory defaults	1011	1	wo)[2]	U32	-	“load”
Node Address	2000	0	rw)[1]	U8	F7h	80h ... F7h
PGN Group Extension (PS)	2001	0	rw	U8	0	0 … FFh
Bit Rate	2010	0	rw)[1]	U8	3	3 = 250 kbit/s 2 = 500 kbit/s
Termination Resistor	2050	0	rw	U8	0	0=OFF, 1=ON
Low Pass Output Filter	2103	0	rw	U16	0	0 ... 65535
Mounting Option)[5]	2110	0	rw	U8	1	1=2A, 2=2B, 3=2C
Dynamic Compensation)[6]	2111	0	rw	U16	1	0=OFF, 1=ON
Measurement						
Resolution (in steps of 0.001°)	6000	0	rw	U16	10	10, 100, 1000
Slope long16 inclination angle round x axis	6010	0	ro	I16	no	-180 ... +180 [°]
Operating parameters slope long16)[4]	6011	0	ro / rw)[3]	U8	0	
Slope long16 preset value	6012	0	rw	I16	0	-180 ... +180 [°]
Slope lat16 inclination angle round y axis	6020	0	ro	I16	no	-180 ... +180 [°]
Operating parameters slope lat16)[4]	6021	0	ro / rw)[3]	U8	0	
Slope lat16 preset value	6022	0	rw	I16	0	-180 ... +180 [°]
Cyclic timer	6200	0	rw	U16	100	0 … 2^{16}-1 ms

)[1] Effective after "store parameters" and next power-up
)[2] “save”: LSB...MSB: 73h 61h 76h 65h
“load”: LSB...MSB: 6Ch 6Fh 61h 64h
Reload factory defaults does not affect Node-Id and Bit Rate
)[3] Write access to objects 6012, 6022 only when scaling function enabled (Object 6011, 6021)
)[4] See Table below
)[5] Set preset to 0 for both axes while the sensor is in the new zero-position
)[6] PTK sensors only

Bit structure of object 6011, 6021, Operating Parameters:

