TURCK

Manual

Draw wire encoder
DW60/DW120

CANopen®

Table of Contents

List of Abbreviations

Abbreviation	Meaning
NMT	Network Management
SDO	Service Data Object
PDO	Process Data Object
TPDO	Transmit Process Data Object
RPDO	Receive Process Data Object
DLC	Data Length Code

Symbols used / Warnings and Safety instructions

The following elements are to be considered when using warnings and safety instructions

DANGER	This symbol, together with the signal word "Danger", indicates immediately imminent threat to life and health of persons. Ignoring this warning will result in serious damage to health with the possibility of life threatening injuries
WARNING	This symbol, together with the signal word "Warning", indicates a potential danger to life and health of persons. Ignoring this warning may result in serious damage to health with the possibility of life threatening injuries
CAUTION	This symbol, together with the signal word "Caution", indicates a potentially dangerous situation. Ignoring this warning may result in minor injuries or to damage to property.
NOTICE	Hints, recommendations and information for efficient and trouble-free operation.
SAFETY INSTRUCTION	A safety instruction indicates concrete or potential hazards. It is intended to protect you against accidents. Carefully read and adhere to safety instructions.

Table 1

1. General information – Features

CANopen offers a uniform user interface and therefore allows a simplified system structure with very different appliances. CANopen is optimized for fast data exchange in real-time systems and has various device profiles that have been standardized. The CAN in Automation (CiA) manufacturers and users association is in charge of establishing and standardizing the corresponding profiles. The sensor supports the latest CANopen communication profile according to DS 301 V 4.2.0.

CANopen offers

- Comfortable access to all device parameters
- Configuration of the network and of the devices
- Device synchronization within the network
- Cyclic and event-driven process data traffic
- Simultaneous input or output of data

CANopen uses three communication objects (COB) with various characteristics

- Process Data Objects (PDO) for real-time data
- Service Data Objects (SDO) for parameters and program transmission
- Network Management (NMT, Life-Guarding, Heartbeat)

All device parameters are saved in an object dictionary. This object dictionary contains the description, data type and structure of the parameters, as well as the address (index). The dictionary is structured in a communication profile section, a device profile-related section and a manufacturer-specific section

2. CANopen connections

CAN Specification	Full CAN 2.0B (ISO11898)
Communication profile	CANopen CiA 301 V 4.2.0, Slave
Device profile	Encoder, absolute linear; CiA 406 V 3.2.0
Error control	Producer Heartbeat, Emergency Message, Node Guarding
Node ID	Default: 7*, Adjustable via SDO
PDO	1 x TPDO, static mapping
PDO Modes	Event-triggered, Time-triggered, Sync-cyclic, Sync-acyclic
Transmission rate	Default: 250 kbit/s, 1 Mbps, 800, 500, 250, 125, 50, 20 kbps, adjustable via SDO
Bus connection	5-pin M12 connector
Integrated bus termination resistor	120 ohm, ready-to-activate via SDO
Bus, galvanic isolation	No, (Yes in preparation)
Voltage supply	8-30 VDC
Current consumption	Typically 10 mA for 24 V, typically 20 mA for 12 V
Measuring rate	1 kHz with 16-bit resolution
Repeatability	±0.5 %, ±0.25 % or ±0.1 % (depending on the selected linearity)
Resolution	0.002 % of the measuring range
Electrical protection	Reverse polarity protection
EMC	DIN EN61326-1:2013, conformity with directive 2014/30/EU

*In case of a redundant CANopen both units share the same bus, with different node IDs (7 and 8)

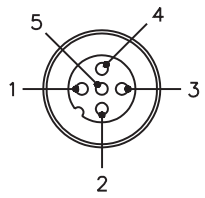
Standard Wiring (CANopen Output):

Signal Type	H1151 Pin	3	2	1	4	5
CANopen	Connection Type	Common (0V)	+V	CAN GND	CAN High	CAN Low

Standard Wiring (CANopen Output):

Signal Type	Cable Color:	WH	BN	GY	GN	YE
CANopen	Connection Type	Common (0V)	+V	CAN GND	CAN High	CAN Low

Wiring Diagram:

CANopen Output
Male Encoder View

Mating Cordset: RKC 572-*M/S3117

*Length in meters

3. Data transmission

With CANopen, data is transferred using two different communication types (COB=Communication Object) with different characteristics:

- Process Data Objects (PDO - real-time capable)
- Service Data Objects (SDO)

The Process Data Objects (PDO) are used for highly-dynamic exchange of real-time data (e.g. encoder position, speed, status of the compared positions) with a maximum length of 8 bytes. This data is transferred with high priority (low COB identifier). PDOs are broadcast messages and make their real-time data available simultaneously to all desired recipients.

