Accelerometer for CAN-Interface

M-A552AC1x

Data Sheet

(P/N: X2F000031000100)

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Table of Contents

1 OVERVIEW 1
1.1 FEATURES 1
1.2 APPLICATIONS 2
1.3 BLOCK DIAGRAM 2
1.4 DEFINITIONS 3
2 PRODUCT SPECIFICATIONS 4
2.1 ABSOLUTE MAXIMUM RATINGS 4
2.2 RECOMMENDED OPERATING CONDITION 4
2.3 PERFORMANCE & ELECTRICAL SPECIFICATIONS 5
2.4 TIMING SPECIFICATIONS 8
2.5 NON-VOLATILE MEMORY SPECIFICATIONS 10
2.6 CONNECTOR SPECIFICATIONS 10
3 MECHANICAL DIMENSIONS 11
4 TYPICAL PERFORMANCE CHARACTERISTICS 12
5 CONNECTION EXAMPLE 13
5.1 PRECAUTIONS FOR WIRING AND CABLING 13
5.2 PRECAUTIONS FOR SUPPLYING POWER 14
6 CONTROL SEQUENCE 15
6.1 MESSAGES 15
6.2 OBJECT DICTIONARY 16
6.2.1 READ/WRITE SEQUENCE 16
6.2.2 OBJECT DICTIONARY ACCESS TIME 17
6.2.3 OBJECT DICTIONARY LIST 18
6.3 CHANGE NMT MODE 21
6.3.1 RESET NODE (81h) 22
6.3.2 RESET COMMUNICATION (82h) 22
6.4 MEASUREMENT 23
6.4.1 SYNCHRONOUS MODE 23
6.4.2 TIMER EVENT MODE 24
6.4.3 MEASUREMENT VALUES 25
6.4.4 INTERNAL FILTER 27
6.4.5 User Defined Filter 31
6.5 TIME SETTING 33
6.6 HEARTBEAT 34
6.7 SYNC PRODUCER 34
6.8 APPLICATION OF SYNC COUNTER 36
6.9 AUTO OUTPUT SETTING 38
6.10 CAN NODE SETTING 38
6.11 BUS STATUS & LED INDICATOR 39
7 HANDLING NOTES 42
7.1 CAUTIONS FOR ATTACHING 42
7.2 OTHER CAUTIONS 43

7.3 LIMITED WARRANTY 43
8 PART NUMBER / ORDERING INFO. 44
Appendix1. MESSAGES 45
A.1.1. NMT message 45
A.1.2. SYNC message 45
A.1.3. TIME message 45
A.1.4. TPDO1 message 46
A.1.5. TPDO2 message 46
A.1.6. TPDO3 message 47
A.1.7. TPD04 message 47
A.1.8. TSDO message 47
A.1.9. RSDO message 48
A.1.10. HB message 48
Appendix2. OBJECT DICTIONARY 49
A.2.1. COMMUNICATION PROFILE （DS-301） 49
A.2.1.1 Device type 49
A.2.1.2 Error register 49
A.2.1.3 Manufacturer status register 50
A.2.1.4 SYNC COB-ID 50
A.2.1.5 Communication cycle period 50
A.2.1.6 Manufacturer device name 50
A.2.1.7 Manufacturer hardware version 51
A.2.1.8 Manufacturer software version 51
A.2.1.9 Save all parameters 51
A.2.1.10 Restore all default parameters 51
A.2.1.11 TIME COB-ID 52
A.2.1.12 Producer heartbeat time 52
A.2.1.13 Synchronous counter overflow value 52
A.2.1.14 RSDO COB-ID 52
A.2.1.15 TSDO COB-ID 53
A.2.1.16 TPDOn COB-ID 53
A.2.1.17 TPDO transmission type 54
A.2.1.18 TPDO1 mapping 54
A.2.1.19 TPDO2 mapping 54
A.2.1.20 TPDO3 mapping 55
A.2.1.21 TPDO4 mapping 55
A.2.1.22 NMT startup mode 55
A.2.2. MANUFACTURE PROFILE 56
A.2.2.1 CAN node-ID 56
A.2.2.2 CAN bitrate 56
A.2.2.3 Timer interval 56
A.2.2.4 Apply parameters 57
A.2.2.5 User defined filter parameter set 57
A.2.2.6 UDF host interface (Number of tap) 58
A.2.2.7 UDF host interface (Current address index) 58
A.2.2.8 UDF host interface (Read/Write data) 59
A.2.2.9 Sample counter 59
A.2.2.10 Time of day 59
A.2.2.11 Time difference 60
A.2.3. MEASURING DEVICE PROFILE(DS-404) 61
A.2.3.1 AI sensor type 1-3 61
A.2.3.2 AI input PV 1-3(Ax/Ay/Az) 61
A.2.3.3 AI physical unit PV 1-3 62
A.2.3.4 AI filter type 1-4 62

A.2.3.5 Al filter tap constant 62
9 3rd PARTY LICENSE 64
10 Standards and Approvals 66
10.1 NOTICE 66
10.2 CE Statement 66
10.3 RoHS & WEEE Statement 66
10.4 UKCA Statement 66
10.5 FCC Compliance Statement for American users 67
10.6 Industry ICES Compliance Statement for Canadian users 67
11 REVISION HISTORY 68

1 OVERVIEW

The M-A552 is a three-axis digital output accelerometer featuring ultra-low noise, high stability, and low power consumption using fine processing technology of Quartz. Incorporating both high accuracy and durability, the versatile M-A552 is well suited to a wide-range of challenging applications such as SHM, seismic observation, condition monitoring for industrial equipment, and pose detection for industrial machinery (i.e. construction machinery/attachments, agricultural machinery/ implements, robots).
The M-A552 is packaged in a water-proof and dust-proof metallic case supporting CAN bus interface. This ruggedized unit is suitable for industrial use that requires remote mounting, long-distance wiring, and/or simplified development of a multi-node measurement system that requires accurate synchronization performance for the multiple units.

1.1 FEATURES

Table 1-1 Features

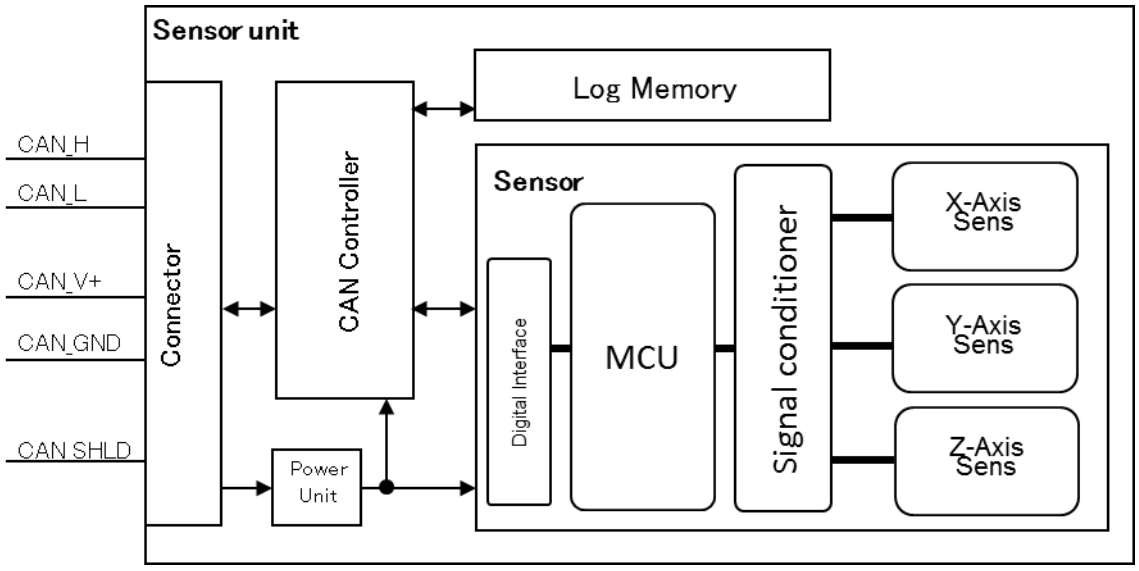
Item		Specification	Note
Sensor			
	Integrated sensor	Model: M-A552AC1x Internal sensor M-A352 Detection range ±15G Initial Bias error ±4mG(@25℃) Resolution 0.06uG Low noise 0.5μg/√Hz typ Selectable output format: Acceleration / Tilt Angle Programmable low-pass digital filters	
Interface			
	Protocol	CANopen	
	Physical layer	ISO11898-2 (High speed CAN)	
	Data Link layer	ISO11898-1 (High speed CAN)	
	Frame format	CAN2.0A	
	Profile	DS-301	Standard profile
		DS-404	Device profile for measuring devices
	Structures	DS-303-1	5pin "micro" Connector
		DS-303-2	SI unit
		DS-303-3	LED
	Bit rate	1M/ 800k/ 500k/ 250k/ 125k/ 50k/ 20k/ 10k bps	1Mbps (Default setting)
	Node-ID	1 to 127	1 (default setting)
	Sampling rate	Max 1,000 sps (Timer event mode) / 500sps (Sync mode)	Selectable
Other function			
	Indicator	Run-LED (Green)/ Error-LED (Red)	Accordance with DS-303-3

Item		Specification	Note
	Terminator	Not included	A terminator should be attached to the network.
General characteristics			
	Voltage supply	9 to 32 V	
	Power consumption	35 mA typ	Vin=12V
	Operating temperature range	-30 to +70°C	
External dimension			
	Outer packaging	Overall metallic shield chassis	
	Size	65 x 60 x 30mm (Including projection.)	
	Weight	128g	
	Interface connector	CAN connector: 5-pos, M12, water-proof	
	Water-proof , Dust-proof:	Corresponds with IP67	
Regulation			
	CE	CE marking (EN61326/RoHS Directive)	ClassA
	USA	FCCpart15B	ClassA

1.2 APPLICATIONS

- Structural health monitoring
- Seismic measurements
- Vibration control and stabilization
- Motion analysis and control

1.3 BLOCK DIAGRAM



igure 1-1 Block Diagram

1.4 DEFINITIONS

The definition of terms used in this manual.

CAN-ID
: An identifier for CAN data and remote frames. This unit uses 11bit CAN-ID.

Client
: A device that sends a request to a server. In this manual, the host device like a PC becomes the client.

COB
: Communication Object, consists of 1 or more CAN frames, COB encompasses all types of data transmitted via CANopen.

COB-ID
: COB Identifier; defines a unique COB and also determines its priority.

Consumer
: A device that receives messages from a producer and communicates with a producer.

DLC
: Data Length Code, this shows the number of bytes in the data field of the message.

FC
: Function Code, this is the high-order 4 bits of the CAN-ID.

HB
: Heartbeat

NMT
: Network Management

Node-ID (NID)
: 7 bits network-wide unique identifier for each CANopen device. It is inserted in the low-order 7 bits of COB-ID. Values from 1 to 127 are normally used, 0 is used for special purpose.

OD
: Object Dictionary; list of user-accessible parameters stored in the slave node.

Producer
: A device that sends messages to one or more consumers.

RSDO
: Receive Service Data Object, Receive SDO request from CANopen bus master.

Server
: A device that contains an OD. It returns a response when it receives the request from client. In this manual, SDO server refers to the sensor unit.

SYNC
: Synchronization Object

TPDO
: Transmit PDO channel

TSDO
: Transmit SDO response to CANopen bus master

2 PRODUCT SPECIFICATIONS

2.1 ABSOLUTE MAXIMUM RATINGS

Table 2-1 Absolute Maximum Rating

Parameter	Term	Conditions	Range	Unit
Power supply voltage	V_{IN}	CAN_V+ to CAN_GND	-0.3～+32V	V
Port input voltage	V_{port}	CANH/CANL to CAN_GND	-32～+32	V
Voltage to chassis (CAN Shield)	V_{com}	All signals including power source	50	V
Storage temperature	T_{STG}		-40～+85	°C
Operating temperature	T_{OPR1}		-30～+70	°C
Acceleration / Shock		Half-sine 1msec *1	1,000	G

If the unit is operated beyond the absolute maximum rating, malfunction may occur or the unit may fail completely. Although the unit may appear to operate normally, reliability may decrease.
CAUTION:
*1 Excessive vibration or shock independent of the above listed conditions may also cause malfunction or failure!

2.2 RECOMMENDED OPERATING CONDITION

Table 2-2 Recommended Operating Conditions

,Vin=12V,RL=60Ω,unless otherwise specified; all voltages are defined with respect to ground

Parameter	Term	Condition	Min.	Typ	Max.	Unit
Power supply voltage	V_{IN}	CAN_V+ to CAN_GND *2	9 *1	12	24	V
Port input voltage	V_{PORT}	CANH/CANL to GND	-2	-	7	V
Operating temperature	T_{OPE}		-30	-	70	°C
Start up time	-	Power-on to start output.		1600	2000	msec
	-	Warm-up period for best performance		15		min

*1 When power supply voltage is 9V or less, the master may not be able to communicate with this node normally even if the run-LED turns on.
*2 The power supply voltage must reach the recommended operating condition within 2 seconds after power is applied to this node.

2.3 PERFORMANCE & ELECTRICAL SPECIFICATIONS

Table 2-3 Sensor Section Specifications

VIN=12V, Ta=-30 to 70°C, ±1G, unless otherwise noted

Parameter	Test Conditions / Comments	Min	Typ	Max	Unit
MISALIGNMENT					
Case to Axis				±0.5	Deg
Axis to Axis	1 σ, Axis-to-axis, Δ = 90° ideal,RT			±0.1	Deg
Cross Axis Sensitivity			±0.2		%
ACCELERATION *1					
Sensitivity					
Output Dynamic Range				±15	G
Scale Factor			0.06		µG/LSB
Sensitivity Error	25℃, ≤ 1G		±500		ppm
Nonlinearity	≤ 1G, Best fit straight line, RT			±0.03	% of FS
Bias					
Initial Error	1 σ, −30°C ≤ T_A ≤ +70°C			±4	mG
Bias Repeatability	TA=25℃, VIN=12V For 1 year after shipment		3		mG
Bias Temperature Error	25℃			±2	mG
Temperature sensitivity			±0.1		mG/℃
Bias Instability	AVR, Average		0.2		uG
Velocity Random Walk	Average		1.2E-4		(m/sec)/√hr
Noise					
Noise Density	T_A=25°C, average 0.5Hz to 6Hz,		0.5	2	µG/√Hz
	T_A=25°C, peak 0.5Hz to 100Hz			60	uG//√Hz
Cantilever Resonance frequency	25℃, VIN=12V		850		Hz
VRC	at 50Hz 25℃, VIN=12V			±50	µG/G^2
Frequency Property					
-6 dB Bandwidth	User selectable	9		460	Hz
TILT ANGLE *2					
Sensitivity					
Dynamic Range				±1.0472 (±60)	rad (deg)
Scale Factor			0.002		µrad/LSB
Nonlinearity	25℃, ±45deg			±0.03	% of FS
Misalignment	1 σ, Axis-to-axis, Δ = 90° ideal			±1.745 (±0.1)	mrad (deg)
Bias					
Bias Repeatability	TA=25℃, VIN=12V For 1 year after shipment		±3 (±0.17)		mrad (deg)
Bias Temperature Error	25℃			±2 (±0.11)	mrad (deg)
Noise					
Noise Density	T_A=25°C, average 0.5Hz to 6Hz,		0.5	2	µrad/√Hz, rms

Parameter	Test Conditions / Comments	Min	Typ	Max	Unit
TEMPERATURE SENSOR					
Output Range		-30		85	℃
Scale Factor *3	at 25℃ T[℃]=SF*a+34.987		-0.0037918		°C/LSB

*1. The calibrated standard 1G gravitational acceleration value is 9.80665 m/s^2.

*2. The tilt angle is internally calculated from gravitational acceleration by the following expression.
Tilt Angle Calculation Formula

$$\theta = \mathrm{asin}(\mathrm{G})[rad]$$

*3. This is a reference value used for the internal temperature correction, and is not guaranteed to ac curately output the interior temperature.

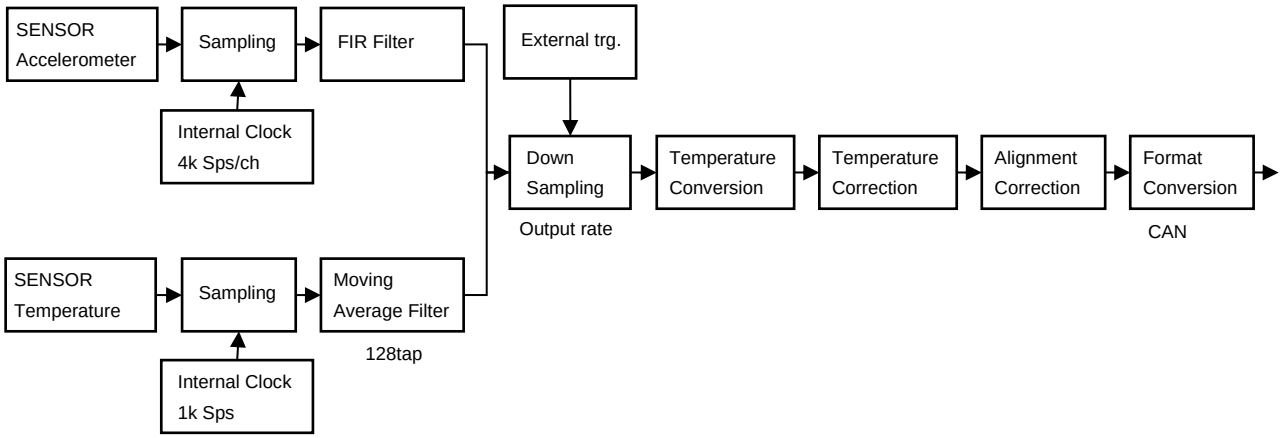


Figure 2-1 Functional Block Diagram

Table 2-4 CAN Characteristics

Ta=25°C, Vin=12V, RL=60Ω, unless otherwise specified; all voltages are defined with respect to ground; positive current flows into the sensor unit.

