

CANOpen – CAN PROTOCOL APPLICATION NOTE

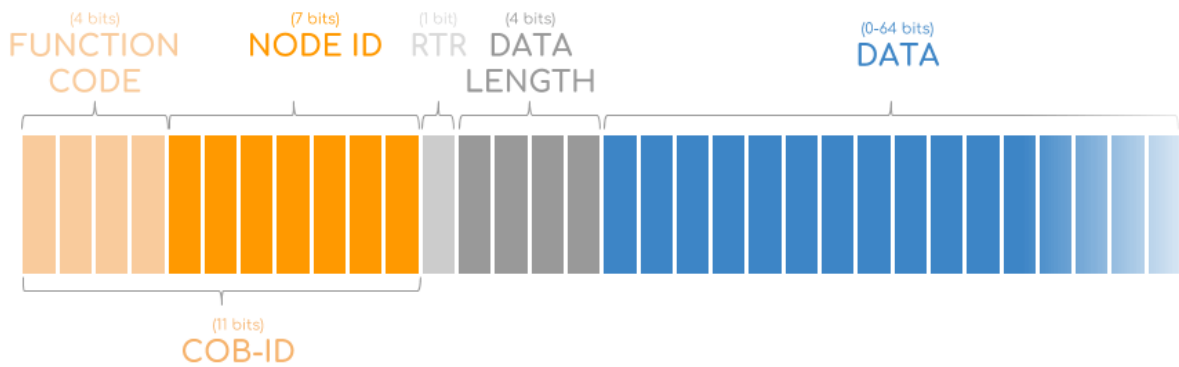
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1. Description.

CAN Protocol	CANOpen standards
CAN-bus Speed	250 Kbit/s(default)
CAN identifier	11 bits

2. CANOpen frame.

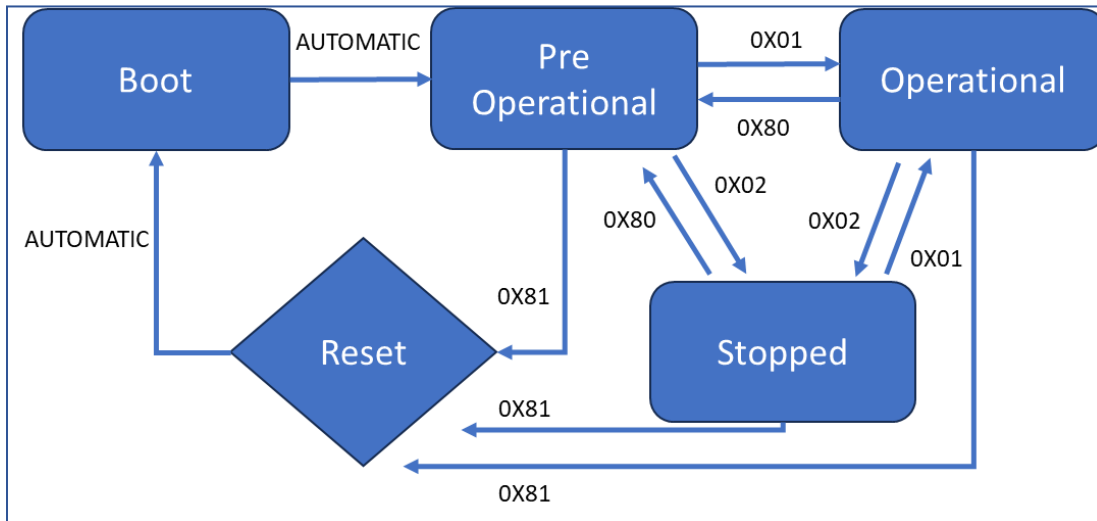


The 11-bit CAN ID is referred to as the Communication Object Identifier (COB-ID) and is split in two parts: By default, the first 4 bits equal a function code and the next 7 bits contain the node ID.

COMMUNICATION OBJECT	FUNCTION CODE (4 bit, bin)	NODE IDs (7 bit, bin)	COB-IDs (hex)	COB-IDs (dec)	#
1 NMT	0000	0000000	0	0	1
2 SYNC	0001	0000000	80	128	1
3 EMCY	0001	0000001-1111111	81 - FF	129 - 255	127
4 TIME	0010	0000000	100	256	1
5 Transmit PDO 1	0011	0000001-1111111	181 - 1FF	385 - 511	127
Receive PDO 1	0100	0000001-1111111	201 - 27F	513 - 639	127
Transmit PDO 2	0101	0000001-1111111	281 - 2FF	641 - 767	127
Receive PDO 2	0110	0000001-1111111	301 - 37F	769 - 895	127
Transmit PDO 3	0111	0000001-1111111	381 - 3FF	897 - 1023	127
Receive PDO 3	1000	0000001-1111111	401 - 47F	1025 - 1151	127
Transmit PDO 4	1001	0000001-1111111	481 - 4FF	1153 - 1279	127
Receive PDO 4	1010	0000001-1111111	501 - 57F	1281 - 1407	127
6 Transmit SDO	1011	0000001-1111111	581 - 5FF	1409 - 1535	127
Receive SDO	1100	0000001-1111111	601 - 67F	1537 - 1693	127
7 HEARTBEAT	1110	0000001-1111111	701 - 77F	1793 - 1919	127

3. Network Management.

The device supports CANopen network management functionality NMT Slave.