The Service Data Objects (SDO) are the communication channel for the transmission of device parameters (e.g. programming of the encoder resolution). As these parameters are transmitted acyclically (e.g. only once when starting the network up), the SDO objects have a low priority (high COB identifier).

For an easier identifier management, CANopen uses the "Predefined Master/Slave Connection Set". All identifiers are defined with standard values in the objects dictionary. Some identifiers can however be modified in a customer-specific way by means of SDO access.

The 11-bit identifier consists in a 4-bit function code and a 7-bit node number.

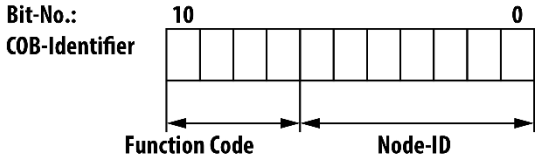


Figure 1

NOTICE	The higher the value of the COB identifier, the lower its priority!

4. NMT – Network Management

All NMT commands are transferred as an unconfirmed NMT Object. Because of the broadcast communication model, the NMT commands are recognized by each station.
An NMT Object is structured as follows:

NMT COB ID	Byte 0	Byte 1
000h	Command byte	Node ID (module address)

Table 2

The COB ID of the NMT object is always 000h.
Byte 0 contains the command byte

The following table shows the possible commands:

Command byte (hex)	Description
01h	Start_Remote_Node: switch to Operational
02h	Stop_Remote_Node: switch to Prepared
80h	Enter_Pre-Operational_State: switch to Pre-Operational
81h	Reset_Node: reset the node
82h	Reset_Communication: reset the communication

Table 3

The module addressed in byte 1 reacts to the command of byte 0.
A maximum of 127 stations (from 1 to 127) can be linked together in CANopen.

If this byte 1 is set to 0, all stations are addressed simultaneously, so all modules perform the command of byte 0.

Three different modes are available: Pre-Operational, Operational and Stopped mode. Commands 81h and 82h lead to a reset of the module(s). A reset corresponds to a re-starting of the module, i.e. the module is briefly in Initialization mode and sends a boot-up sequence (701h to 7FFh). Then the sensor switches to the mode defined as the start condition.

Not every mode allows an access to an object.
The following table shows when an access is possible.

Object	Operating Mode			
	Initialization	Pre-Operational	Operational	Stopped
PDO			X	
SDO		X	X	
SYNC		X	X	
Emergency		X	X	X
NMT		X	X	X
Node Guard (Heartbeat)		X	X	X
Boot-Up	X			

Table 4

5. The process data object – PDO

The process data exchange with CANopen is CAN bus-specific, therefore without protocol overhead. The broadcast features of the CAN bus remain maintained. A message can thus be received and processed by all nodes (Producer-Consumer model). So the rigid master/slave principle does not apply for data exchange with PDOs.

Since the protocol structure is missing in the telegrams, the station(s) on the bus that are the recipients of this data must know how the information is positioned in the data area of the PDO (which bit/byte corresponds to which value). This is why this declaration takes place previously during network initialization by means of the so-called PDO mapping, which allows placing the required information at a specific location in the data area of a PDO.

The sensor CANopen interface (CC1) only supports the TPDO1 and has a data length of 2 bytes. Depending on the selected node ID (node address), the COB ID lies between 181h (node 1) and 1FFh (node 127). The TPDO1 values range has 16 bits and can therefore theoretically take values between zero and 65535. However, our sensor devices are set consistently with the start value 5000 and the end value 55000. This makes position assignment easier for the user. It must be noted that the start value (5000) of a draw wire encoder is not located at the "rubber bumper stop" position, but at a small pull-out length. Therefore, TPDO1 data values < 5000 are possible. The same applies to the end position. Values > 55000 are possible. But an overflow or underflow of the 16-bit values range is excluded.

TPO1 181h…1FFh	Data0 Low byte	Data1 High byte

Table 5

6. SDO communication

The Service Data Objects (SDO) are the communication channel for the transmission of device parameters. As these parameters are transmitted acyclically (e.g. only once when starting the network up), the SDO objects have a low priority (high COB identifier).

Structure of the SDO telegram:

COB-ID	DLC	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
SDO identifier	Data length	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3

Table 6

The SDO identifier is defined as follows:
Client (control) → Server (Absolute encoder): **600h** + Node ID
Server (Absolute encoder) → Client (control): **580h** + Node ID

Data length (DLC) is always 8:
1 command byte + 2 index bytes (Object) + 1 subindex byte + 4 data bytes

The command defines whether data is to be written (download) or read (upload) and how many user data bytes are included.