Parameter	Term	Condition	Min.	Typ	Max.	Unit
Output voltage (dominant)	$V_{O\ (dom)}$	CANH	2.75	3.5	4.5	V
		CANL	0.5	1.5	2.25	V
Output voltage (recessive)	$V_{O\ (rec)}$	CANH/CANL	2	2.5	3	V
Differential output voltage(dominant)	$V_{O\ (dif)dom}$	CANL to CANH	1.5	-	3	V
Differential output voltage(recessive)	$V_{O\ (dif)rec}$	CANL to CANH	-120	-	12	mV
Output current (dominant)	$I_{OS\ (dom)}$	CANL=open; VCANH=+0.3V	-100			mA
		CANH=open; VCANL=+32V			100	mA
Output current (recessive)	$I_{OS(rec)}$	$V_{CANH}=V_{CANL}$	-5	-	5	mA

Table 2-5 Current Consumption

Ta=25°C, RL=60Ω, unless otherwise specified; all voltages are defined with respect to ground; positive currents flow into the sensor unit; NMT= Operational, Synchronous mode, no heartbeat, Sensor sample rate 500sps, SYNC producer off

Parameter	Term	Condition	Min.	Typ	Max.	Unit
Mean current in measurement state	$I_{IN(SYNC)}$	Vin=12V, SYNC intervals = 2ms, CAN bitrate = 1Mbps	-	35	-	mA
		Vin=24V, SYNC intervals = 2ms CAN bitrate = 1Mbps	-	20	-	mA
Mean current in idle state	$I_{IN(ready)}$	Vin=12V	-	30	-	mA
		Vin=24V	-	18	-	mA
Maximum input current	$I_{IN(max)}$		-	-	60	mA

2.4 TIMING SPECIFICATIONS

Table 2-6 Measurement Timing Characteristics @1Mbps CAN bitrate

Parameter	Term	Condition	Min.	Typ	Max.	Unit
Response time	t_{RS}	from received SYNC to send TPDO	0.8	-	-	msec
Sampling period	t_{SC}	accuracy	-1	-	+1	%

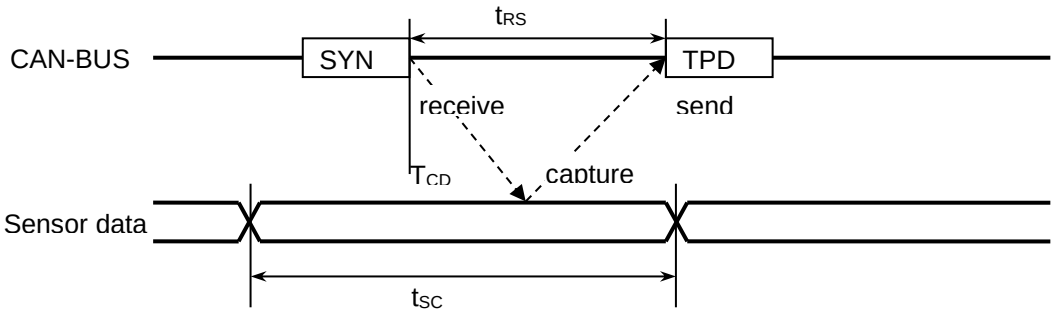
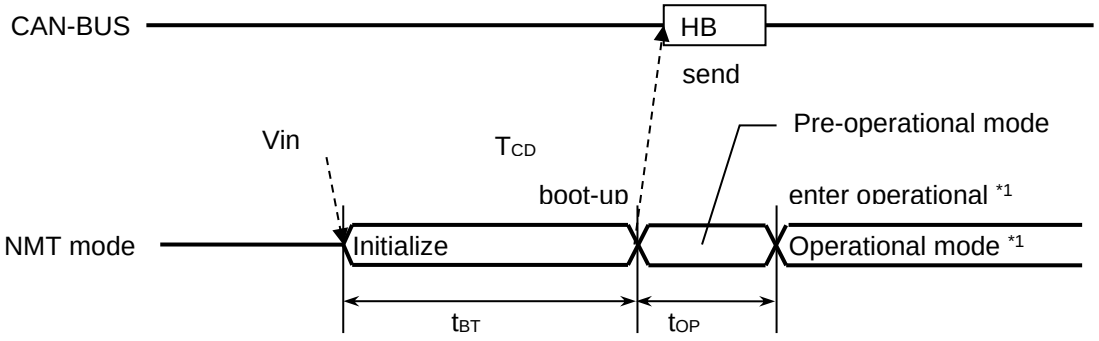


Figure 2-2 Measurement Timing Characteristic

Table 2-7 State Change Timing Characteristics

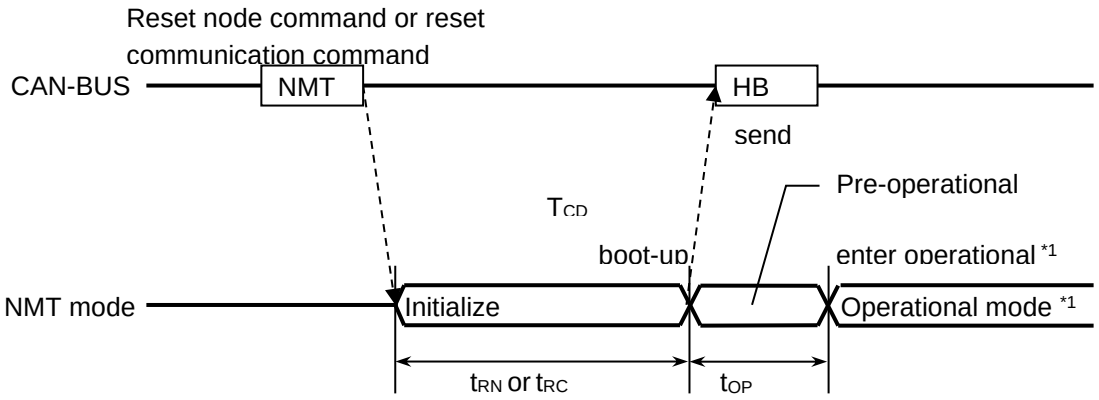
Parameter	Term	Description	Min.	Typ	Max.	Unit
Power-On boot-up time	t_{BT}	Time to boot-up completion from power on.	-	-	4000	msec
Reset node boot-up time	t_{RN}	Time to boot-up completion from a reset node command reception.	-	-	2000	msec
Reset communication boot-up time	t_{RC}	Time to boot-up completion from a reset communication command reception.	-	-	500	msec
Enter Start time	-	Time to Start mode from Pre-operational or Stop mode	-	-	500	msec
Enter Stop time	-	Time to Stop mode from Operational or Pre-operational	-	-	100	msec
Enter Pre-operational time	-	Time to Pre-operational mode from Operational or Stop mode	-	-	1300	msec
Reset node complete time	t_{RN} + t_{OP}	Time to NMT completion from a reset node command reception.	-	-	3000	msec

To confirm the NMT mode status after boot-up, decode the status flag in the HB message or set the startup mode OD [1F80h, 00h] to pre-operational mode and manually change to operational mode via NMT Start command.
The LED indicator changes into green after mode setting.



*1 When start-up mode is the operational mode.

Figure 2-3 Boot-up Timing Characteristics



*1 When start-up mode is the operational mode.

Figure 2-4 Reset Timing Characteristics

2.5 NON-VOLATILE MEMORY SPECIFICATIONS

Table 2-8 Non-volatile Memory Parameter Save Characteristics

Ta=-30°C～+70°C

Parameter	Term	Condition	Min.	Typ	Max.	Unit
The number logging of cycles	Nlog		100000	-	-	cycles
Retention time	t_{RET2}	Powered	10	-	-	years

2.6 CONNECTOR SPECIFICATIONS

Table 2-9 Connector Specification

Model number	SACC-DSI-MS-5CON-M12-SCO SH
Manufacturer	PHOENIX CONTACT

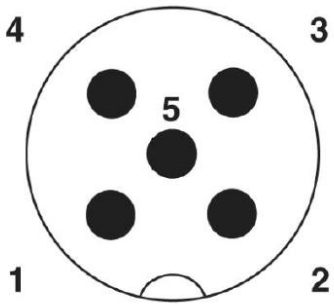


Figure 2-5 Terminal Layout

Table 2-10 Terminal Function

No	Pin Name	I/O	Description
1	CAN_SHLD	-	CAN Shield *1
2	CAN_V+	I	External power supply (9-30V)
3	CAN_GND	-	Ground
4	CAN_H	I/O	CAN H bus line
5	CAN_L	I/O	CAN L bus line

NOTE: This device should be connected to a connector that satisfies at least the IP67 water and dust proof specification.

*1 CAN_SHLD is connected to the case. CAN_SHLD is internally connected to CAN_GND via a capacitor 0.01uF/100V.

3 MECHANICAL DIMENSIONS

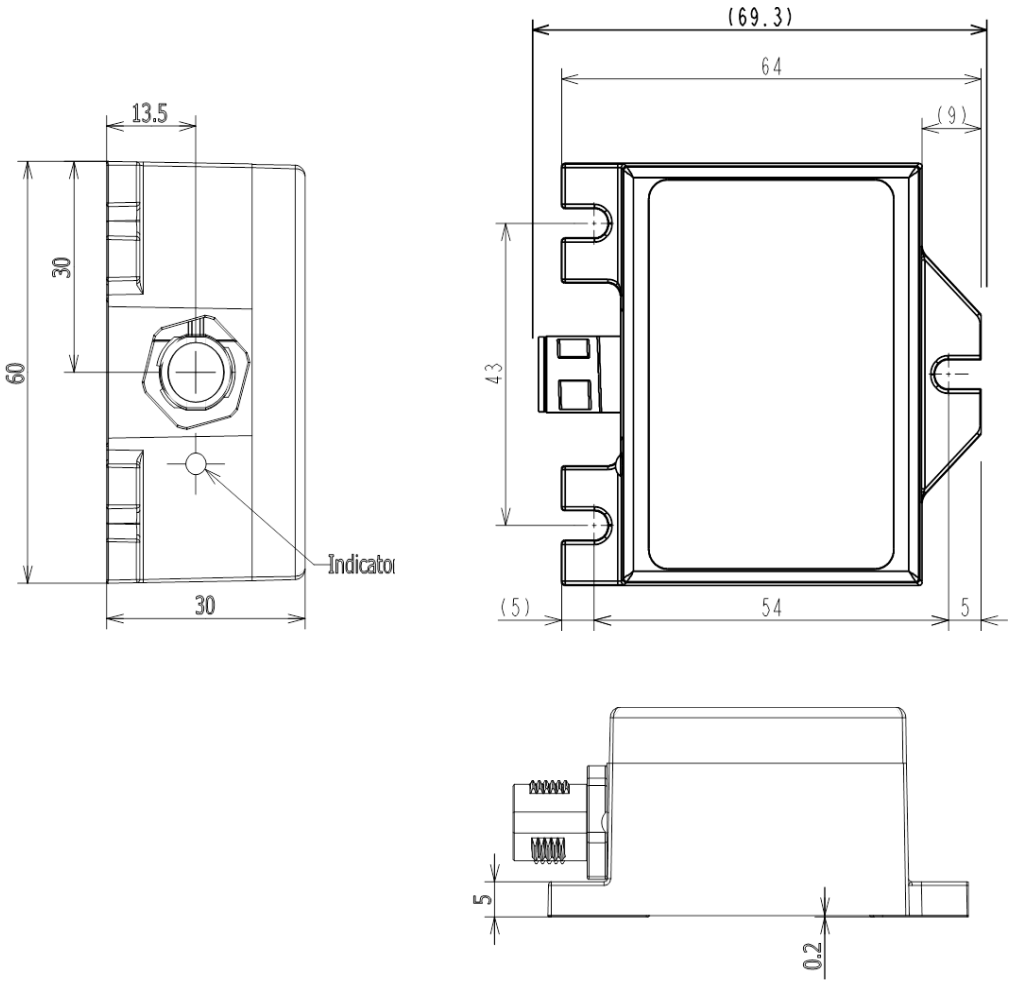


Figure 3-1Outline Dimensions (millimeters)

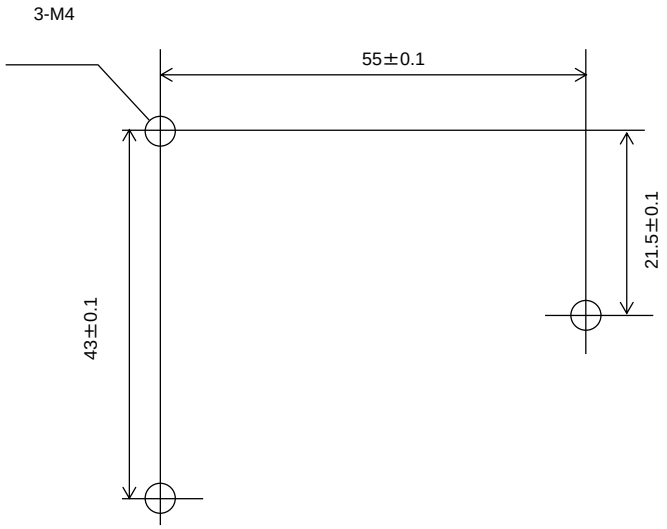


Figure 3-2 Recommended Mounting Dimension

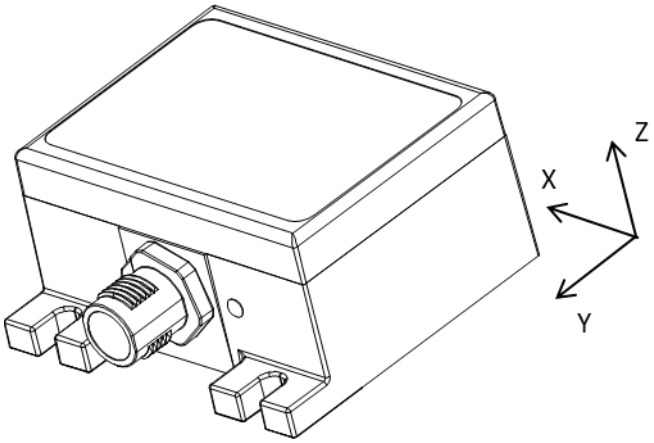


Figure 3-3 Axial direction

4 TYPICAL PERFORMANCE CHARACTERISTICS

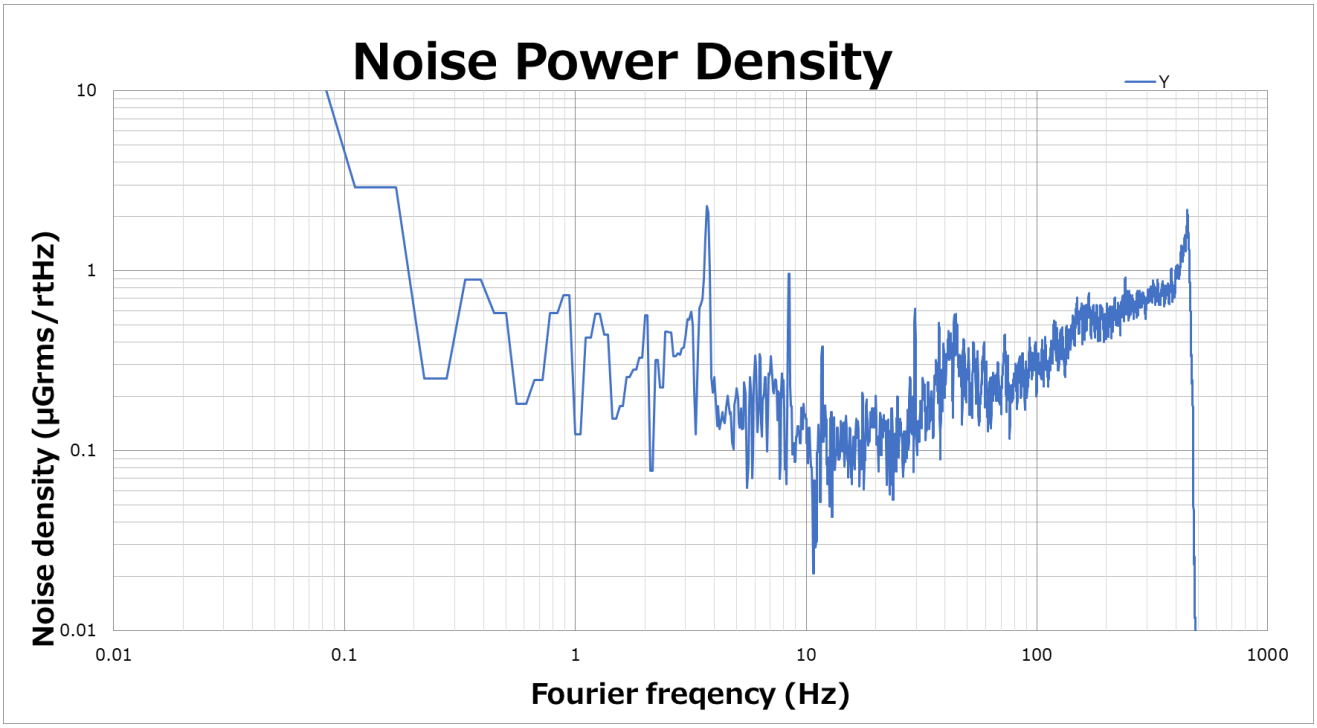


Figure 4-1 Noise Density Characteristics (fc=100Hz)

The above graph is a typical example of product characteristics and is not guaranteed by the specification.

5 CONNECTION EXAMPLE

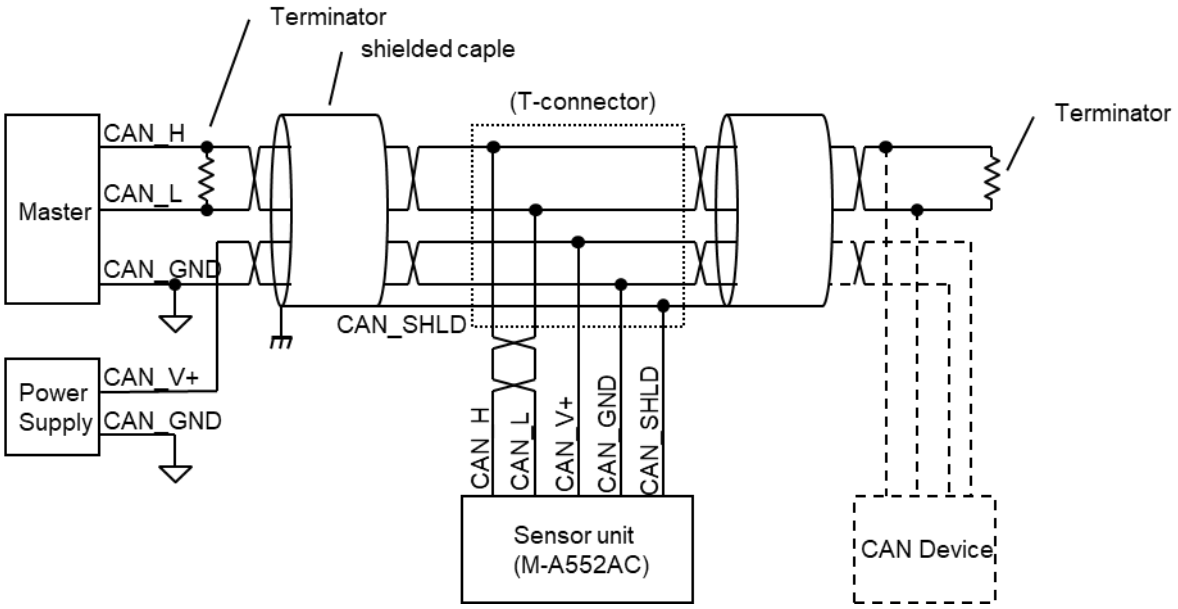


Figure 5-1 Connection Example

5.1 PRECAUTIONS FOR WIRING AND CABLING

- This product has no internal terminator. The user is required to connect a terminator to both ends of the cable.
- It is recommended that shield connects to ground.
- It is recommended that the cable meets the requirements of the CAN standard.
- Refer to Table 5-1 which defines the maximum practical length of cable wiring in a CAN network. Communication may be unstable depending on the system environment even if the system satisfies Table 5-1
- Care must be given to the effects of voltage drop by line resistance for the power supply line (CAN_V+, CAN_GND).