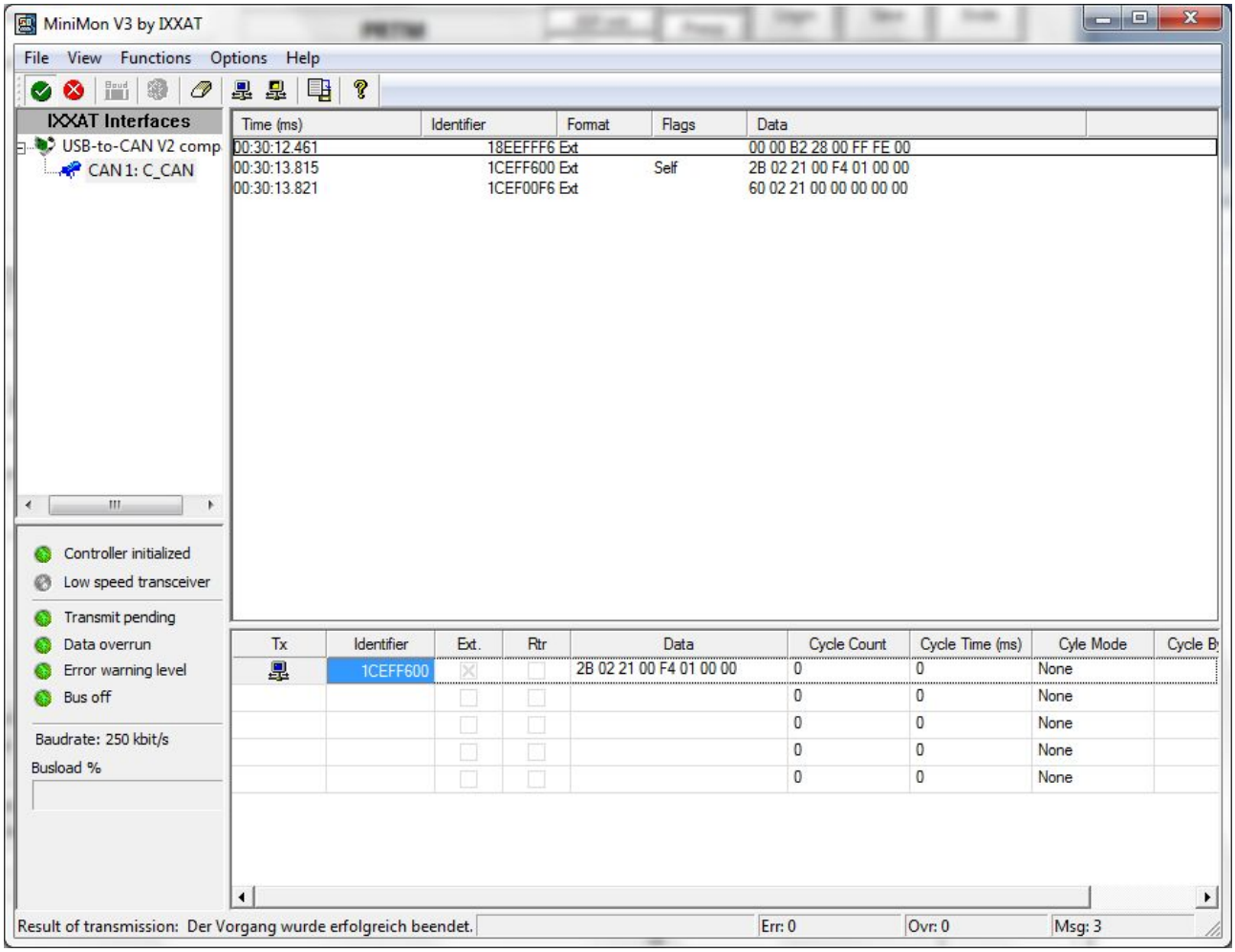
b7	b6	b5	b4	b3	b2	b1	b0
ms			r			s	i

i Slope Inversion
0: slope inversion disabled
1: slope inversion enabled
s Scaling Enable
0: scaling disabled
1: scaling enabled
r reserved
ms Manufacturer specific

CANJ1939 Example Protocols

The example protocols are prepared using the USB-to-CAN Interface with CAN-Monitor „IXXAT“ (HMS Industrial Networks AB). The examples enable the user to configure and run the CANopen sensor from a host PC without using a CANopen master ECU.

CAN Monitor Screen



Example: Address-Claiming and Change Parameter

Time (ms)	Identifier	Format	Flags	Data
00:30:12.461	18EEFFF6	Ext		00 00 B2 28 00 FF FE 00
00:30:13.815	1CEFF600	Ext	Self	2B 02 21 00 F4 01 00 00
00:30:13.821	1CEF00F6	Ext		60 02 21 00 00 00 00 00

After boot up the sensor claims address F6h by "Address Claim" message (line 1). The filter (Object 2102-00) will be changed to 1F4h by a configuration message (line 2) and the sensors sends a response message (line 3).

Example: Change Node-ID

Time (ms)	Identifier	Format	Flags	Data
00:33:31.336	18EEFFF6	Ext		00 00 B2 28 00 FF FE 00
00:33:32.195	1CEFF600	Ext	Self	2F 00 20 00 F4 00 00 00
00:33:32.196	1CEF00F6	Ext		60 00 20 00 00 00 00 00
00:33:33.459	1CEFF600	Ext	Self	23 10 10 01 73 61 76 65
00:33:33.475	1CEF00F6	Ext		60 10 10 01 00 00 00 00
00:33:34.670	18EEFFF4	Ext		00 00 B2 28 00 FF FE 00

After boot up and address claim (line 1) the node-ID (2000h) will be changed from F6h to F4h (line 2, 3). The changed setting is stored nonvolatile by "SAVE" (line 4, 5). The sensor node-ID stays unchanged (line 5, 6) and will become valid on next power up cycle (line 6). Note: While the configurable parameters will become valid immediately node-ID and baud rate stay unchanged until the next power cycle.

Example: Autostart

Time (ms)	Identifier	Format	Flags	Data
00:21:20.412	18EEFFF6	Ext		00 00 B2 28 00 FF FE 00
00:21:20.605	18FF00F6	Ext		59 00 00 00 00 00 00 80
00:21:20.805	18FF00F6	Ext		ED 3F 00 00 00 00 00 80
00:21:21.005	18FF00F6	Ext		0C 00 00 00 00 00 00 80
00:21:21.205	18FF00F6	Ext		F0 3E 00 00 00 00 00 80
00:21:21.405	18FF00F6	Ext		0B 00 00 00 00 00 00 80
00:21:21.605	18FF00F6	Ext		84 00 00 00 00 00 00 80

After boot up (line 1) a "Start all Nodes" message (line 2) will switch all sensors from pre-operational to operational starting the transmission of the process data objects (lines 3...).