Command	Description	User data	Function
22h	SDO(rx), Download Request (request)	undefined	Send parameters to the sensor
23h		4 bytes	
2Bh		2 bytes	
2Fh		1 byte	
60h	SDO(tx), Download Response (response)	-	Confirmation of parameters take-over to the client
40h	SDO(rx), Upload Request	-	Request parameters from the sensor
42h	SDO(tx), Upload Response	undefined	Send parameters to the client
43h		4 bytes	
4Bh		2 bytes	
4Fh		1 byte	
80h	SDO(tx), Abort Domain Transfer (abort because of an error)	4 bytes	Sensor sends error code to the client

Table 7

In the event of an error, an error message with command 80h (SDO Abort Message) replaces the normal confirmation (response). Index and subindex belong to the previously indicated object. The error code (abort code) sent is written in bytes 5 to 8.

The sensor electronics include the following objects from the communication profile of CiA 301:

Object	Name	Attribute
1000h	Device Type	ro
1001h	Error Register	ro
1005h	COB-ID SYNC Message	rw
1010h	Store Parameters	rw
1011h	Restore default Parameters	rw
1014h	Emergency COB-ID Message	ro
1017h	Heartbeat Producer Time	rw
1018h	Identity Object	ro
1029h	Error behavior object	ro
1800h	1st Transmit PDO Parameters	rw
1A00h	1st Transmit PDO Mapping	ro
2100h	Manufacturer specific profile area (baud rate)	rw
2101h	Manufacturer specific profile area (node address)	rw
2102h	Manufacturer specific profile area (termination)	rw
2104h	Manufacturer specific profile area (auto start)	rw
2105h	Manufacturer specific profile area (save)	rw
6004h	Position Value	ro

Table 8

Object 1000h: Device Type

This object send the device type according to CiA. The data area of this object contains the CiA guideline and the device profile.

Object 1001h: Error Register

This object indicates the error case according to CiA.

Object 1005h: COB ID SYNC Message

This object defines the COB ID for the SYNC message. It also defines whether the device generates or receives SYNC objects. The sensor only receives messages. The standard COB ID value is 80h, but it can be modified by the user between 001h and 7FFh.

NOTICE	The sensor only responds to SYNC commands when the transmission type in Object 1800h has been set accordingly.

Object 1010h: Store Parameters

This object saves the current values of the COB ID SYNC, the heartbeat timer, the transmission type and the event timer in the non-volatile memory of the sensor.
This object has 1 subindex. Subindex 0 indicates now many subindexes are supported (here 1). Subindex 1 shows that only the option "store all parameters" is supported. In the case of a write command, data area D0 to D3 of this subindex must contain the values 73h, 61h, 76h and 65h to perform the storage.

(These values correspond to the ASCII codes of the letters **s a v e**.)

Object 1011h: Restore default Parameters

This object allows resetting parameters COB ID SYNC, heartbeat timer, transmission type and event timer to their delivery condition. This condition is 0h for the heartbeat, 80h for the COB ID SYNC, 0h for the event timer and 01h for the transmission type. This object has 1 subindex. Subindex 0 indicates now many subindexes are supported (here 1).

Subindex 1 shows that only the option "restore all parameters" is supported. In the case of a write command, data area D0 to D3 of this subindex must contain the values 6Ch, 6Fh, 61h and 64h to perform the storage.

(These values correspond to the ASCII codes of the letters **l o a d**.)

Object 1014h: COB ID Emergency (COB ID for emergency messages)

This object indicates on which COB ID the emergency messages are sent. The COB ID is determined by the selected Node ID and cannot be modified (read only). The behavior in case of an error is described in Object 1029h Error Behavior.

Object 1017h: Producer heartbeat time

The producer heartbeat defines the cycle time of the heartbeat. The value range has 2 bytes and uses the unit ms. It allows selecting a cycle time from 1 ms to 65535 ms. If zero is input, no heartbeat is sent, which means that this function is disabled.

Object 1018h: Identity object

This object contains manufacturer-specific information. It has 2 subindexes. Subindex 0 indicates now many subindexes are supported (here 2). Subindex 1 contains the vendor ID (registered at the CiA organization). Subindex 2 contains a product code.

Object 1029h: Error behavior

This object has 1 subindex. Subindex 0 indicates now many subindexes are supported (here 1). Subindex 1 indicates that in the event of an error the sensor responds in accordance with the CiA specification "01h = No change of the NMT state".

Object 1800h: TPDO1 communication parameters

This object contains the parameters for process data object PDO1 and supports 5 subindexes.

Subindex 0 indicates now many subindexes are supported (here 5).

Subindex 1 contains the COB ID (Data0 and Data1) of TPDO1. (Example: if Node ID = 7, the TPDO1 has COB ID 187h). Write access to the COB ID is not possible, so TPDO1 is always Node-ID + 180h. Data3 of this subindex contains value 40h. This indicates that RTR frames (remote transmission frames) are not possible with this PDO.