Table 5-1 Maximum Recommended Total Length of Cable (Reference)

CAN bitrate	Total length
1000kbps	40m
500kbps	100m
250kbps	250m
125kbps	500m

5.2 PRECAUTIONS FOR SUPPLYING POWER

- The user should be aware of serious risks on the power supply exposure to the following:
  High voltage noise by increased resistance and inductance on power supply line.
  Surge voltage from lightning and environmental equipment.
- Figure 5-2 describes the external reference protection circuit against the lightning surge with a surge level based on IEC61000-4-5, +/-1kV(power supply line to the power supply ground) and +/-2kV(power supply line to the earth).

VP: CAN_V+ (Power supply)
PGND: CAN_GND (Power supply ground)
FGND: EARTH (System ground earth)
U3039: Surge absorber to power supply ground (Okaya Electric Industries)
ERZ-V14D390: Surge absorber to earth ground (Panasonic)

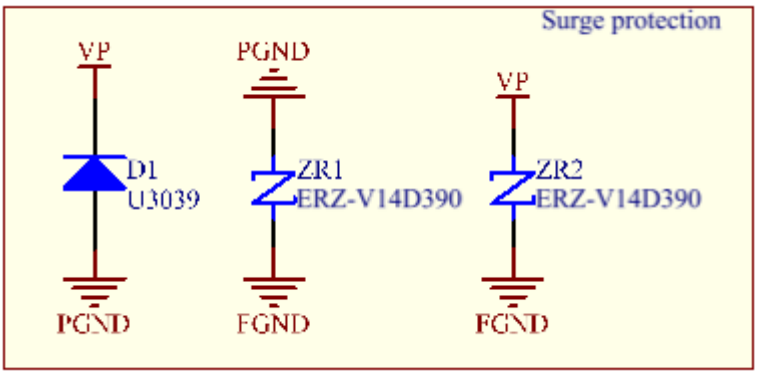


Figure 5-2 Surge Protection Circuit

6 CONTROL SEQUENCE

6.1 MESSAGES

This host device communicates with the sensor unit using the message types as shown by Table 6-1. See Appendix1 for the detailed description of the message types.

Table 6-1 Message List

COB	CAN-ID (11bits)		DLC	Data field (Byte) *1								Description
	FC 4bits	Node-ID 7bits		1	2	3	4	5	6	7	8	
NMT	0000b	0000000b	2	Cs	Id							Cs=command specifier Id=node-ID
SYNC	0001b	0000000b	1	Cn								Cn=SYNC counter
			0									
TIME	0010b	0000000b	6	Dy		Ms						Dy=days Ms=milliseconds
TPDO1	0011b	0000001b to 1111111b	8	Ax(Ix)				Ay(Iy)				Ax/Ay=Acceleration data Ix/Iy=Tilt angle data
TPDO2	0101b	0000001b to 1111111b	6	Az(Iz)				Sc				Az=Acceleration data Iz=Tilt angle data Az=Acceleration data Sc=Sample counter
TPDO3	0111b	0000001b to 1111111b	6	Dy		Ms						Dy=days Ms=milliseconds
TPDO4	1001b	0000001b to 1111111b	4	Temperature			-					Tmp=Temperature Unit：°C Two's complement and three byte fixed zero point bit23: Sign part bit22-10 : Integer part bit9-0 : Fraction part
TSDO	1011b	0000001b to 1111111b	8	Cs	Pi		Ps	Pd				Cs=command specifier Pi=index, Ps=sub-index Pd=data
RSDO	1100b	0000001b to 1111111b	8	Cs	Pi		Ps	Pd				Cs=command specifier

								Pi=index, Ps=sub-index Pd=data
HB	1110b	0000001b to 1111111b	1	St				St=state

*1 Byte order is little endian

6.2 OBJECT DICTIONARY

6.2.1 READ/WRITE SEQUENCE

To read and write an OD entry, the client sends a request to the server, the server answers the message from the client. The client may request read-OD and write-OD accesses while the sensor unit is in the pre-operational mode or operational mode. This unit supports expedited SDO communication, so the data length of OD is 1, 2 or 4 Bytes.

Read-OD Sequence

1. The SDO client sends a request using the command (Cs) 40h RSDO message and specifies the index (Pi) and sub-index (Ps).
2. The SDO server replies using a TSDO message with the OD value copied to the Pd data field. The SDO server specifies 43h, 4Bh or 4Fh in the command (Cs) depending on the size of the data field.

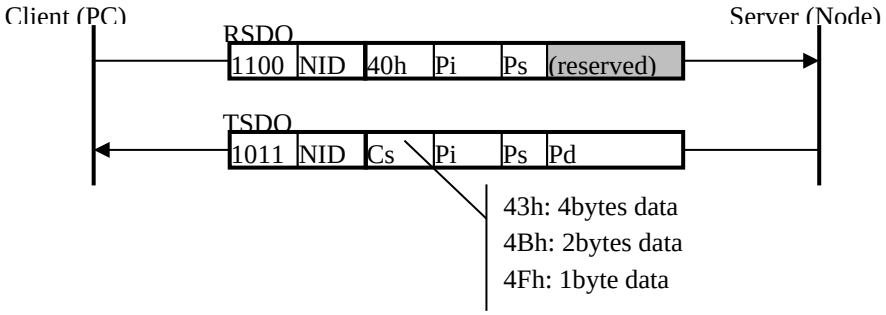


Figure 6-1 Read-OD Sequence

Write-OD Sequence

1. The SDO client sends a request by the RSDO message and specifies the index (Pi), sub-index (Ps) and data (Pd). The client specifies 23h, 2Bh or 2Fh to the command (Cs) depending on the size of the data field.
2. The SDO server replies using the command (Cs) 60h TSDO message, when the data has been written correctly.

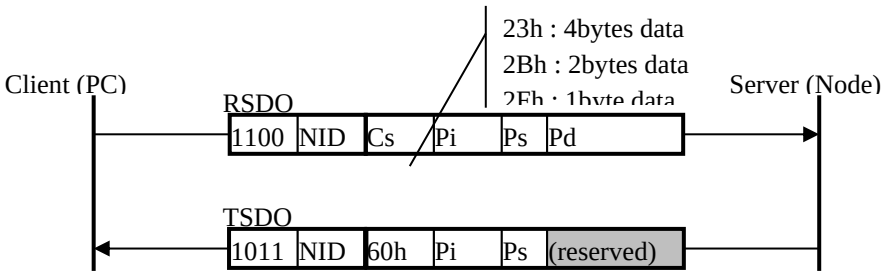


Figure 6-2 Write-OD Sequence

If an error has occurred, the SDO server returns the command (Cs) 80h TSDO message with an abort code, shown in Table 6-2, contained in the data (Pd) of the write-OD sequence and the read-OD sequence.

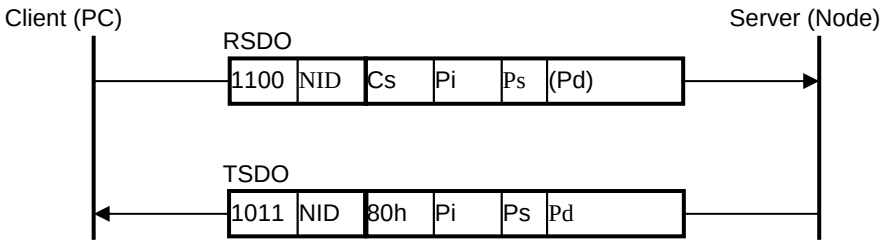


Figure 6-3 OD Abort Sequence

Table 6-2 List of Abort Codes

Abort code	Description
05040000h	SDO protocol time out
05040001h	Client/server command specifier not valid or unknown.
05040005h	Out of memory.
06010000h	Unsupported access to an object.
06010001h	Attempt to read a write only object.
06010002h	Attempt to write a read only object.
06020000h	Object does not exist in the object dictionary.
06060000h	Access failed due to a hardware error.
06070010h	Length of service parameter does not match.
06090011h	Sub-index does not exist.
06090030h	Invalid value for parameter.
08000000h	General error
08000021h	Data cannot be transferred or stored to the application because of local control.
08000022h	Data cannot be transferred or stored to the application because of the present device state.

6.2.2 OBJECT DICTIONARY ACCESS TIME

Table 6-3 describes O.D. execution time.
Keeping O.D access time more than O.D execution time is recommended.
See Appendix2 OBJECT DICTIONARY for a detailed description of each OD entry.

Table 6-3 OD Execution Time

Index	Sub	Function	Execution Time (max)	Comment
1010h	01h	Save all parameters	200msec	

1011h	01h	Restore all default parameters	100msec	
2005h	00h	Apply parameters	1000msec	
2007h	00h	UDF LOAD (Write: 11h)	15sec	
2007h	00h	UDF SAVE (Write: 21h)	27sec	
-	-	OD other than the above	1msec	

6.2.3 OBJECT DICTIONARY LIST

Table 6-4 to Table 6-6 contains the list of OD on the sensor unit. See Appendix2 for a detailed description of each OD entry.

Example

Index	Sub	Function	Type	Access	Default Value	Save
(1)	(2)	（Overview）	(3)	(4)	(5)	(6)

(1) Index Number
(2) Sub Index Number
(3) Data type
U8 = 8bit unsigned integer (0 to 255)
U16 = 16bit unsigned integer (0 to 65535)
U32 = 32bit unsigned integer (0 to 4294967295)
I16= 16bit signed integer (-32768 to 32767)
VS4 = Array[4] of character (ex: 65766173h = "save")
(4) Access type
const = Constant (never changed)
ro = read only
rw = read /write
(5) Default value
(6) An OD entry that has '#' in “Save” column supports saving to non-volatile memory.

Table 6-4 DS-301 OD (Communication Parameters)

Index	Sub	Function	Type	Access	Default Value	Save
1000h	00h	Device type	U32	const	0002 0194h	
1001h	00h	Error register	U8	ro	00h	
1002h	00h	Manufacturer status register	U32	ro	0000 0000h	
1005h	00h	SYNC COB-ID	U32	rw	0000 0080h	#
1006h	00h	Communication cycle period	U32	rw	0000 0000h	#
1008h	00h	Manufacturer device name	VS4	const	3235 3541h	
1009h	00h	Manufacturer hardware version	VS4	const	3031 4341h	
100Ah	00h	Manufacturer software version	VS4	const	3030 2E31h	
1010h	00h	highest sub-index supported	U8	const	01h	
	01h	Save all parameters	VS4	rw	0000 0001h	
1011h	00h	highest sub-index supported	U8	const	01h	
	01h	Restore all default parameters	VS4	rw	0000 0001h	
1012h	00h	TIME COB-ID	U32	const	8000 0100h	
1017h	00h	Producer heartbeat time	U16	rw	0000h	#
1019h	00h	Synchronous counter overflow value	U8	rw	00h	#
1200h	00h	highest sub-index supported	U8	const	02h	
	01h	RSDO COB-ID	U32	ro	0000 0600h + NID	
	02h	TSDO COB-ID	U32	ro	0000 0580h + NID	
1800h	00h	highest sub-index supported	U8	const	02h	
	01h	TPDO1 COB-ID	U32	rw	4000 0180h + NID	#
	02h	TPDO1 transmission type	U8	rw *1	01h	#
1801h	00h	highest sub-index supported	U8	const	02h	
	01h	TPDO2 COB-ID	U32	rw	4000 0280h + NID	#
	02h	TPDO2 transmission type	U8	ro *1	01h	
1802h	00h	highest sub-index supported	U8	const	02h	
	01h	TPDO3 COB-ID	U32	rw	4000 0380h + NID	#
	02h	TPDO3 transmission type	U8	ro *1	01h	
1803h	00h	highest sub-index supported	U8	const	02h	
	01h	TPDO4 COB-ID	U32	rw	C000 0480h + NID	#
	02h	TPDO4 transmission type	U8	ro *1	01h	
1A00h	00h	highest sub-index supported	U8	const	02h	
	01h	TPDO1 mapping1 (Ax)	U32	const	9130 0120h	
	02h	TPDO1 mapping2 (Ay)	U32	const	9130 0220h	
1A01h	00h	highest sub-index supported	U8	const	02h	
	01h	TPDO1 mapping3 (Az)	U32	const	9130 0320h	
	02h	TPDO2 mapping2 (Sc)	U32	const	2100 0010h	
1A02h	00h	highest sub-index supported	U8	const	02h	
	01h	TPDO3 mapping1 (Dy)	U32	const	2101 0110h	
	02h	TPDO3 mapping2 (Ms)	U32	const	2101 0220h	
1A03h	00h	highest sub-index supported	U8	const	01h	
	01h	TPDO4 mapping1 (Tmp)	U32	const	91300420h	
1F80h	00h	NMT Startup Mode	U32	rw	0000 0008h	#

*1 When OD[1800h,02h] is set, the same value is set in OD[1801h,02h], OD[1802h,02h] and OD[1803h,02h] automatically.

Table 6-5 Manufacturer OD

Index	Sub	Function	Type	Access	Default Value	Save
2000h	00h	highest sub-index supported	U8	const	02h	
	01h	CAN node-ID	U8	rw	01h	#
	02h	CAN bitrate	U8	rw	00h	#
2001h	00h	Timer interval	U32	rw	0000 0002h	#
2005h	00h	Apply parameters	U8	rw	10h	#
2007h	00h	User Defined Filter Parameter Set	U8	rw	00h	
2008h	00h	highest sub-index supported	U8	const	03h	
	01h	Number of taps	U16	ro	00h	#*
	02h	Start/Current address	U16	rw	0000h	
	03h	Read/Write data	I32	rw	0000 0000h	
2100h	00h	Sample counter	U16	rw	0000h	
2101h	00h	highest sub-index supported	U8	const	02h	
	01h	Timestamp day	U16	ro	indefinite	
	02h	Timestamp millisecond	U32	ro	indefinite	

*This is saved with the “UDF SAVE” command

Table 6-6 DS-404 OD (Measurement Device Profile)

Index	Sub	Function	Type	Access	Default Value	Save
6110h	00h	highest sub-index supported	U8	const	04h	
	01h	AI sensor type 1	U16	const	2905h	
	02h	AI sensor type 2	U16	const	2905h	
	03h	AI sensor type 3	U16	const	2905h	
	04h	AI sensor type 4	U16	const	0064h	
6131h	00h	highest sub-index supported	U8	const	04h	
	01h	AI physical unit PV 1	U32	const	00F1 0000h	
	02h	AI physical unit PV 2	U32	const	00F1 0000h	
	03h	AI physical unit PV 3	U32	const	00F1 0000h	
	04h	AI physical unit PV 4	U32	const	002D 0000h	
61A0h	00h	highest sub-index supported	U8	const	04h	
	01h	AI filter type 1	U8	const	02h	
	02h	AI filter type 2	U8	const	02h	
	03h	AI filter type 3	U8	const	02h	
	04h	AI filter type 4(reserved)	U8	const	00h	
61A1h	00h	highest sub-index supported	U8	const	04h	
	01h	AI filter tap constant 1	U8	rw *1	09h	#
	02h	AI filter tap constant 2	U8	ro *1	09h	
	03h	AI filter tap constant 3	U8	ro *1	09h	
	04h	AI filter tap constant 4(reserved)	U8	ro	09h	
9130h	00h	highest sub-index supported	U8	const	04h	
	01h	AI input PV 1	I32	ro	indefinite	

Index	Sub	Function	Type	Access	Default Value	Save
	02h	AI input PV 2	I32	ro	indefinite	
	03h	AI input PV 3	I32	ro	indefinite	
	04h	AI input PV 4 (Tmp)	I32	ro	indefinite	

*1 When OD[61A1h,01h] is set, the same value is set from OD[61A1h,02h] to OD[61A1h,04h] automatically.

6.3 CHANGE NMT MODE

The sensor unit changes its NMT mode, shown in Figure 6-4, upon receiving a request from the NMT producer.
NMT mode status is described by LED (green) pattern in Table 6-13. The sensor unit performs measurement operation in operational mode and OD configuration in pre-operational mode. The main difference between operational mode and pre-operational mode is that TPDO output is only valid during operational mode. Some ODs do not permit modification in operational mode. Refer to Table 6-7 and Appendix2 for details.
The measurement operation is suspended in stop mode. During stop mode, all functions are suspended except the output of heartbeat message. Therefore, the host cannot access the OD during stop mode. The sensor measurement is active during operational mode only. The current NMT mode is reflected in the status parameter (St) of the heartbeat message.

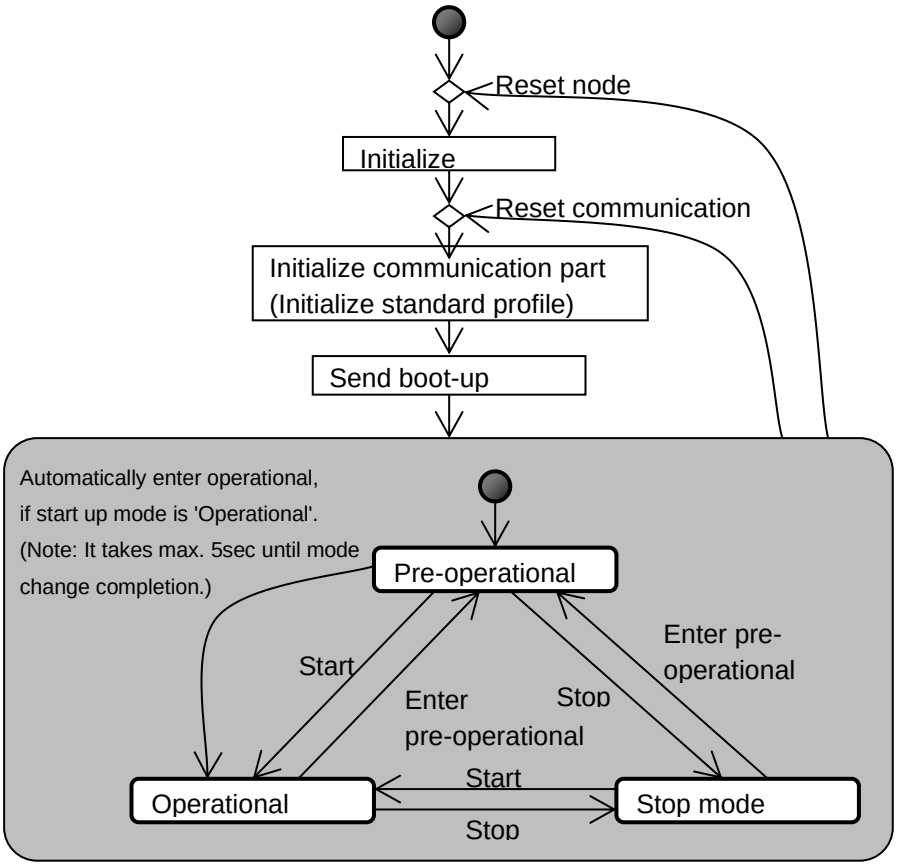


Figure 6-4 NMT State Change Diagram

The sensor unit sends the bootup message (heartbeat message (700h + NID) with status parameter 00h) when the initialization state is finished, and the unit enters pre-operational mode. In this state, the sensor unit is continuously sending the bootup message until any other CAN node on the network sends back ACK. This unit can be configured to automatically enter operational mode after initialization by clearing the NMT startup mode OD [1F80h, 00h] bit2. In this case, it could take a minimum of five seconds from when the power supply is applied until the unit completes the transition to operational mode.

The reset node command and the reset communication command can be used to reset this unit. The reset node command resets the entire system including software and hardware. The reset communication command resets the DS-301 OD (communication parameters).
The NMT messages for each NMT state command are shown in Figure 6-5. The host device can broadcast to all NMT consumers in the network by setting "00h" to the node-ID parameter (Id) of the NMT message.