Every CANopen device contains an internal Network Management server that communicates with an external NMT master. One device in a network, generally the host, may act as the NMT master. Through NMT messages, each CANopen device's network management server controls state changes within its built-in Communication State Machine.

The "Communication State Machine" in all CANopen devices, however, is identical as specified by the DS301. NMT messages have the highest priority. The 4 NMT messages that control the Communication State Machine each contain 2 data bytes that identify the node number and a command to that node's state machine.

Table 1 shows the 4 NMT messages supported, and Table 2 shows the correct message for sending these messages.

NMT Message	COOB-ID	Data Byte 0	Data Byte 1
Start Remote Node	0	0x01	Node-ID*
Stop Remote Node	0	0x02	Node-ID*
Pre-operational State	0	0x80	Node-ID*
Reset Node	0	0x81	Node-ID*

Node-ID - Slave address from 0x01 to 0x7F

Table 1

Arbitration Field		Data Field							
COB-ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
0x000	See table1	See table2	These bytes are not sent						

Table 2

4. Baud rate.

Baud rate can be configurable via Layer Setting Services and Protocol (LSS), the default Baud rate is 250kbit/s.

BAUD RATE Kbps	INDEX
1000	0x00
800	0x01
500	0x02
250	0x03
125	0x04

Table 3

5. Node-ID.

Node-ID can be configurable via Layer Setting Services and Protocol (LSS), The default Node-ID is 7F.

An example of the settings implemented via the LSS services can be found in the following table (Change the node ID of a sensor from 7F to 5, set the transmission rate to 125 kbps, save settings).

Step	Object	Nº bytes	DATA
Prepare	NMT Stop	0x000	2 02 7F
	LSS Switch mode ON	0x7E5	8 04 01 00 00 00 00 00 00
Select	LSS Configure node ID	0x7E5	8 11 05 00 00 00 00 00 00
	LSS Configure Timming	0x7E5	8 13 00 04 00 00 00 00 00
Save	LSS Store Config	0x7E5	8 17 00 00 00 00 00 00 00
	LSS Switch mode OFF	0x7E5	8 04 00 00 00 00 00 00 00
Reset	NMT reset	0x000	2 81 05

Table 4

6. SDO Communication.

The device fulfills the SDO Server functionality. Service Data Object (S.D.O.) the access to entries of a device Object Dictionary is provided.

Table 5 show the structure of SDO-request by the Master.

Arbitration Field		Data Field							
COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x600 + Node-ID	8	CMD	INDEX		SUB INDEX	DATA	DATA	DATA	DATA

Table 5

Table 6 show the structure of SDO-answer by the Slave.

Arbitration Field		Data Field							
COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x5807+ Node-ID	8	CMD	INDEX		SUB INDEX	DATA	DATA	DATA	DATA

Table 6

Data Object Write Access (form Host to Slave):

Each access to object dictionary is checked by the slave for validity. Any write access to nonexistent objects, to read - only objects or with a non-corresponding data format are rejected and answered with a corresponding error message.

CMD determines the direction of data transfer and the size of the data object:

- 0x23 Sending of 4-byte data (bytes 5 - 8 contains a 32-bit value).
- 0x2B Sending of 2-byte data (bytes 5, 6 contains a 16-bit value).
- 0x2F Sending of 1-byte data (byte 5 contains an 8-bit value).

The Slave answers:

- 60 hex Data sent successfully.
- 80 hex Error.

Data Object Read Access (form Slave to Host):

Any read access to non-existing objects is answered with an error message.

CMD determines the direction of data transfer:

- 0x40 read access (in any case).

The Slave answers:

- 0x42 Bytes used by node when replying to read command with 4 or less data.
- 0x43 Bytes 5 - 8 contain a 32-bit value.
- 0x4B Bytes 5, 6 contain a 16-bit value.
- 0x4F Byte 5 contains an 8-bit value.
- 0x80 Error.