Subindex 2 defines the transmission type Possible values are 1 to 240 and 255 (decimal). For values 1 to 240, a TPDO1 is sent when a Sync telegram is received (see Object 1005h COB ID SYNC Message). For value 1 a TPDO1 is sent with every Sync, for value 2 only with every second Sync and so on, up to 240. For value 255, Sync operation is disabled. In this case, TPDO1 process data is sent cyclically in Operational mode, without having been initiated by a Sync telegram. The cycle time (repetition rate) is defined in subindex 5.

Subindexes 3 & 4 have no function and are not used.

Subindex 5 defines the cycle time of the TPDO1 telegrams when the 255 function has been selected previously in subindex 2. The value range has 2 bytes and uses the unit ms.

It allows selecting a repetition rate from 1 ms to 65535 ms. No TPDO1 are sent if the input value is zero.

(In this condition, the TPDO1 is disabled, as there will be no response to Sync telegrams even after subindex 2 has been set to 255).

Object 1A00h: TPDO1 mapping parameters

This object contains the mapping parameters for process data object TPDO1 and has 1 subindex.

Subindex 0 indicates now many subindexes are supported (here 1).

Subindex 1 refers to Object 6004h and indicates that the process data has a values range of 16 bits.

Objects 21xxh: Manufacturer specific profile area

Object 2100h: Baud Rate (baud rate setting)

This object allows setting the baud rate of the sensor. Values range is from 1 to 7.

These values correspond to the following baud rates:

Value	Baud rate
1	1Mbps
2	800kbps
3	500kbps
4	250kbps
5	125kbps
6	50kbps
7	20kbps

Table 9

Changes are only taken over after a new start or reset of the sensor. Prerequisite is that storage using Object 2105h has been performed.

Object 2101h: Node Number

This object allows modifying the node address. As a standard, this value is set to 0x07h. Values range is from 1 to 127. Therefore CANopen allows operating up to 127 stations on a bus. (Node number 0 is reserved by the NMT and shall not be used!)

Changes are only taken over after a new start or reset of the sensor. Prerequisite is that storage using Object 2105h has been performed.

Object 2102h: CANbus termination (enable/disable the termination resistor)

This object allows switching the bus termination on or off. Accordingly, an internal 120 ohm terminating resistor is interposed between the CAN-High and CAN-Low lines.

Changes are only taken over after a new start or reset of the sensor. Prerequisite is that storage using Object 2105h has been performed.

Object 2104h: NMT Auto start

This object allows defining the start mode of the sensor when powering it. Values range is from 0 to 1. With zero, the sensor is in Pre-Operational mode after power-on or a reset, with 1 the sensor starts immediately in Operational mode, without having received the corresponding command from the NMT. Changes are only taken over after a new start or reset of the sensor. Prerequisite is that storage using Object 2105h has been performed.

Object 2105h: Store parameters of manufacturer specific profile area

This object allows storing the current parameters of Objects 2100h, 2101h, 2102h, 2104h in the sensor. In the case of a write command, data area D0 to D3 of this subindex must contain the values 73h, 61h, 76h and 65h to perform the storage. (These values correspond to the ASCII codes of the letters **s a v e**.)

Object 6004h: Position value (current position value)

The current sensor position value is stored here. Values range is 16 bits. The low byte of this16-bit value is Data 0, the high byte is Data 1.

Error messages (SDO abort codes)

In case of a faulty communication, an error message is sent on the SDO.

In this case, the command byte has always the value 80h.

The following table shows the possible error messages:

Code	Meaning
0504 0001h	Client/server command specifier not valid or unknown
0601 0002h	Attempt to write a read only object
0602 0000h	Object does not exist in the object dictionary
0607 0012h	Data type does not match, length of service parameter too high
0607 0013h	Data type does not match, length of service parameter too low
0609 0011h	Sub-index does not exist
0609 0030h	Invalid value for parameter
0800 0021h	Data cannot be transferred or stored to the application because of local control

Table 10

7. Emergency Message

Emergency telegrams are sent autonomously by the sensor in the event of an error. The difference must be made between the SDO error messages in case of a faulty access to a SDO object and the "actual" error messages from emergency messages. An error message is sent at the first occurrence of an error. If the cause of the error is corrected and is no longer present, another error message is sent with error code 0000h.

The COB ID of the emergency-message is calculated using the Node-ID (module address) + 80h.

The following error codes are possible with the sensor:

Byte_1	Byte_0	
00h	00h	No error
81h	20h	CAN in error passive mode
81h	50h	CAN-ID collision

Table 11

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