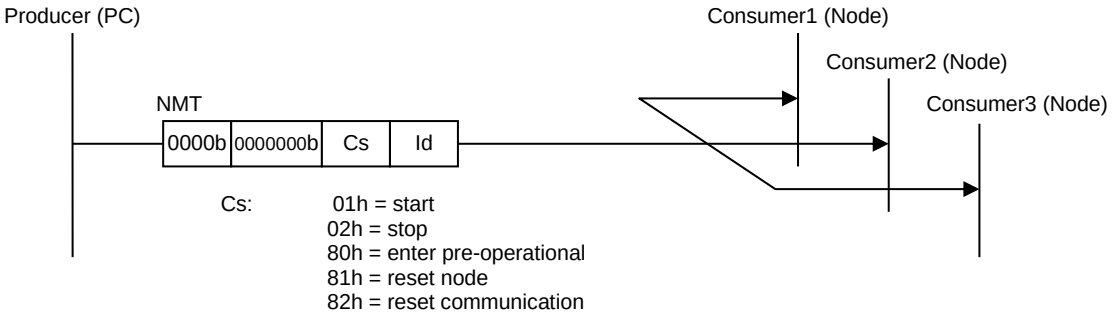


Figure 6-5 NMT Message

Table 6-7 Valid Function of Each NMT State

Function	Initialization	Pre-operational	Operational	Stop
Boot-up message	valid	-	-	-
TPDO producer	-	-	valid	-
SDO server	-	valid	valid	-
SYNC producer	-	-	valid	-
TIME consumer	-	valid	valid	-
HB producer	-	valid	valid	valid
Sensor			active	

6.3.1 RESET NODE (81h)

Sensor unit is initialized in the same way as power reboot.

6.3.2 RESET COMMUNICATION (82h)

Sensor unit is initializes the following O.D. parameters.

- ・OD[1005h]sub[00h]
- ・OD[1006h]sub[00h]
- ・OD[1017h]sub[00h]
- ・OD[1019h]sub[00h]
- ・OD[180xh]sub[01h] / sub[02h]
- ・OD[1F80h]sub[00]

6.4 MEASUREMENT

During operational mode, this sensor unit sends TPDO messages whenever it receives a SYNC message or is triggered by a sensor sampling event. TPDO messages can only be sent during operational mode. This unit has two transmit modes as classified by the kind of trigger shown at Table 6-8 Transmit Mode.

Table 6-8 Transmit Mode

Transmit mode	Trigger	Operation
Synchronous mode	SYNC message	This unit sends TPDO periodically after the specified number of SYNCs.
Timer event mode	Sensor sampling event	This unit sends TPDO periodically with interval equal to sensor sampling event.

6.4.1 SYNCHRONOUS MODE

Synchronous mode is the mode used to send TPDO messages periodically after a specified number of SYNCs. A host can specify 1 to 240 as the value of SYNC period.
When Synchronous mode selected, the output data rate must be set to less than 500sps (more than minimum interval 2ms). Otherwise, the user may experience abnormal behavior.
A sample procedure for activating this mode is given below.

1. Enter pre-operational mode.
2. Disable TPDO1, TPDO2, TPDO3 and TPDO4.
   Write C000 0180h + NID to TPDO1 COB-ID OD [1800h, 01h].
   Write C000 0280h + NID to TPDO2 COB-ID OD [1801h, 01h].
   Write C000 0380h + NID to TPDO3 COB-ID OD [1802h, 01h].
   Write C000 0480h + NID to TPDO4 COB-ID OD [1803h, 01h].
3. Set counter overflow value
   Write 00h to Synchronous counter overflow value OD [1019h,00h].
   Refer to 6.8 APPLICATION OF SYNC COUNTER in case of setting value of 02h-F0h.
4. Set to synchronous mode
   Write desired value for SYNC period (1 to 240) to TPDO1 transmission type OD [1801h, 02h].
   The same value is set to TPDO2/3/4 transmission type OD [180x, 02h].
5. Set Internal Filter
   Write value (00h-03h) to AI filter tap constant1 OD[61A1h, 01h].
6. Apply OD[1800h,02h], OD[2001h,00h], OD[61A1h,01h] settings.
   Write x1h to OD[2005h,00h] to Apply parameters. (This takes several seconds to complete.)
7. Enable TPDO (ex. TPDO1/2/3 on)
   Write 4000 0180h+NID to TPDO1 COB-ID OD[1800h,01h].
   Write 4000 0280h+NID to TPDO2 COB-ID OD[1801h,01h].
   Write 4000 0380h+NID to TPDO3 COB-ID OD[1802h,01h].
8. After the sensor unit has been set to operational mode, TPDOs will be sent when the specified number of SYNCs are received.

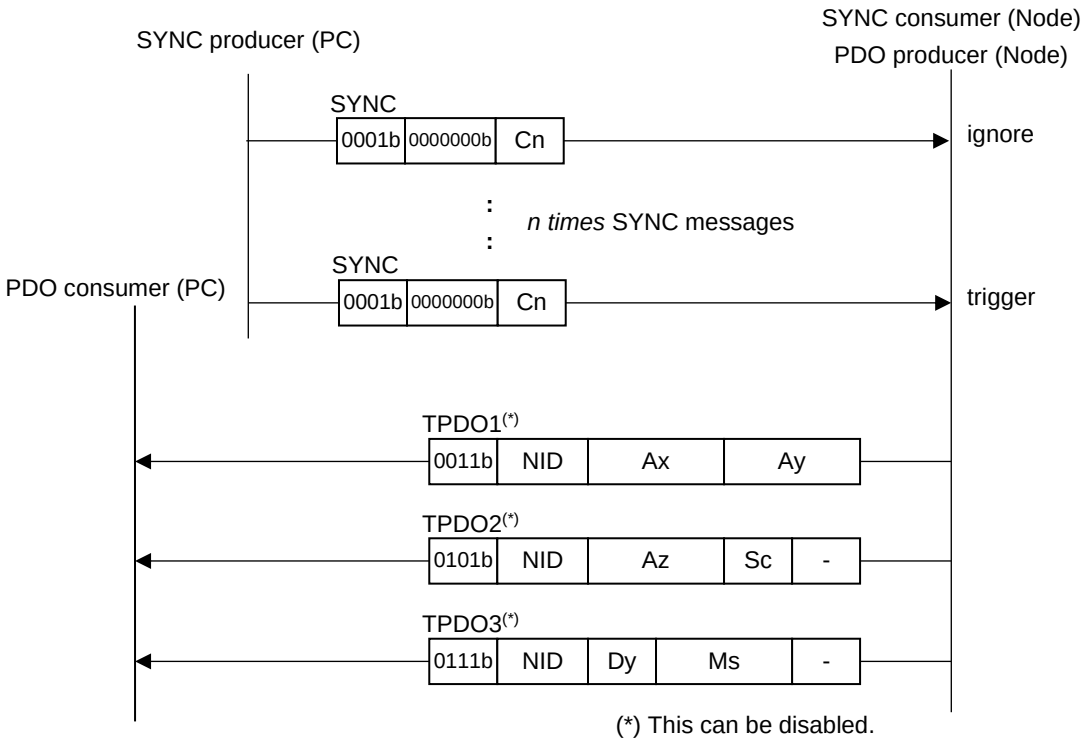


Figure 6-6 Synchronous Mode Sequence

6.4.2 TIMER EVENT MODE

The timer event mode is the mode used to send TPDO message periodically with interval equal to sensor event timer. A sample procedure for activating this mode is given below.

1. Enter pre-operational mode.
2. Disable TPDO1, TPDO2, TPDO3 and TPDO4.
   Write C000 0180h+NID to TPDO1 COB-ID OD [1800h,01h].
   Write C000 0280h+NID to TPDO2 COB-ID OD [1801h,01h].
   Write C000 0380h+NID to TPDO3 COB-ID OD [1802h,01h].
   Write C000 0480h+NID to TPDO4 COB-ID OD [1803h,01h].
3. Set to timer event mode.
   Write FEh to TPDO1 transmission type OD [1800h,02h].
4. Set the timer interval.
   Write interval timer value to Timer interval OD [2001h,00h].
5. Set Internal Filter
   Write value (00h-03h) to AI filter tap constant1 OD [61A1h, 01h].
6. Apply OD [1800h,02h], OD [2001h,00h], OD [61A1h,01h] settings.
   Write x1h to OD [2005h,00h] to apply parameters. (This takes several seconds to complete.)
7. Enable TPDO
   Write 4000 0180h+NID to TPDO1 COB-ID OD [1800h,01h].
   Write 4000 0280h+NID to TPDO2 COB-ID OD [1801h,01h].
   Write 4000 0380h+NID to TPDO3 COB-ID OD [1802h,01h].
8. After the sensor unit has been set to operational mode, TPDOs will be sent by timer event trigger.

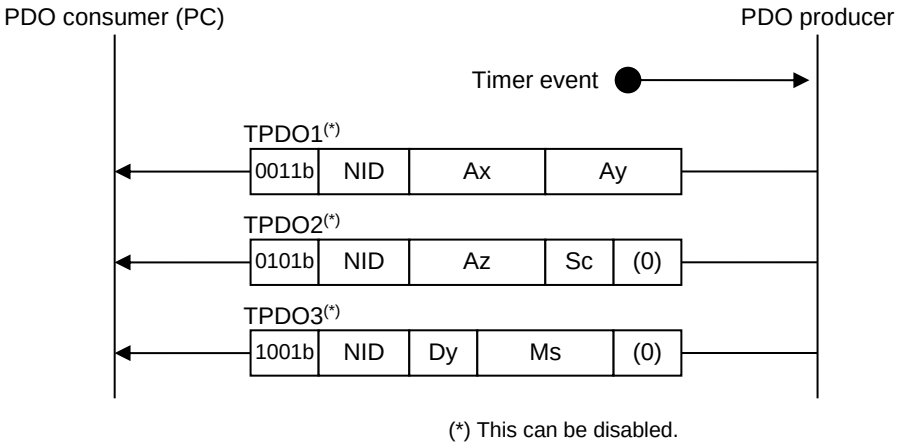


Figure 6-7 Timer Event Mode Sequence

6.4.3 MEASUREMENT VALUES

The accelerometer axes are defined as is shown in Figure 6-8 and the list of measurement values are shown in Table 6-9.

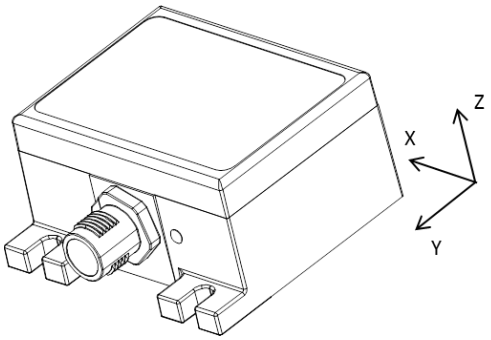


Figure 6-8 Definition of Axes

Table 6-9 List of Measurement Values

Name	Code	OD mapping	Sensor type	Data type	Unit
Acceleration (x)	Ax (Ix)	OD [9130h,01h]	accelerometer	INTEGER32	Accelerometer $1/2^{24}$ G (Q24 format signed fixed point) Inclinometer $1/2^{29}$ radian (Q29 format signed fixed point)
Acceleration (y)	Ay (Iy)	OD [9130h,02h]			
Acceleration (z)	Az (Iz)	OD [9130h,03h]			

Name	Code	OD mapping	Sensor type	Data type	Unit
Days	Dy	OD [2101h,01h]	time stamp	UNSIGNED16	Days (from 1/1/1984 in the Gregorian calendar)
Milliseconds	Ms	OD [2101h,02h]		UNSIGNED32	msec (from 0:00am)
Sample counter	Sc	OD [2100h,01h]	counter	UNSIGNED16	Count
Temperature	Tmp	OD [9130h,04h]	temperature	INTEGER32	Temperature 32bit 2's complement binary

Accelerometer

The accelerometer data format is Q24 represent as signed 32bit fixed point in 2's complement.

Unit: G

bit31: sign (+/-)

bit30-24: integer

bit23-0: fraction

For out of range measurements, the unit outputs 0x63000000(+99G) or 0x9D000000(-99G).

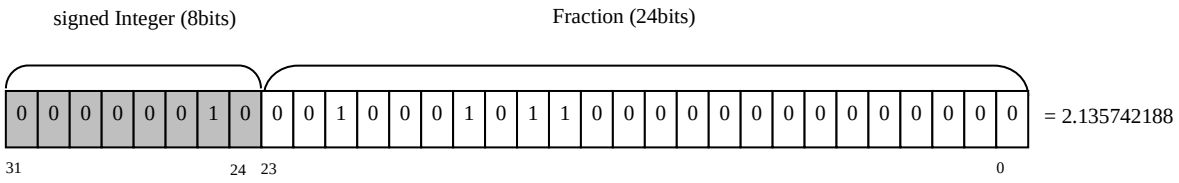


Figure 6-9 Q24 Signed Fixed-point Format

Tilt angle

The tilt angle data format is Q29 represented as signed 32bit fixed point in 2's complement.

Unit: radian

bit31: sign(+/-)

bit30-29: integer

bit28-0: fraction

For out of range measurement, the output is 0x374AC286 (+99degree) or 0xC8B53D7A (-99degree).

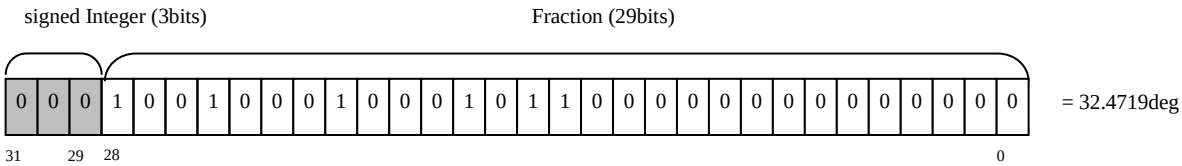


Figure 6-10 Q29 Signed Fixed-point Format

Temperature

The internal temperature sensor value can be read from this register.

The output data format is 32-bit two's complement format.

Please refer to the below formula for conversion to temperature in centigrade. Please refer to Table 2.3 Sensor Specification for the scale factor value.

The reference value in this register is for the temperature correction. There is no guarantee that the value provides the absolute value of the internal temperature.

T [℃] = SF * a + 34.987

SF: Scale Factor
A: Temperature sensor output data (decimal)

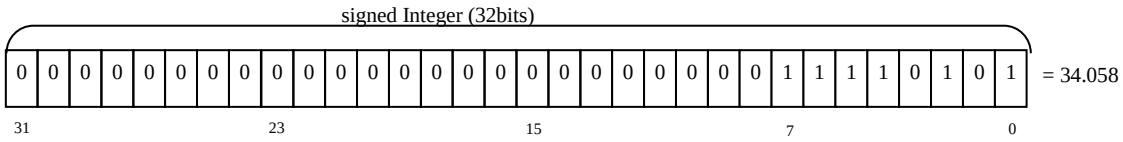


Figure 6-11 Temperature Data Format

6.4.4 INTERNAL FILTER

The sensor unit contains internal programmable FIR filters. The FIR filter settings can be set using OD[61A1h,01h]. Filter parameters correspond to the Kaiser window parameters.
The number of TAPs can be set to 64, 128, or 512, and the cutoff frequency Fc can be selected according to the output sample rate. Figure 6-12 to Figure 6-15 show the typical characteristic of the filters.

The proper filter cutoff frequency depends on the timer interval (sampling rate). Referring to Table 6-10, after the timer interval is set, the cutoff frequency is reset to default setting. When the sampling rate is set, the filter should be set again if a supported cutoff frequency different from default is desired.

0001: FIR Kaiser Filter TAP=64、fc=83

0010: FIR Kaiser Filter TAP=64、fc=220

0011: FIR Kaiser Filter TAP=128、fc=36

0100: FIR Kaiser Filter TAP=128、fc=110

0101: FIR Kaiser Filter TAP=128、fc=350

0110: FIR Kaiser Filter TAP=512、fc=9

0111: FIR Kaiser Filter TAP=512、fc=16

1000: FIR Kaiser Filter TAP=512、fc=60

1001: FIR Kaiser Filter TAP=512、fc=210

1010: FIR Kaiser Filter TAP=512、fc=460

1011: Reserved
1100: User Defined FIR Filter TAP=64
1101: User Defined FIR Filter TAP=128
1110: User Defined FIR Filter TAP=512
1111: not used

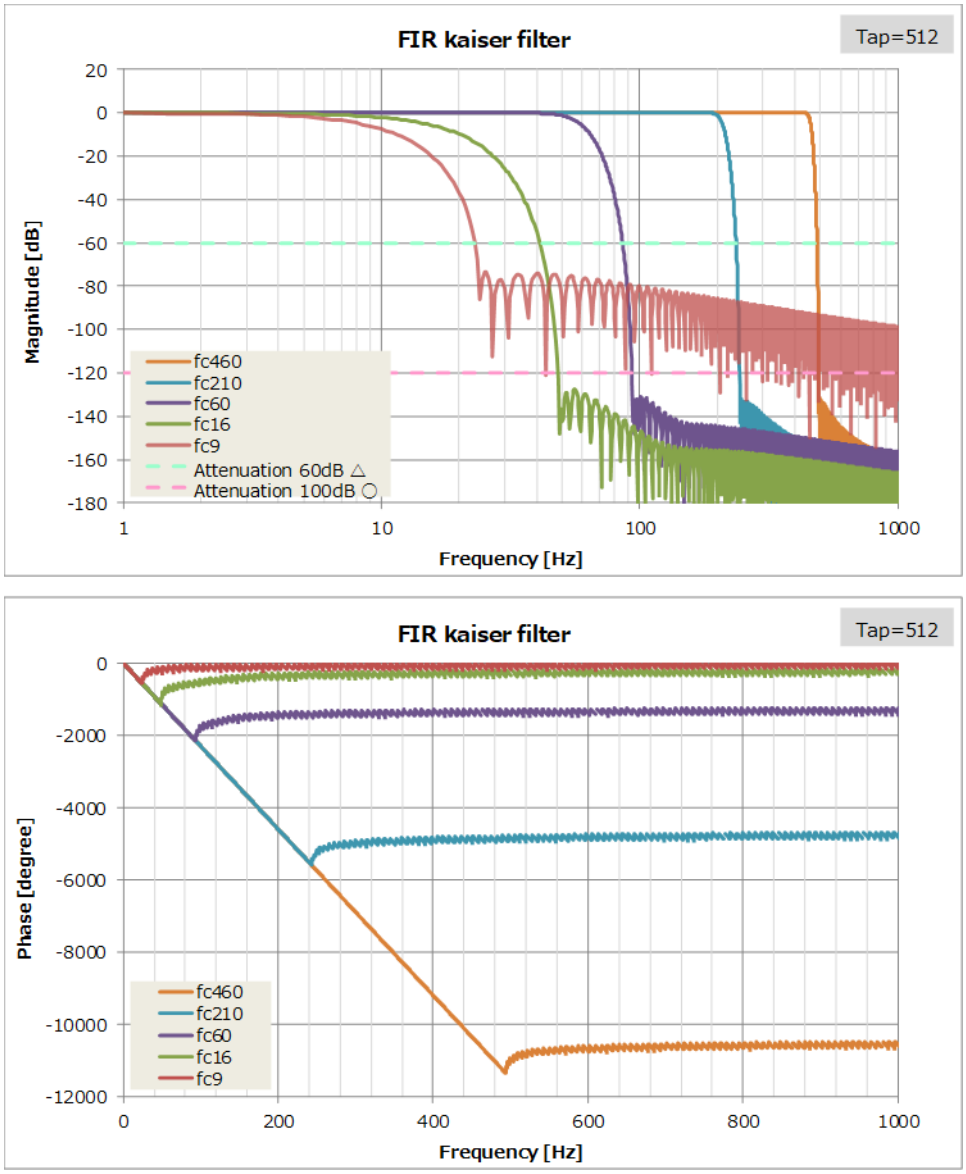


Figure 6-12 FIR Kaiser Characteristics－TAP512

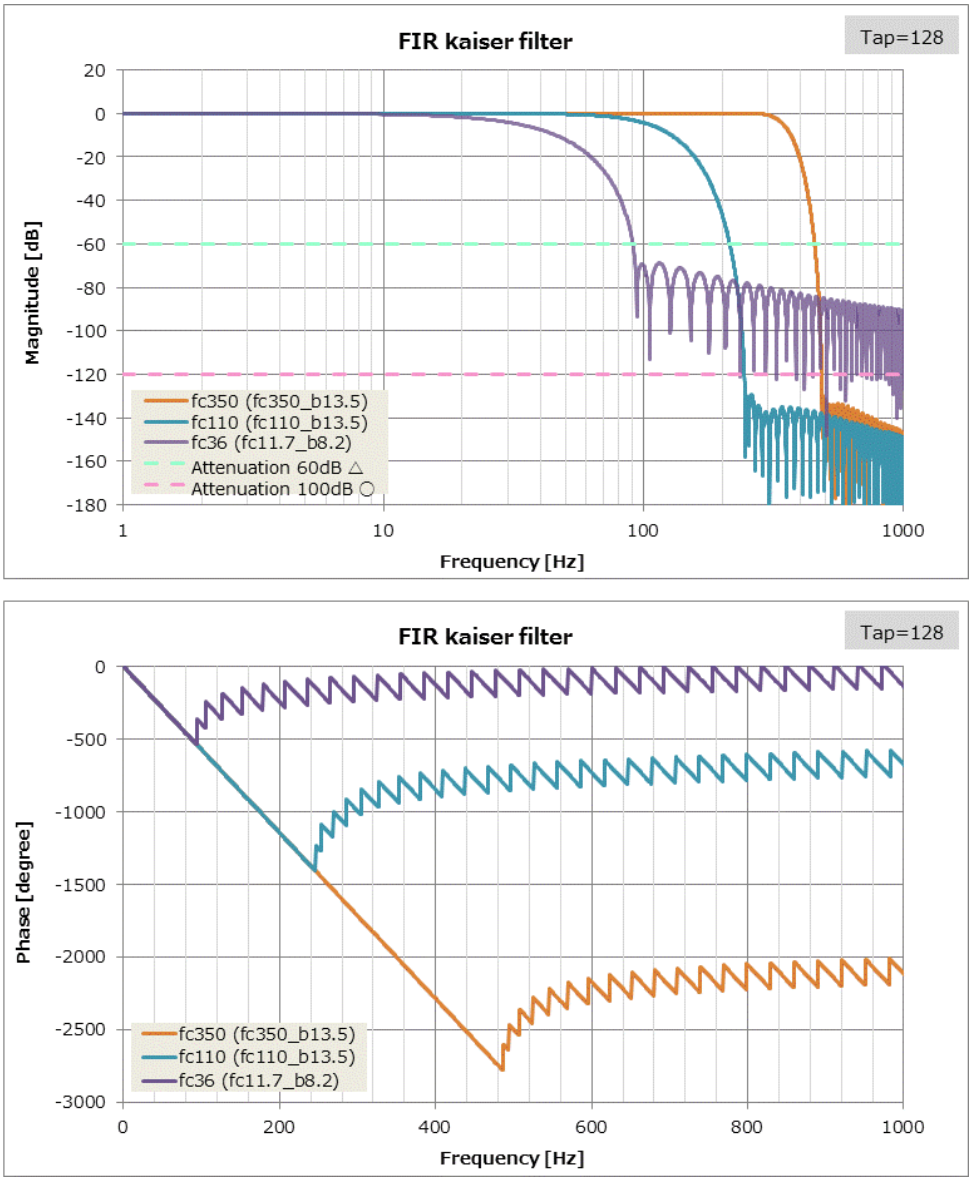


Figure 6-13 FIR Kaiser Characteristics－TAP128

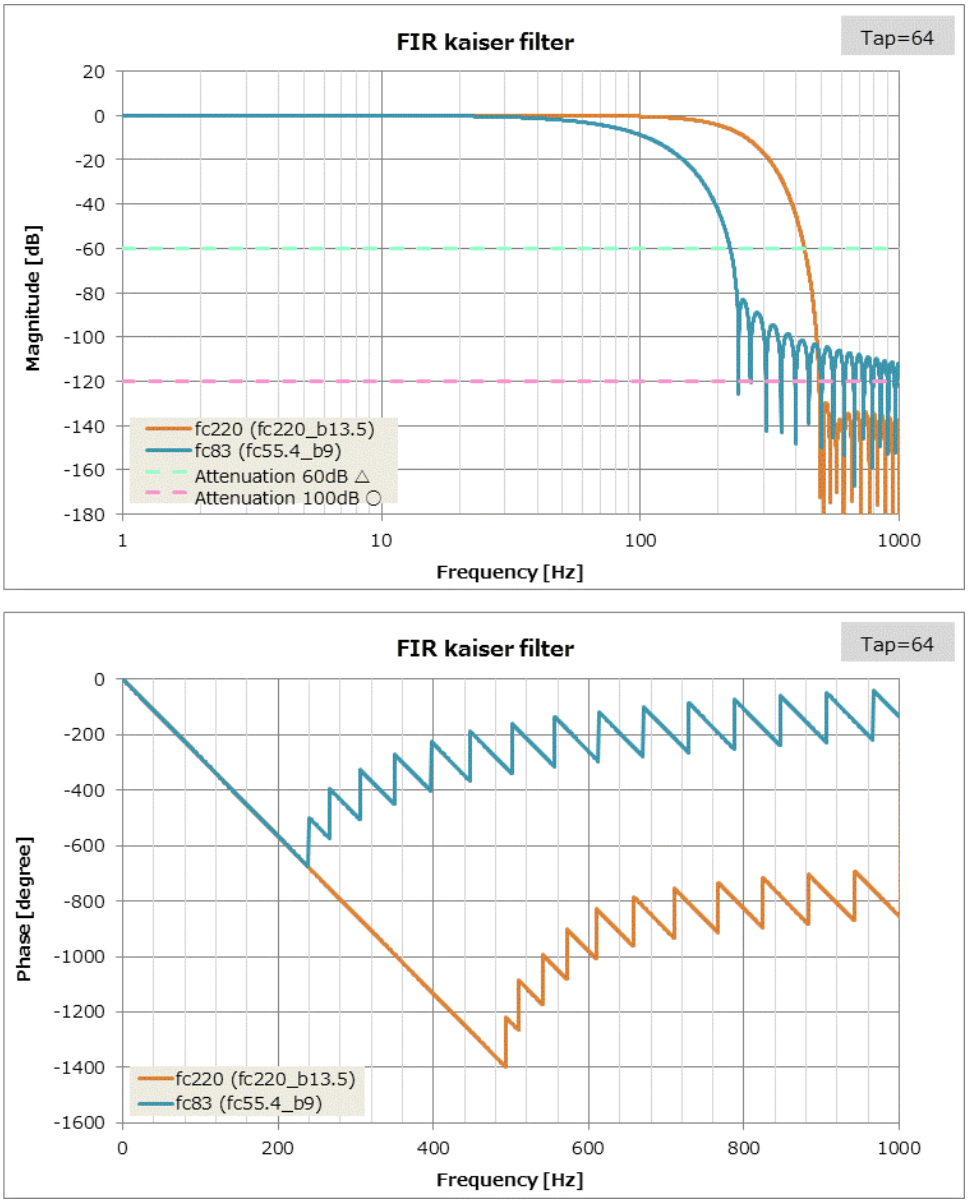


Figure 6-14 FIR Kaiser Characteristics－TAP64

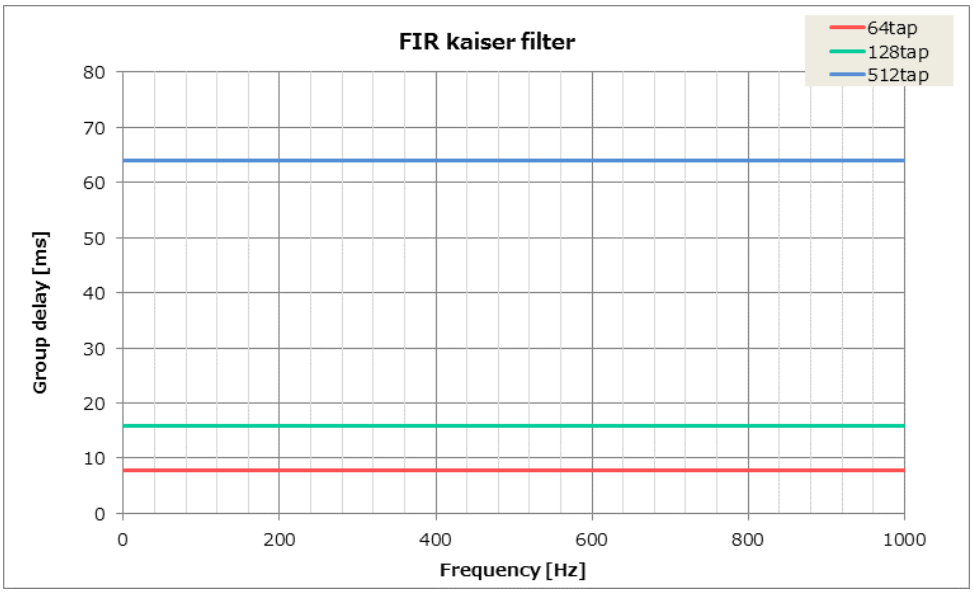


Figure 6-15 FIR Kaiser Characteristics－Group Delay

Table 6-10 Supported Settings Output Rate and Filter Cutoff Frequency

Filter		Group Delay	Timer Interval (Output Rate)				
			50sps	100sps	200sps	500sps	1,000sps
512Tap	460Hz	63.875ms	-	-	-	-	OK*1
	210Hz		-	-	-	OK*1	OK
	60Hz		-	-	OK*1	OK	OK
	16Hz		-	OK*1	OK	OK	OK
	9Hz		*1	*	*	*	*
128Tap	350Hz	15.875ms	-	-	-	-	OK
	110Hz		-	-	-	OK	OK
	36Hz		-	-	*	*	*
64Tap	220Hz	7.875ms	-	-	-	-	OK
	83Hz		-	-	-	*	*

OK: F_{Loss} < -120 dB Recommended setting

* : F_{Loss} < -60 dB Although a possible setting, some decrease in measurement quality due to aliasing

－ : Fn < Fc Invalid setting. When using internal timer measurement, measurement data returns with error “0x64000000".

*1. When the sampling rate is set, the filter should be set again if a supported cutoff frequency different from default is desired.

6.4.5 User Defined Filter

This product has a user-defined filter (UDF) function that allows users to arbitrarily define and set FIR filter coefficients that differ from the pre-defined characteristics described in the previous section. These coefficients are stored in non-volatile memory. Therefore, the filter coefficients are retained when the unit is power cycled. However, only one set of user-defined FIR coefficients can be saved.

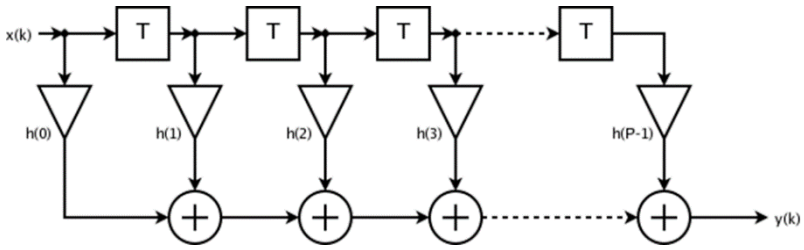


Figure 6-16 FIR Filter Block Diagram

The user-defined filter coefficient programming method is as follows.

- Set the FIR filter coefficient in each index location in the RAM work area by SDO command / response using the Host Interface（OD[2008h,01] ~ OD[2008h,03]）.
- Save / read FIR coefficients programmed in the RAM work area to UDF valid area (non-volatile memory) by command（OD[2007h,00]）.
- The group delay characteristic of FIR filter can be calculated by the following formula.

Group Delay(msec) = (Tap Number -1)/(fsampling(kHz) x 2) fsampling = 4kHz

For specific SDO command / response specifications, please refer to Appendix2. A.2.2.1 to A.2.2.4.

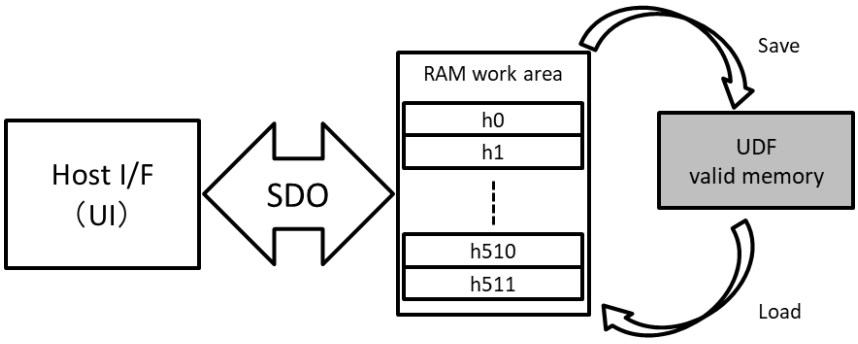


Figure 6-17 User Defined Filter (UDF) Access Method

UDF access procedure example:

The user-defined filter related settings can only be programmed in pre-operational mode.

1. Switch to pre-operational mode.
2. Set the measurement mode by OD[1800h, 02h] of TPDO transmission type. See 6.4.1 or 6.4.2 for details. See A.2.1.17 for TPDO transmission type.
3. Write [0001h] to OD[2001h, 00] for temporary setting.
4. Configure the Tap Number of the UDF FIR coefficients.
   Set the tap number in OD [2008h, 01] as an unsigned 16-bit integer. (Set from 64/128/512）

5. Access the FIR coefficients in the RAM work area.
   Set the index value in OD [2008h, 02].
   (ex: For tap64: 0 to 63, for tap512: set in the range of 0 to 511)

   When reading FIR coefficients
   The FIR coefficient can be read from OD [2008h, 03] as signed 32 bits.
   When the FIR coefficient value is returned, the index in OD [2008h, 02] is automatically incremented by 1, so for subsequent read accesses, continuous reading is possible without setting the index on OD [2008h, 02]

   When writing FIR coefficients
   Write the signed 32-bit FIR coefficient to OD [2008h, 03].
   After writing this FIR coefficient value, the index of OD [2008h, 02] is automatically incremented by 1, so for subsequent write accesses, continuous writing is possible without setting the index on OD [2008h, 02]

   NOTE: It is not recommended to read and write alternately because the index is automatically incremented for each read / write. When performing batch reading and writing, or when reading and writing data one by one, set an index each time for each access.

6. Continue to write or read the FIR coefficients for the specified tap number as per step 2.
7. Save the RAM work area data to the UDF valid area.
   Write 21h to OD[2007h, 00] (LED blinks with Double Flash pattern)
   Check the completion of the command by polling and reading OD[2007h, 00]
8. Set the filter tap constant to the correct user-defined filter in OD[61A1h, 01].
9. Set the Timer interval in OD [2001h, 00]
10. Write [x1h] (x can be 0, 1, or 2) to OD[2005h, 00] and confirm the sensor parameters.

Sensor data will now be processed with the user-defined filter set above.

6.5 TIME SETTING

The internal timer in this sensor unit is initialized by the host sending a time message. If there are several time stamp consumers in the bus, the time message will set the internal timer of all nodes in the bus.
The time is represented as days since January 1 1984 (readable from OD [2101h, 01h]) and milliseconds since 0:00 midnight (readable from OD [2101h, 02h]). The OD must not be read from until at least 3 milli-seconds have elapsed since the last time message has been sent. The sensor unit can accept a time message during pre-operational and operational modes. However, it is recommended that the time message be sent to a node in pre-operational mode to prevent delays in setting the internal timer of the unit.
Do not set a value equal to or larger than 86400000msec (one day maximum) to the milliseconds parameter (Ms) of the time message. The valid values for days parameter (Dy) is 0 to 65535.

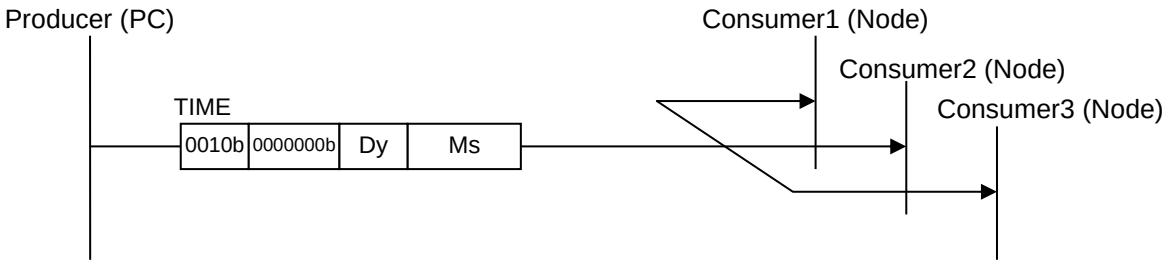


Figure 6-18 TIME Sequence

Table 6-11 Time Information Format

Item	Bit field	Content	Value	Comment
Dy	bit15-0	Days from 1 Jan,1984	0 to 65535	Gregorian calendar
Ms	bit3-0	reserved	(fixed 0)	
	bit31-4	Milli-second from 0:00am	0 to 86399999	Local time

6.6 HEARTBEAT

If enabled, the sensor unit can send a periodic heartbeat message indicating its status. The HB consumer uses this message to check the state of a sensor unit. HB consumer can detect abnormality of sensor unit and its communication. This unit operates as HB producer only.

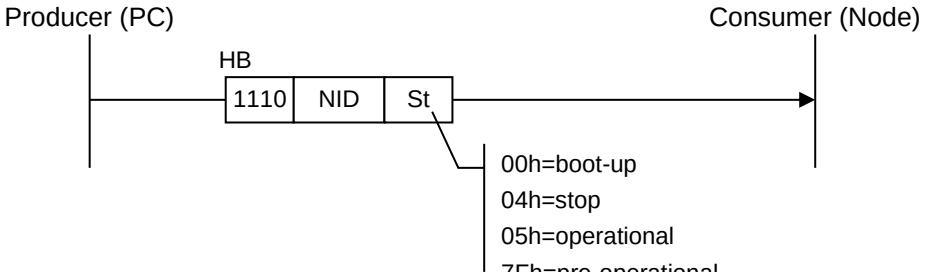


Figure 6-19 HB Sequence

The period of the heartbeat message is specified by the value of producer heartbeat time OD [1017h]. If this OD is set to 00h, HB message is disabled. By default, this message is disabled. The sensor unit sends one heartbeat message as a bootup message after initialization is complete, regardless of the value specified in OD [1017h, 00h]. There is no way to disable the bootup message output.

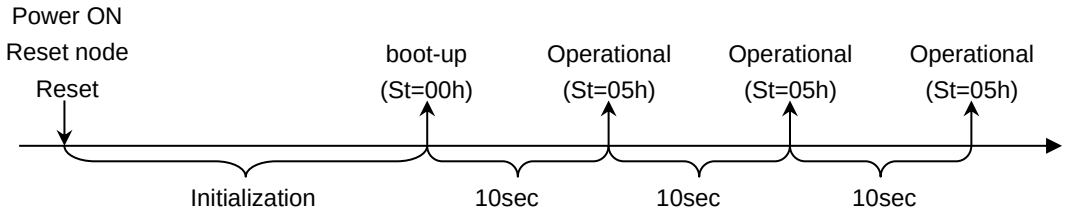


Figure 6-20 HB Operation Example

6.7 SYNC PRODUCER

The sensor unit can be configured to transmit a periodic SYNC message by enabling the SYNC producer function. By using this function, other SYNC consumers can be synchronized to transmit TPDOs simultaneously. This unit can also send TPDO messages after receiving its' own SYNC message.

A sample procedure for activating this mode is given below.

1. Disable SYNC producer.
   Write 0000 0080h to SYNC COB-ID OD [1005h, 00h].
   Write 0000 0000h to Communication cycle period OD [1006h, 00h].
2. Set SYNC counter overflow value. (Note: This step is optional.)
   Write desired value (00h or 02h to F0h) to synchronous counter overflow value OD [1019h, 00h].
   If this OD is set to 00h, the SYNC counter function is disabled, and the SYNC message does not contain a SYNC counter parameter (Cn).
   Refer to 6.8 in case of setting value of 02h-F0h.
3. Set SYNC period value.
   Write desired value in units of microseconds (0000 0000h to FFFF FFFFh) to communication cycle period OD [1006h, 00h]. Values written to this OD are automatically rounded down to milliseconds; therefore, the write value must be a multiple of 1000. If this OD is set to 0000 0000h, the sensor unit will not send SYNC messages.
4. Enable SYNC producer. SYNC message will be sent periodically.
   Write 4000 0080h to SYNC COB-ID OD [1005h, 00h].

If the sensor unit operates as SYNC producer and the SYNC counter overflow value OD [1019h, 00h] has a value of 02h to F0h, the SYNC message transmitted by the unit will contain a counter parameter (Cn). The counter starts from 1 and increments by 1 after each SYNC message. When the counter reaches the overflow value, on the next SYNC message the counter returns to 1.

(ex) Synchronous counter overflow value is

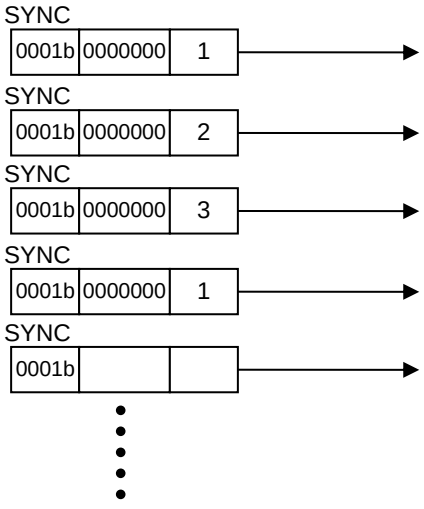


Figure 6-21 SYNC Counter Overflow Example

6.8 APPLICATION OF SYNC COUNTER

This section describes the application with SYNC counter in the synchronous mode.

Ex1. TPDO output once every three times SYNC message
TPDO is output according to the number of receptions of SYNC messages. And it does not depend on the presence of the counter value of the SYNC counter.
A sample procedure for this mode is given below.

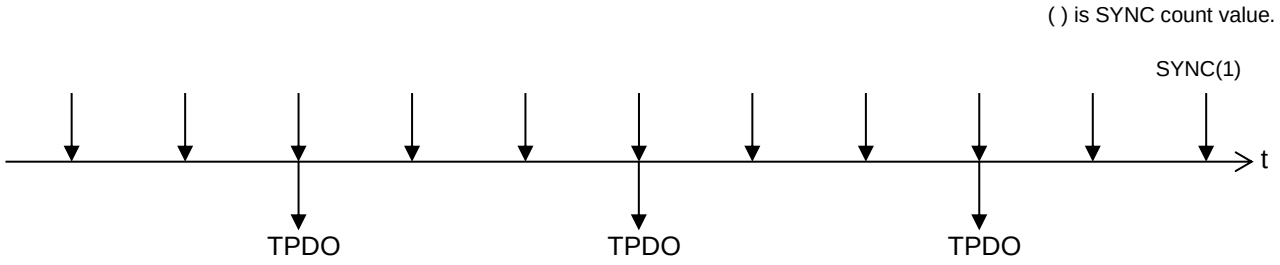


Figure 6-22 TPDO Output Once Every Three SYNC Messages

1. Enter pre-operational mode.
2. Disable TPDO1, TPDO2, TPDO3 and TPDO4.
   Write C000 0180h + NID to TPDO1 COB-ID OD [1800h, 01h].
   Write C000 0280h + NID to TPDO2 COB-ID OD [1801h, 01h].
   Write C000 0380h + NID to TPDO3 COB-ID OD [1802h, 01h].
   Write C000 0480h + NID to TPDO3 COB-ID OD [1803h, 01h].
3. Disable SYNC producer.
4. Set SYNC counter overflow value.
   Write 00h to synchronous counter overflow value OD [1019h, 00h].
5. Set SYNC period value.
   Write desired value in units of microseconds (0000 0000h to FFFF FFFFh) to communication cycle period OD [1006h, 00h]. Values written to this OD are automatically rounded down to milliseconds; therefore, the write value must be a multiple of 1000. If this OD is set to 0000 0000h, the sensor unit will not send SYNC messages.

   The following 6 to 7 steps refer to TPDOn where (n = 1, 2, 3).

6. Set to synchronous mode (SYNC period value set to 3 for example).
   Write 03h for SYNC period (1 to 240) to TPDO1 transmission type OD [1800h, 02h].
   The same value is set to TPDO2/3/4 transmission type OD [180x, 02h].
7. Enable TPDOn.
   Write 4000 0180h+NID to TPDO1 COB-ID OD [1800h,01h]
   Write 4000 0280h+NID to TPDO2 COB-ID OD [1801h,01h]
   Write 4000 0380h+NID to TPDO3 COB-ID OD [1802h,01h]
8. Enter operational mode.
9. Enable SYNC producer. SYNC message will be sent periodically.

Ex2. TPDO output once when SYNC counter is multiple of three

TPDO is output when the SYNC counter value of the SYNC message becomes the multiple of n. The SYNC counter must be included in the SYNC message.
A sample procedure for this mode is given below, in this case, the synchronous counter overflow value is set to 5, and the SYNC period value is set to 3.

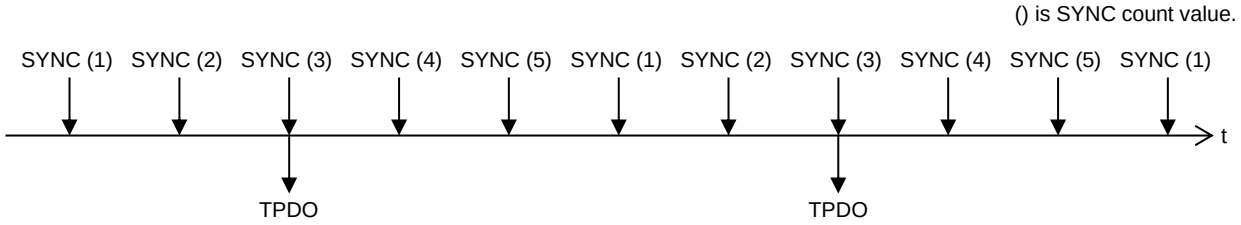


Figure 6-23 TPDO Output Once When SYNC Counter is Multiple of Three

1. Enter pre-operational mode.
2. Disable TPDO1, TPDO2, TPDO3 and TPDO4.
   Write C000 0180h + NID to TPDO1 COB-ID OD [1800h, 01h].
   Write C000 0280h + NID to TPDO2 COB-ID OD [1801h, 01h].
   Write C000 0380h + NID to TPDO3 COB-ID OD [1802h, 01h].
   Write C000 0480h + NID to TPDO3 COB-ID OD [1803h, 01h].
3. Disable SYNC producer.
4. Set SYNC counter overflow value.
   Write 05h to synchronous counter overflow value OD [1019h, 00h].
5. Set SYNC period value.
   Write desired value in units of microseconds (0000 0000h to FFFF FFFFh) to communication cycle period OD [1006h, 00h]. Values written to this OD are automatically rounded down to milliseconds; therefore, the write value must be a multiple of 1000. If this OD is set to 0000 0000h, the sensor unit will not send SYNC messages.
10. Set to synchronous mode (SYNC period value set to 3 for example).
    Write 03h for SYNC period (1 to 240) to TPDO1 transmission type OD [1800h, 02h].
    The same value is set to TPDO2/3/4 transmission type OD [180x, 02h].
11. Enable TPDOn.
    Write 4000 0180h+NID to TPDO1 COB-ID OD [1800h,01h]
    Write 4000 0280h+NID to TPDO2 COB-ID OD [1801h,01h]
    Write 4000 0380h+NID to TPDO3 COB-ID OD [1802h,01h]
12. Enter operational mode.
13. Enable SYNC producer. SYNC message will be sent periodically.

6.9 AUTO OUTPUT SETTING

This section describes the Auto output setting, which enables the sensor unit to send measurement data output immediately after boot-up and initialization.

A sample procedure for this mode is given below.

1. Enter pre-operational mode.
2. Disable TPDO1, TPDO2, TPDO3 and TPDO4.
   Write C000 0180h + NID to TPDO1 COB-ID OD [1800h, 01h].
   Write C000 0280h + NID to TPDO2 COB-ID OD [1801h, 01h].
   Write C000 0380h + NID to TPDO3 COB-ID OD [1802h, 01h].
   Write C000 0480h + NID to TPDO4 COB-ID OD [1803h, 01h].
3. Set to sampling mode.
   Write FEh to TPDO1 transmission type OD [1800h, 02h].
   (The same value is set to TPDO2/3/4 transmission type OD [180x, 02h].)
4. Set the timer intervals.
   Write interval timer value to Timer interval OD [2001h,00h].
5. Set Internal Filter
   Write value to AI filter tap constant 1 OD [61A1h, 01h].
6. Enable TPDO.
   Write 4000 0180h+NID to TPDO1 COB-ID OD [1800h,01h]
   Write 4000 0280h+NID to TPDO2 COB-ID OD [1801h,01h]
   Write 4000 0380h+NID to TPDO3 COB-ID OD [1802h,01h]
   Write 4000 0480h+NID to TPDO3 COB-ID OD [1803h,01h]
7. Set NMT startup mode to Operational
   Write 0000 0008h to NMT startup mode OD[1F80h,00h].
8. Save OD settings to non-volatile memory
   Write 6576 6173h to Save all parameters OD [1010h,01h].
   During the saving process, do not power off the device before completion (Otherwise non-volatile memory can be corrupted).
9. Reboot.

6.10 CAN NODE SETTING

This section describes the node setting, which changes the node-ID and CAN bitrate of the sensor unit. Only one node should be connected so that the node-ID does not overlap.

1. Enter pre-operational mode.
2. Set node-ID and CAN bitrate.
   Write value of 0 -127 as node-ID to CAN node-ID OD [2000h,01h].
   Write following value to CAN bitrate OD [2000h,02h].

00h=1Mbps	01h=800kbps	02h=500kbps
03h=250kbps	04h=125kbps	05h=50kbps
06h=20kbps	07h=10kbps	

3. Save OD settings to non-volatile memory
   Write 65766173h to Save all parameters OD [1010h,01h].

During the saving process, do not power off the device before completion (Otherwise non-volatile memory can be corrupted).

4. Reboot.

6.11 BUS STATUS & LED INDICATOR

Bus status and error mode of the unit is defined as shown in Table 6-12. The bus status depends on the frequency of a bus error (send error or receive error).
NOTE: During system boot-up, the bus status does not change to the bus-off, regardless of the frequency of bus error occurrence.

Table 6-12 Bus / Error Status

Bus/Error Status	Descriptions	LED(RED)	Comment
Bus Normal	Normal condition or the error rate is low	Off	The unit is working properly.
Bus Heavy	The error rate on the bus is high.	Single flash ON for 200msec OFF for 1000msec	This is a warning state. The unit is still working.
Boot-up Message Error	The host device is not working during boot-up.		The host device on the bus should be checked.
Bus Off	Critical failure on the bus.	On	The bus has a serious condition and the unit has stopped normal operation. To recover Bus off, the Bus off release procedure or a reboot of the system is necessary.
Parameter Memory Checksum Error	The parameter data saved in non-volatile memory is incorrect.	Blink ON for 200msec OFF for 200msec	The most recent save parameter operation failed and must be saved again. After successful save parameter operation, reboot the system.

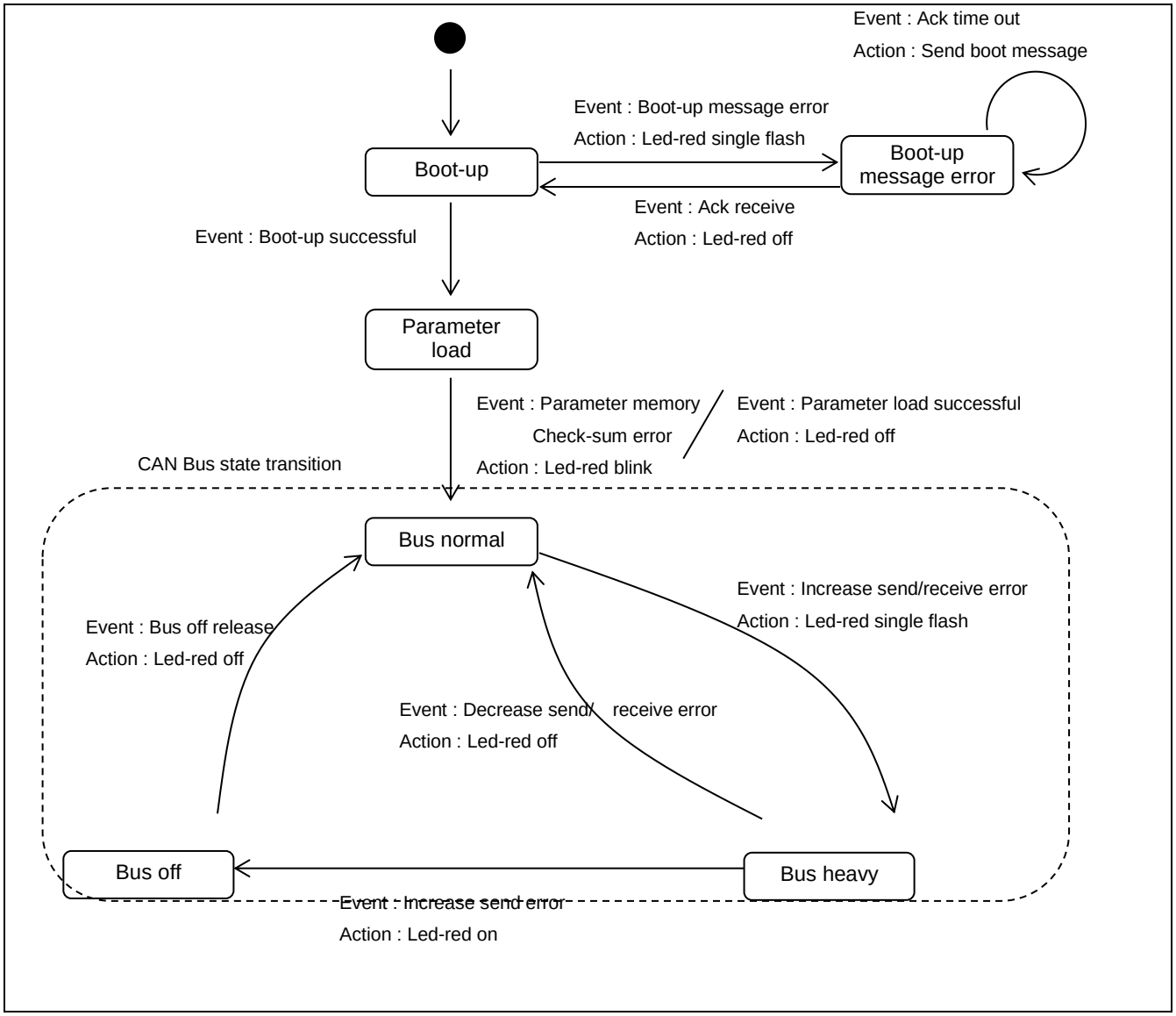


Figure 6-24 CAN Bus State Transition Diagram

During Bus-off state, the unit enters a special mode where message transmission is prohibited.
The unit can still receive NMT commands during Bus-off state.

The procedure to recover from Bus-off state is given below.

- Power off and Power on of the unit, or
- Send the reset node command or reset communication command after receiving of the 11-bit recessive signal 128 times (Normally, except for master device on the network, no other node should be transmitting any message on the bus during this period).

The protocol used for LED indicators is a slightly modified version of the CANopen specification as described in CiA DS-303-3. When the green LED and the red LED are ON, the indicator looks orange, because of the bi-color LED.

Table 6-13 Run LED Status

Status	Run LED (green)	Comment
Initialization	Off	
Pre-operational	Blinking	ON for 200msec, OFF for 200msec
Operational	On	
Stopped	Single flash	ON for 200msec, OFF for 1000msec
Erase non volatile memory	Double flash	ON for 200msec, OFF for 200msec、 ON for 200msec, OFF for 1000msec

7 HANDLING NOTES

7.1 CAUTIONS FOR ATTACHING

- The product contains quartz crystal oscillator created by microfabrication. Take precaution to prevent falling or excessive impact. Do not use the product after an accidental fall or it experiences excessive impact. The possibility of a failure and risk of malfunction from failure increases.
- Excessive vibration, shock, continuous stress, or sudden temperature change may increase the possibility of failure.
- The product should be kept powered on for more than 15 minutes to measure with highest precision and accuracy.
- Do not connect the product to a CAN bus network with the supply voltage turned on.
- When attaching the product, ensure that the product is properly mounted to avoid mechanical stress such as a warping or twisting. In addition, ensure appropriate torque is applied when tightening the screws but not too excessive to cause the mount of the product to deform or break. Use screw locking techniques as necessary.
- When setting up the product, ensure that the equipment, jigs, tools, and workers maintain a good ground in order not to generate high voltage discharge. Applying over current or static electricity to the product may damage the product permanently.
- When installing the product, ensure that metallic or other conductive material do not enter the product. Otherwise, malfunction or damage of the product may result.
- If excessive shock is applied to the product when, for example, the product falls, the quality of the product may be degraded. Ensure that the product does not fall when you handle it.
- Before you start using the product to obtain measurements, test it in the actual equipment under the actual operating environment to confirm proper operation.
- When connecting a cable to this product, tighten the screw enough after inserting it completely. This product may not satisfy IP67 if tightening is insufficient.
- Do not use the product in a situation where power is always applied to the joint of connector.
- Ensure that the signals are wired correctly with attention to the name and the polarity of each signal.
- Since the product has capacitors inside, inrush current occurs immediately after power-on. Evaluate in the actual environment in order to check the effect of the supply voltage sag caused by inrush current in the system.

7.2 OTHER CAUTIONS

- This product is water-proof and dust-proof in conformity with IP67. We do not guarantee the operation of the product when exposed to condensation, dust, oil, corrosive gas (salt, acid, alkaline, etc), or direct sunlight which surpass IP67. Do not use this product under water.
- Only use a connector that conforms with IP67. In case of improper or incomplete connection, water-proofness and dust-proofness is not guaranteed.
- This product is not designed to be radiation resistant.
- Never use this product if the operating condition is over the absolute maximum rating. Otherwise, permanent damage to the product may result.
- If the product is exposed to excessive external noise or other similar conditions, degradation of the precision, malfunction, or damage to the product may result. The system needs to be designed so that the noise itself is suppressed or the system is immune to the noise.
- This product is not designed to be used in equipment that demands extremely high reliability and where its failure may threaten human life or property (for example, aerospace equipment, submarine repeater, nuclear power control equipment, life support equipment, medical equipment, transportation control equipment, etc.). Seiko Epson Corporation will not be liable for any damages caused by the use of the product for those applications.
- Do not apply shock or vibration to the packing box. Do not spill water over the packing box. Do not store or use the product in an environment where dew condensation occurs due to rapid temperature change.
- Do not put mechanical stress on the product while it is stored.
- Do not alter or disassemble the product.
- Do not use in water except if it gets temporarily wet based on IP67. This product does not achieve the sufficient waterproof performance if the connector is mated incorrectly or if the mating connector does not satisfy IP67.
- The power supply to this product must satisfy the voltage rating within 2 seconds after it is turned on.
- Do not use thinner or similar liquids on this product. When cleaning this product, alcohol may be used.
- Total length of cables should be less than the maximum total length of cable defined in Table 5-1. It is recommended that the cable satisfy the CAN standard.

7.3 LIMITED WARRANTY

- The warranty period for this product is 12 months from the date of shipment.
- During the warranty period, if any defect attributable to our company is found, we will replace the product free of charge.

8 PART NUMBER / ORDERING INFO.

The following is the ordering code for the product:

Product Name	Model Name	Product Number	Comment
Accelerometer for CAN Interface	**M-A552AC10**	**X2F000031000100**	

Appendix1. MESSAGES

A.1.1. NMT message

COB-ID		DLC	CAN data field							
FC	NID		1	2	3	4	5	6	7	8
0000b	0000000b	2	Cs	Id						

Cs command specifier
01h = start
02h = stop
80h = enter pre-operational
81h = reset node
82h = reset communication
otherwise = reserved

Id consumer node-ID
00h = all node
01h-7Fh = node-ID
otherwise = reserved

This message changes the state of the node specified by Id. If the reset node or reset communication command is specified by Cs, this message resets the node. If Id is 00h, this message affects all nodes in the network.
The sensor unit operates as NMT consumer only.

A.1.2. SYNC message

COB-ID		DLC	CAN data field							
FC	NID		1	2	3	4	5	6	7	8
0001b	0000000b	1	Cn							
		0								

Cn SYNC counter
01h-F0h = count value
otherwise = reserved

This message is used for the synchronized transmission of the PDO sequence. This message gives the measurement trigger to all SYNC consumers on the network. A SYNC consumer that receives a SYNC message returns measurement data as TPDO message. The SYNC message has an optional counter Cn which can be used by SYNC consumers that support this feature. SYNC messages which have no Cn will have DLC = 0.

The sensor unit can operate as a SYNC consumer or SYNC producer. When operating as a SYNC producer, the SYNC counter is optional and is enabled by OD [1019h, 00h].

A.1.3. TIME message

COB-ID		DLC	CAN data field							
FC	NID		1	2	3	4	5	6	7	8
0010b	0000000b	6	Dy		Ms					

Dy time of day
0000h-FFFFh = the elapsed days from 1.Jan,1984
Ms time difference
bit3-0: (fixed 0)
bit31-4: the elapsed milli-second from 0:00am(midnight)

This message sets the time synchronization for all timestamp consumers on the network. The sensor unit operates as timestamp consumer only. A recommendation is to send this message in pre-operational mode, to prevent delays in setting the internal timer of the unit. Do not set a value to bit31-4 (Ms) greater than or equal to 86400000msec (the maximum value of one day).

A.1.4. TPDO1 message

COB-ID		DLC	CAN data field							
FC	NID		1	2	3	4	5	6	7	8
0011b	Node-ID	8	Ax (Ix)				Ay (Iy)			

Ax acceleration along x-axis (fixed point)
Ay acceleration along y-axis (fixed point)
(Ix) Tilt angle along x-axis (fixed point)
(Iy) Tilt angle along y-axis (fixed point)

The sensor unit outputs signed fixed-point format using the TPDO1 message.

Acceleration
The format is Q24 signed 32bit fixed point format.
Unit: G

Tilt angle
The tilt angle data format is Q29 signed 32bit fixed point format.
Unit: radian

Transmission of TPDO1 message is triggered by a SYNC message or sensor sampling event. A host device may enable or disable TPDO1 output by TPDO1 COB-ID OD [1800h, 01h].
Concerning the data format, refer to 6.4.3 MEASUREMENT VALUES

A.1.5. TPDO2 message

COB-ID		DLC	CAN data field							
FC	NID		1	2	3	4	5	6	7	8
0101b	Node-ID	6	Az(Iz)				Sc		-	

Az acceleration along z-axis (fixed point)
(Iz) Tilt angle along z-axis (fixed point)
Sc sample counter (0 to 65535)

The sensor unit outputs measurement data using the TPDO2 message. Transmission of TPDO2 message is triggered by a SYNC message or sensor sampling event. A host device may enable or disable TPDO2 output by TPDO2 COB-ID OD [1801h, 01h].

A.1.6. TPDO3 message

COB-ID		DLC	CAN data field							
FC	NID		1	2	3	4	5	6	7	8
0111b	Node-ID	6	Dy		Ms				-	

Dy time of day
0000h-FFFFh = the elapsed days from 1. Jan,1984
Ms time difference
bit3-0: (fixed 0)
bit31-4: the elapsed milli-second from 0:00am(midnight)

The sensor unit outputs the time information of measurement data using the TPDO3 message. Transmission of TPDO3 message is triggered by a SYNC message or sensor sampling event. A host device may enable or disable TPDO3 output by TPDO3 COB-ID OD [1802h, 01h]

A.1.7. TPD04 message

COB-ID		DLC	CAN data field							
FC	NID		1	2	3	4	5	6	7	8
1001b	Node-ID	4	Temperature				-			

The sensor unit outputs the temperature data using the TPDO4 message.

Temperature
The temperature data is represented in the binary form.
Unit: degree C
Refer to 6.4.3 MEASUREMENT VALUES

Transmission of TPDO4 message is triggered by a SYNC message or sensor sampling event. A host device may enable or disable TPDO4 output by TPDO4 COB-ID OD [1803h, 01h]

A.1.8. TSDO message

COB-ID		DLC	CAN data field							
FC	NID		1	2	3	4	5	6	7	8
1011b	Node-ID	8	Cs	Pi		Ps	Pd			

Cs command specifier
43h = 4byte data (read sequence)
4Bh = 2byte data (read sequence)
4Fh = 1byte data (read sequence)
60h = success (write sequence)
80h = failure (write sequence)
Pi index
Ps sub-index
Pd (read sequence) data
(write sequence) fixed 0000h
(error case) abort code

The sensor unit sends this message as a response to a request message from an SDO client. In a read sequence, this message contains the data output. In a write sequence, this message contains the result of the write operation. If an error occurred, this message contains the abort code.

A.1.9. RSDO message

COB-ID		DLC	CAN data field							
FC	NID		1	2	3	4	5	6	7	8
1100b	Node-ID	8	Cs	Pi		Ps	Pd			

Cs command specifier
40h = read request (read sequence)
23h = 4byte data (write sequence)
2Bh = 2byte data (write sequence)
2Fh = 1byte data (write sequence)
Pi index
Ps sub-index
Pd (write sequence) data
(read sequence) don't care

The SDO client sends this message as request to the sensor unit. In a read sequence, the SDO client sets the index and sub-index. In a write sequence, it sets the index, sub-index and data.

A.1.10. HB message

COB-ID		DLC	CAN data field							
FC	NID		1	2	3	4	5	6	7	8
1110b	Node-ID	1	St							

St state of unit

00h = boot-up
04h = stop
05h = operational
7Fh = pre-operational

If enabled, the sensor unit sends a heartbeat message periodically. This message contains information of the current NMT state of the sensor unit. By default, this message is not enabled. A host device may enable heartbeat output by specifying the heartbeat interval in Producer heartbeat time OD [1017h, 00h]. The sensor unit sends one heartbeat message as a bootup message during initialization, regardless of the value specified in OD [1017h, 00h]. There is no way to disable the bootup message output.

Appendix2. OBJECT DICTIONARY

Example

Index	Sub	Data type	Access type	Default value	Save
(1)	(2)	(3)	(4)	(5)	(6)
Function					
Data field					
Description					
Restriction					

(1) Index No
(2) Sub index No
(3) Data type
U8 = 8bit unsigned integer (0 to 255)
U16 = 16bit unsigned integer (0 to 65535)
U32 = 32bit unsigned integer (0 to 4294967295)
I16= 16bit signed integer (-32768 to 32767)
VS = Array[4] of character (ex: 65766173h = "save")
(4) Access type
const = Constant (never changes)
ro = read only
rw = read /write
(5) Default value
(6) An OD entry that has "#" in "SAVE" column is saved to non-volatile memory.

A.2.1. COMMUNICATION PROFILE （DS-301）

A.2.1.1 Device type

Index	Sub	Data type	Access type	Default value	Save
1000h	00h	UNSIGNED32	const	0002 0194h	-
Function		Device type			
Data field		bit15-0: device profile 0194h(404)=DS-404（DS-404 standard, measurement device profile） bit31-16: measurement type 0002h=Analog input block			

A.2.1.2 Error register

Index	Sub	Data type	Access type	Default value	Save
1001h	00h	UNSIGNED8	ro	00h	-
Function		Error register			
Data field		bit0: generic error 0=no error 1=error bit7-1: (reserved)			
Description		This register shows a generic error status of the sensor unit.			

A.2.1.3 Manufacturer status register

Index	Sub	Data type	Access type	Default value	Save
1002h	00h	UNSIGNED32	ro	0000 0000h	-
Function		Manufacturer status register			
Data field		bit6-0: (reserved) bit7: sensor error 0= no error, 1=error bit8: non volatile memory error 0= no error, 1=error bit31-9: (reserved)			
Description		This register shows a particular error status of the sensor unit. If a sensor error occurred, the bit 7 becomes 1. If a logging memory delete error occurred, the bit 8 becomes 1.			

A.2.1.4 SYNC COB-ID

Index	Sub	Data type	Access type	Default value	Save
1005h	00h	UNSIGNED32	rw	0000 0080h	#
Function		SYNC message output control and SYNC COB-ID			
Data field		bit10-0: SYNC COB-ID (fixed 0001 0000000b) bit29-11: (fixed 0) bit30: generate SYNC message 0=not generate 1=generate bit31: (fixed 0)			
Description		This OD enables or disables the SYNC producer. The host device must set the communication cycle period OD [1006h, 00h] and the synchronous counter overflow value OD [1019h, 00h], before starting the SYNC producer. If the unit operates as SYNC producer and OD [1019h, 00h] = 02h-F0h, the SYNC message transmitted by the unit will have a Cn (counter) parameter with initial value of 1. The SYNC COB-ID is fixed.			
Restriction		The message for “generate” is valid at operational mode only.			

A.2.1.5 Communication cycle period

Index	Sub	Data type	Access type	Default value	Save

1006h	00h	UNSIGNED32	rw	0000 0000h	#
Function		Period of SYNC message output			
Data field		bit31-0: SYNC cycle period [usec] （0000 0000h the SYNC message is not generated.			
Description		This OD sets the period of SYNC message output. The value written to this OD is automatically rounded down to [msec].			
Restriction		When Sync message is generate (OD 1005h /bit30=1) this OD is not changed.			

A.2.1.6 Manufacturer device name

Index	Sub	Data type	Access type	Default value	Save
1008h	00h	VISIBLE_STRING4	const	3235 3541h ("A552")	-
Function		Device name			
Data field		bit31-0: device name 3235 3541h ("A552")			

A.2.1.7 Manufacturer hardware version

Index	Sub	Data type	Access type	Default value	Save
1009h	00h	VISIBLE_STRING4	const	30314341h ("AC10")	-
Function		Hardware version			
Data field		bit31-0: hardware version			

A.2.1.8 Manufacturer software version

Index	Sub	Data type	Access type	Default value	Save
100Ah	00h	VISIBLE_STRING4	const	See “Data field”	-
Function		Software version			
Data field		bit31-0: software version ex. 30302E31h ("1.00") The latest version is stored as an ASCII code			

A.2.1.9 Save all parameters

Index	Sub	Data type	Access type	Default value	Save
1010h	01h	VISIBLE_STRING4	rw	0000 0001h	-
Function		Save OD settings to non-volatile memory			
Data field		(Write) bit31-0: keyword 6576 6173h("save")=save parameters otherwise=ignore			
		(Read) bit31-0: (fixed 0000 0001h)			

Description	When the host device writes "save" (6576 6173h) in ASCII to this OD, all saveable OD are stored to non-volatile memory. Confirm the save OD command is accepted by SDO response. Wait for at least 200msec after execution, and then reset or reboot. During saving process, the power supply must be stable. In case of power off or unstable level, non-volatile memory may be written incorrect data.

A.2.1.10 Restore all default parameters

Index	Sub	Data type	Access type	Default value	Save
1011h	01h	VISIBLE_STRING4	rw	0000 0001h	-
Function		Load OD with factory default values from non-volatile memory			
Data field		(Write) bit31-0: keyword 6461 6F6Ch("load")=restore parameters otherwise=ignore			
		(Read) bit31-0: (fixed 0000 0001h)			
Description		When the host device writes "load" (6461 6F6Ch) in ASCII to this OD, all saveable OD are restored to factory default values. It takes for 1sec to load the values. The newly-restored values are not saved automatically to non-volatile memory. The host device is required to send a save command to make the changes permanent. Finally, a reboot or NMT Reset Node message is required before the changes in OD become valid.			

A.2.1.11 TIME COB-ID

Index	Sub	Data type	Access type	Default value	Save
1012h	00h	UNSIGNED32	const	8000 0100h	-
Function		TIME message COB-ID			
Data field		bit10-0: TIME COB-ID (fixed 0010 0000000b) bit30-11: (fixed 0) bit31: (fixed 1)			
Description		The TIME consumer is always enabled. The TIME COB-ID is fixed.			

A.2.1.12 Producer heartbeat time

Index	Sub	Data type	Access type	Default value	Save
1017h	00h	UNSIGNED16	rw	0000h	#
Function		Period of heartbeat output			
Data field		bit15-0: heartbeat cycle period [msec]			
Description		This OD sets heartbeat cycle time in milliseconds. The heartbeat message output becomes valid after a non-zero value is written to this OD. The heartbeat message output is disabled when 0000h is written to this OD.			

A.2.1.13 Synchronous counter overflow value

Index	Sub	Data type	Access type	Default value	Save
1019h	00h	UNSIGNED8	rw	00h	#
Function		SYNC counter output control and overflow value			
Data field		bit7-0: synchronous counter overflow value 00h=SYNC message has no counter 02h-F0h=overflow value otherwise=reserved			
Description		When the host device sets 02h-F0h to this OD, the SYNC message transmitted by the unit (when operating as SYNC producer) has an optional counter. The SYNC producer increments the counter value by 1 every time it sends a SYNC message. When the counter value matches the maximum value defined by this OD, the counter resets to 1 at the next SYNC. The SYNC counter starts with a value of 1 in the first SYNC message, which is transmitted when 1 is written to bit 30 of the SYNC Producer Enable OD [1005h, 00h]. The SYNC message has no optional counter when 00h is written to this OD.			
Restriction		The host device can change the value of this OD only when the communication cycle period OD [1006h, 00h] is 0000 0000h.			

A.2.1.14 RSDO COB-ID

Index	Sub	Data type	Access type	Default value	Save
1200h	01h	UNSIGNED32	ro	0000 0600h+NID	-
Function		RSDO message COB-ID			
Data field		bit10-0: RSDO COB-ID (1100 0000000b+ NID) bit31-11: (fixed 0)			
Description		The RSDO COB-ID is permanently fixed to 00000600h + NID.			

A.2.1.15 TSDO COB-ID

Index	Sub	Data type	Access type	Default value	Save
1200h	02h	UNSIGNED32	ro	0000 0580h+NID	-
Function		TSDO message COB-ID			
Data field		bit29-0: TSDO COB-ID (1011 0000000b+ NID) bit31-30: (fixed 0)			
Description		The TSDO COB-ID is permanently fixed to 00000580h + NID.			

A.2.1.16 TPDOn COB-ID

Index	Sub	Data type	Access type	Default value	Save
1800h 1801h 1802h 1803h	01h	UNSIGNED32	rw	4000 0180h+NID 4000 0280h+NID C000 0380h+NID C000 0480h+NID	#

Function	TPDOn message output control and TPDOn COB-ID
Index	1800h=TPDO1, 1801h=TPDO2, 1802h=TPDO3, 1803h=TPDO4
Data field	bit10-0: TPDOn COB-ID (read only) bit29-11: (fixed 0) bit30: (fixed 1) bit31: validity of TPDOn message output 0=TPDOn is enabled 1=TPDOn is not enabled
Description	This OD enables or disables the output TPDOn message. The TPDOn COB-ID is permanently fixed to 0n80h+NID.

A.2.1.17 TPDO transmission type

Index	Sub	Data type	Access type	Default value	Save
1800h	02h	UNSIGNED8	rw	01h	#
1801h			ro	01h	
1802h			ro	01h	
1803h			ro	01h	
Function		TPDOn transmission type			
Index		1800h=TPDO1, 1801h=TPDO2, 1802h=TPDO3, 1803h=TPDO4			
Data field		bit7-0: TPDOn transmission type 00h=synchronous mode (by every SYNC message) 01h-F0h=synchronous mode (by n times SYNC messages) FEh=timer event mode otherwise=reserved			
Description		This OD specifies the transmission type. When the value of this OD is 00h, the transmission type is synchronous mode. The sensor node sends TPDO messages for every SYNC message received. When the value of this OD is 01h to F0h, the transmission type is synchronous mode too. This unit sends TPDO messages when the number of SYNC messages received matches the value of this OD. If the value of Synchronous counter overflow OD [1019h, 00h] is not 00h, this unit sends TPDO messages when the value of SYNC counter (Cn) is a multiple of the value of this OD. When the value of this OD is FEh, the transmission type is timer event mode. In timer event mode, the TPDO is output by the setting of sensor sample rate OD[2001h,00h] .		
Restriction		Only OD[1800h,02h] setting is programmable. OD[1801h,02h], OD[1802h,02h] and OD[1803h,02h] are set automatically. OD[2005h,00h] should be set to apply these parameters.			

A.2.1.18 TPDO1 mapping

Index	Sub	Data type	Access type	Default value	Save
1A00h	01h 02h	UNSIGNED32	const	9130 0110h 9130 0210h	-
Function		TPDO1 mapping			
Data field		bit7-0: data size [bit] bit15-8: sub-index bit31-16: index			

Description	The parameters of TPDO1. Parameter1=Ax: AI input PV 1 OD[9130h,01h] Parameter2=Ay: AI input PV 2 OD[9130h,02h] The mapping is fixed.

A.2.1.19 TPDO2 mapping

Index	Sub	Data type	Access type	Default value	Save
1A01h	01h 02h	UNSIGNED32	const	9130 0320h 2100 0010h	-
Function		TPDO2 mapping			
Data field		bit7-0: data size [bit] bit15-8: sub-index bit31-16: index			
Description		The parameters of TPDO2. Parameter1=Az: AI input PV 4 OD[9130h,03h] Parameter2=Sc: Sample counter OD[2100h,00h] The mapping is fixed.			

A.2.1.20 TPDO3 mapping

Index	Sub	Data type	Access type	Default value	Save
1A02h	01h 02h	UNSIGNED32	const	2101 0110h 2101 0220h	-
Function		TPDO3 mapping			
Data field		bit7-0: data size [bit] bit15-8: sub-index bit31-16: index			
Description		The parameters of TPDO3. Parameter1=Dy: Time of day OD[2101h,01h] Parameter2=Ms: Time difference OD[2101h,02h] The mapping is fixed.			

A.2.1.21 TPDO4 mapping

Index	Sub	Data type	Access type	Default value	Save
1A03h	01h	UNSIGNED32	const	9130 0420h	-
Function		TPDO4 mapping			
Data field		bit7-0: data size [bit] bit15-8: sub-index bit31-16: index			
Description		The parameters of TPDO4. Parameter1=Tmp: Temperature OD[9130h,04h] The mapping is fixed.			

A.2.1.22 NMT startup mode

Index	Sub	Data type	Access type	Default value	Save

1F80h	00h	UNSIGNED32	rw	0000 0008h	#
Function		NMT startup mode			
Data field		bit1-0: (fixed 0) bit2: startup mode 0=enter operational mode autonomously 1=stay pre-operational mode bit3: (fixed 1) bit31-4: (fixed 0)			
Description		This OD sets the NMT state after bootup of the sensor node. If bit 2 of this OD is 0, the sensor node will go to operational state after bootup. There is 3 seconds maximum interval from pre-operational mode to operational mode.			

A.2.2. MANUFACTURE PROFILE

A.2.2.1 CAN node-ID

Index	Sub	Data type	Access type	Default value	Save
2000h	01h	UNSIGNED8	rw	01h	#
Function		CAN node-ID			
Data field		bit7-0: CAN node-ID 01h-7Fh=node-ID otherwise=reserved			
Description		This OD allows the user to set and read the node-ID. Writing to this parameter does not take effect until the sensor unit is rebooted or the reset node command is received. The host device is required to send a save command to make the change permanent.			
Restriction		This parameter can only be modified when the sensor unit is in pre-operational mode.			

A.2.2.2 CAN bitrate

Index	Sub	Data type	Access type	Default value	Save
2000h	02h	UNSIGNED8	rw	00h	#
Function		CAN bitrate			
Data field		bit7-0: CAN bitrate 00h=1Mbps 01h=800kbps 02h=500kbps 03h=250kbps 04h=125kbps 05h=50kbps 06h=20kbps 07h=10kbps otherwise=reserved			
Description		This OD allows the user to set and read the CAN bitrate. Writing to this parameter does not take effect until the sensor unit is rebooted or the reset node command is received. The host device is required to send a save command to make the change permanent.			
Restriction		This parameter can only be modified when the sensor unit is in pre-operational mode.			

A.2.2.3 Timer interval

Index	Sub	Data type	Access type	Default value	Save
2001h	00h	UNSIGNED32	rw	0000 0002h	#
Function		Timer intervals			
Data field		bit15-0 timer interval (0=disable, 1-65535=interval time) bit31-16 (reserved)			
Description		This OD allows the user to set and read the timer intervals. The valid values for bit15-0 are 1, 2, 5, 10, or 20			

	Interval Sampling rate 1(msec) 1,000sps 2(msec) 500sps 5(msec) 200sps 10(msec) 100sps 20(msec) 50sps All other values are invalid
Restriction	OD[2005h,00h] should be set to apply these parameters. This parameter can only be modified when the sensor unit is in pre-operational mode. After the timer interval is set, the internal filter cutoff frequency is reset to default setting. When the timer interval is set, also the AI filter tap should be set again.(Refer to 6.4.4 INTERNAL FILTER)

A.2.2.4 Apply parameters

Index	Sub	Data type	Access type	Default value	Save
2005h	00h	UNSIGNED8	rw	10h	#
Function		Set sensor type and apply parameters			
Data field		bit7-4: application control 0h=apply parameters with unchanged sensor type 1h=apply parameters as Accelerometer 2h=apply parameters as Tilt angle sensor otherwise=ignore bit3-0: (0=read / 1=write / otherwise=ignore)			
Description		This OD allows the user to set the sensor type and apply parameters of associated measurement as follows, - TPDO1 transmission type OD[1800h,02h] - Timer interval OD[2001h,00h] - Filter tap constant1[61A1h,01h] 1xh: Accelerometer 2xh: Tilt angle sensor This parameter can be saved by the Save all parameters command.			
Restriction		This parameter can only be modified when the sensor unit is in pre-operational mode.			

A.2.2.5 User defined filter parameter set

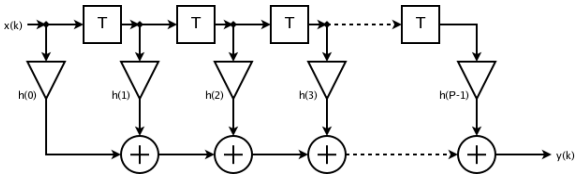
Index	**Sub**	**Data type**	**Access type**	**Default value**	**Save**
2007h	00h	UNSIGNED8	rw	00h	-
Function		Load or save the user defined filter (UDF) parameters			

Data field	bit7-0: application control 11h = UDF Load Load UDF parameter 21h = UDF Save Save UDF parameter otherwise=ignore When command execution completes successfully Return value is rewritten from x1h ⇒ x0h When command execution ends abnormally Return value is rewritten from x1h ⇒ x8h
Description	Executes commands to transfer the UDF parameter data stored between the RAM work area and the user-defined filter (UDF) parameter area in non-voltatile memory. The command execution involves internal memory transfers, and requires a certain amount of processing time. After the command is executed normally, the least significant bit (b0 bit) is cleared to provide indication that the processing has completed. When the command ends abnormally, b3 bit (x8h) is set. To subsequently enable the current UDF filter settings, OD[61A1h, 01] must be set to a user-defined filter setting. To transfer UDF parameter data between the host and the RAM work area use OD[2008h].
Restriction	The commands of this OD can only be executed in pre-operational mode. (In case of violation, 0x08000022 will be returned).

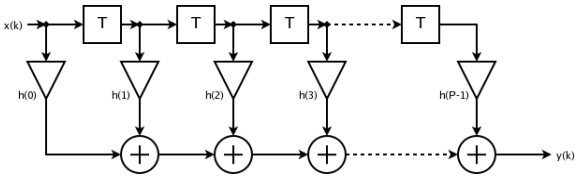
A.2.2.6 UDF host interface (Number of tap)

Index	Sub	Data type	Access type	Default value	Save
2008h	01h	UNSIGNED16	rw	0000h	#
Function		Set the valid tap number of the user-defined filter (UDF) coefficients to be secured in the RAM work area.			
Data field		Bit[15:0] 0000h UDF disabled 0040h UDF tap number 64 0080h UDF tap number 128 0200h UDF tap number 512 ffffh UDF not set			
Description		Set the UDF tap number as listed in the Data field. When data is saved in the UDF valid area (non-volatile area), the tap number of the saved UDF coefficient is returned.			
Restriction		Accessing this OD is only valid in pre-operational mode. (In case of violation, 0x08000022 will be returned) Settings other than the tap number listed in the Data field is not valid. (0x06090030 will be returned upon violation)			

A.2.2.7 UDF host interface (Current address index)

Index	Sub	Data type	Access type	Default value	Save
2008h	02h	UNSIGNED16	rw	0000h	
Function		Set or return the index of the user-defined filter (UDF) FIR coefficient array area prepared in the RAM work area.			
Data field		Bit[15:0] 0000h Start address h(0)⇒h(511)max  			
Description		When reading: Returns the currently set UDF parameter index When writing: Set the desired UDF parameter index This index is incremented by 1 each time parameter reading / writing is performed with OD [2008h, 03h]			
Restriction		This OD can only be changed in pre-operational mode. (In case of violation, 0x08000022 will be returned) An index that exceeds the tap size set in OD [2008h, 01h] cannot be specified. (0x06090030 will be returned upon violation) If OD [2008h, 01] is 0 (UDF disabled), writing is not possible. (0x06090030 will be returned upon violation)			

A.2.2.8 UDF host interface (Read/Write data)

Index	Sub	Data type	Access type	Default value	Save
2008h	03h	INTEGER32	rw	0000 0000h	
Function		Read or write FIR coefficients of user-defined filter (UDF) in 32bit data units			
Data field		Bit[31:0] Set FIR coefficient in 32 bits （start address h0）  			
Description		When reading: Read FIR coefficient data of the index in the RAM work area specified by OD [2008h, 02h] When writing: Write the FIR coefficient data to the index set in OD [2008h, 02h] to the RAM work area.			

	When current reading or writing is completed, the index set by OD [2008h, 02h] is automatically incremented. If the maximum number of taps is reached, the index will return to 0.
Restriction	This OD can only be changed in pre-operational mode. (In case of violation, 0x08000022 will be returned) If OD [2008h, 01] is 0 (UDF disabled), writing is not possible. (0x06090030 will be returned upon violation)

A.2.2.9 Sample counter

Index	Sub	Data type	Access type	Default value	Save
2100h	00h	UNSIGNED16	Rw	0000h	-
Function		Value of the trigger counter			
Data field		bit15-0: count value (0 to 65535)			
Description		The value of the trigger counter is incremented by 1 when the sensor node receives a trigger (SYNC message or timer event). By setting this OD to some value, the trigger counter will start from that value.			

A.2.2.10 Time of day

Index	Sub	Data type	Access type	Default value	Save
2101h	01h	UNSIGNED16	ro	Indefinite	-
Function		current date			
Data field		bit15-0: the elapsed days from 1.Jan,1984			
Description		This OD represents the current date.			

A.2.2.11 Time difference

Index	Sub	Data type	Access type	Default value	Save
2101h	02h	UNSIGNED32	ro	indefinite	-
Function		current time (milliseconds)			
Data field		bit3-0: (fixed 0) bit31-4: the elapsed milli-second from 0:00am(midnight)			
Description		This parameter represents the current local time.			

A.2.3. MEASURING DEVICE PROFILE(DS-404)

A.2.3.1 AI sensor type 1-3

Index	Sub	Data type	Access type	Default value	Save
6110h	01h 02h 03h 04h	UNSIGNED16	const	2905h 2905h 2905h 0064h	-
Function		The sensor type of analog input 1-4.			
Data field		bit15-0: sensor type 2905h(10501)=accelerometer (manufacture specific) 0064h(100)=temperature			

A.2.3.2 AI input PV 1-3(Ax/Ay/Az)

Index	Sub	Data type	Access type	Default value	Save
9130h	01h 02h 03h 04h	INTEGER32	ro	indefinite	-
Function		01-03h: Measurement value of analog input PV1-3 (Ax/Ay/Az) 04h: Measurement value of internal temperature (24bit)			
Data field		bit15-0: process value (fixed point)			
Description		This OD shows the value of 3 axis accelerometer or tilt angle sensor and temperature. The sensor type can be set by Apply parameters command. (refer to A.2.2.4) ● Accelerometer The format is Q24 signed 32bit fixed point format. When the data is a negative number, it is represented in 2's complement. Unit: G bit31: sign(+/-) bit30-24: integer bit23-0: fraction Note) When the combination of output rate and filter cutoff frequency is "abnormal setting", reading acceleration sensor value responds with error code "0x64000000" Note) When the acceleration value exceeds the preset threshold value, reading acceleration value responds with the threshold value. For example, if the preset threshold values are set to +15 G and -15 G, the corresponding response is "0x0F000000" for +15 G or more, and "0xF1000000" for -15 G or less. ● Tilt angle sensor The tilt angle data format is Q29 signed 32bit fixed point format. When the data is a negative number, it is represented in 2's complement. Unit: radian bit31: sign(+/-)			

	bit30-29: integer bit28-0: fraction Note) When the combination of output rate and filter cutoff frequency is "abnormal setting", reading tilt angle sensor value responds with error code "0x64000000" Note) When the tilt angle value exceeds the dynamic range (±60 deg), reading tilt angle value responds with the value of +60 deg or -60 deg. For example, the corresponding response is “0x2182A470” for +60 deg or more, and “0xDE7D5B90” for - 60 deg or less. ● Temperature The temperature data is represented in 32-bit two’s complement binary format. Please refer to the below formula for conversion to temperature in centigrade. Please refer to Table 2.3 Sensor Specification for the scale factor value. The reference value in this register is for the temperature correction. There is no guarantee that the value provides the absolute value of the internal temperature. T [℃]= SF * a + 34.987 SF: Scale Factor A: Temperature sensor output data (decimal) The temperature data is reference data and not guaranteed for accuracy.

A.2.3.3 AI physical unit PV 1-3

Index	Sub	Data type	Access type	Default value	Save
6131h	01h 02h 03h 04h	UNSIGNED32	const	00F1 0000h 00F1 0000h 00F1 0000h 002D 0000h	-
Function		The unit of analog input 1-3.			
Data field		bit31-0: physical unit 00F1 0000h: G (manufacture specific)			

A.2.3.4 AI filter type 1-4

Index	Sub	Data type	Access type	Default value	Save
61A0h	01h 02h 03h 04h	UNSIGNED8	const	02h 02h 02h 00h(reserved)	-
Function		The filter type of analog input 1-4.			
Data field		Bit7-0: filter type			

	02h: Kaiser filter

A.2.3.5 AI filter tap constant

Index	Sub	Data type	Access type	Default value	Save
61A1h	01h 02h 03h 04h	UNSIGNED8	rw ro ro ro	09h 09h 09h 09h	#
Function		The filter cut off frequency of analog input.			
Data field		Bit7-0: filter tap constant 0000: Reserved 0001: FIR Kaiser Filter TAP=64、fc=83 0010: FIR Kaiser Filter TAP=64、fc=220 0011: FIR Kaiser Filter TAP=128、fc=36 0100: FIR Kaiser Filter TAP=128、fc=110 0101: FIR Kaiser Filter TAP=128、fc=350 0110: FIR Kaiser Filter TAP=512、fc=9 0111: FIR Kaiser Filter TAP=512、fc=16 1000: FIR Kaiser Filter TAP=512、fc=60 1001: FIR Kaiser Filter TAP=512、fc=210 1010: FIR Kaiser Filter TAP=512、fc=460 1011: Reserved 1100: User Defined FIR Filter TAP=64 1101: User Defined FIR Filter TAP=128 1110: User Defined FIR Filter TAP=512 1111: not used			
Description		This parameter is applied for analog input 1-4. User-defined filter only accepts the same TAP settings in OD [2008h, 01h] When using a user-defined filter, set the user-defined filter first before setting this OD. Refer to section A.2.2.2 UDF host interface (Number of tap) for details. Regarding user-defined filters, the user must ensure the UDF cutoff characteristics is consistent with sampling theorem based on the sampling rate (timer period).			
Restriction		This parameter can only be changed in the pre-operational mode. OD[2005h,00h] should be set to apply these parameters.			

	The proper value depends on timer interval setting, refer to 6.4.4 INTERNAL FILTER. When the timer interval is changed, this parameter must be set again.

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10 Standards and Approvals

The following standards are applied only to the unit that are labeled. (EMC is tested using the EPSON power supplies)

10.1 NOTICE

This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.
The connection of a non-shielded interface cable to this product will invalidate the EMC standards of the device.
Any changes or modifications not expressly approved by Seiko Epson Corporation could void your authority to operate the equipment.

10.2 CE Statement

This product conforms to the following Directives and Norms,

Directive 2014/30/EU
EN 61326-1 Class A

Directive 2011/65/EU:
EN IEC 63000:2018

Representative information,
Epson Europe Electronics GmbH
Riesstrasse 15
80992 Munich
Germany

10.3 RoHS & WEEE Statement

The crossed out wheeled bin label that can be found on your product indicates that this product should not be disposed of via the normal household waste stream. To prevent possible harm to the environment or human health please separate this product from other waste streams to ensure that it can be recycled in an environmentally sound manner. For more details on available collection facilities please contact your local government office or the retailer where you purchased this product.

AEEE Yönetmeliğine Uygundur.

Обладнання відповідає вимогам Технічного регламенту обмеження використання деяких небезпечних речовин в електричному та електронному обладнанні

10.4 UKCA Statement

This product conforms to the following Directives and Norms,

Directive 2014/30/EU
BS EN 61326-1 Class A

Directive 2011/65/EU:
EN IEC 63000:2018
Representative information,
Epson (UK) Ltd.Westside
Westside, London Road, Hemel
Hempstead, Hertfordshire, HP3 9TD,
United Kingdom

10.5 FCC Compliance Statement for American users

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
(1) This device may not cause harmful interference, and
(2) This device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

10.6 Industry ICES Compliance Statement for Canadian users

CAN ICES-3(A)/NMB-3(A)

11 REVISION HISTORY

Rev. No.	Date	Page	Category	Contents
Rev. 20191015	2019/10/15	All	New	Preliminary
Rev.20200720	2020/07/20	7 34 35 63	Revised	Corrected some of the characteristics in Table 2-4 Corrected typo in Table 6-10 6.4.5User Defined Filter Group delay calculation formula added Added setting value of 1ms interval
Rev.20200930	2020/09/30	-	Revised	Change contact of International sales operations (End of book)
Rev 20220401	2022/4/1	44	Modify	Product Number Change
Rev.20230101	2023/1/1	8 17 27 31 38 38 58 61 62 66	Revised	Table 2-7 State Change Timing Characteristics revised. Table 6-3 OD Execution Time Clerical erroe correction 6.4.4 Change “User Defined FIR Filter TAP=4” to “Reserved” 6.4.5 UDF access procedure example Revised 6.9 Sample procedure example revised. 6.10 Sample procedure example revised. A.2.2.6 UDF tap number 4 deleted. A.2.3.2 Clerical error correction A.2.3.5 UDF tap number 4 deleted. 10Revised with standard update
Rev.20251113	2025/11/13	Front cover Back cover	Update	Corporate logo change Contact information change
Rev.20260129	2026/1/29	48	Modify	The description of the LIMITED WARRANTY has been revised.

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