7. PDO Sensor data (transmit PDO#1).

This PDO transmits asynchronously the position value of the angle sensor. Default transmission rate is 100 ms. The Tx PDO#1 shall be transmitted cyclically if the cyclic timer (object 0x1800.5) is programmed > 0. Values between 1 ms and 65535 ms shall be selectable by parameter settings. The Tx PDO#0 will be transmitted by entering the “Operational” state.

Default PDO values	
Default PDO	PDO #1
CAN ID	1FFh
Data Length	8
Node-ID	7F (default value)
Transmission Rate	100 ms (default value)

Data Field:

Data 0	Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7
Angle1 MSB	Angle1 LSB	Angle2 MSB	Angle2 LSB	0xFF	0xFF	Error	CRC
16 bits, Resolution: 0.1° Range 0 ... 3600 Ex:0x0C56=315.8° Data0 = 0x0C Data1 = 0x56		16 bits, Resolution: 0.1° Range 0 ... 3600 Ex:0x0C56=315.8° Data0 = 0x0C Data1 = 0x56		Reserved		8 bits, Range 0 ... 255	8 bits, Range 0 ... 255

Error code:

HEX CODE	Description
0x00	No error.
0x01	Error Hall sensor communication.
0x02	Hall sensor in error status.
0x03	Initialize error.
0x04	Angle out of range.
0x05	Checksum error
0x06 to 0xFF	T.B.D.

Message Checksum is used to verify the signal path from the transmitting device to the receiving device. The checksum is calculated using the first 7 data bytes, and it is calculated as follows:

```
uint8_t getChecksum (uint8_t data[])
{
    uint8_t XOR;
    uint8_t c;

    for (uint8_t i = 0; i < 8; i++)
    {
        c = data[i];
        XOR ^= c;
    }

    return XOR;
}
```

Example PDO#1 transmission: Angle 1 = 359,9°, Angle 2 = 0.0°, Node-ID = 0x05.

Arbitration Field		Data Field							
COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x185	8	0x0E	0x0F	0x00	0x00	0xFF	0xFF	0x00	0x01

8. CANopen features summary.

Communication Profile The parameters which are critical for communication are determined in the Communication profile. This area is common for all CANopen devices.

Index	Sub Index	Name	Type	Access	Default value	Comments
1000h		Device Profile	Uint 32	Ro	0x00000000	No standardized device profil adapted
1001h		Error Register	Uint 8	Ro	0x00	Always ZERO
1008h		Manufacturer Device Name	String	Ro	"PS2P", "PST", "PSC" or "PSCI"	More info in Piher website.
1009h		Manufacturer Hardware Version	String	Ro	"1.00"	

100Ah		Manufacturer Software Version	String	Ro	"1.14"	
1010h	0	Save all parameters	Uint 32	Rw		"save" (0x65766173) to store config parameters
1011h	0	Restore all parameters	Uint 32	Rw		"load" (0x64616F6C) to restore config parameters
1014h	0	Emergency ID	Uint 32	Rw	0x80+Node-ID	
1017h	0	Producer time/Heart beat	Uint 16	Rw	0	Min. = 0 & Max. = 65536 with unit = 1ms; If 0: NOT USED
1018h	0	Identity object	Uint 8	Ro	4	Refer to Vendor ID: 0x0000FFFF
	1	Vendor ID	Uint 32	Ro	0x0000FFFF	
	2	Product code	Uint 32	Ro	0x00000000	
	3	Revision number	Uint 32	Ro	0x00000000	
	4	Serial number	Uint 32	Ro	0x00000000	

SDO Server Parameter:

Index	Sub Index	Name	Type	Access	Default value	Comments
1800h	0	Subindex supported	Uint 8	Ro	6	
	1	COB_ID	Uint 32	Ro	0x180 + Node-ID	
	2	Transmission Type	Uint 8	RW	0xFF	0xFF-Asynchronous transmission 0x01 to 0xF0 - Synchronous transmission
	3	Inhibit time	Uint 16	RW	0x0000	
	4	Reserved	Uint 8	RW	0x00	
	5	Event Timer	Uint 16	RW	100	millisecond
	6	Start counting Sync	Uint 8	RW	0x00	Boolean 0 – false(stop); 1 – true (start)

TxPDO Mapping Parameter:

Index	Sub Index	Name	Type	Access	Default value	Comments
1A00h	0	Number of entries	Uint 8	Ro	8	
	1	1st Mapped Object	Uint 32	Ro	0x21100108	
	2	2st Mapped Object	Uint 32	Ro	0x21100208	
	3	3st Mapped Object	Uint 32	Ro	0x21100308	
	4	4st Mapped Object	Uint 32	Ro	0x21100408	
	5	5st Mapped Object	Uint 32	Ro	0x21100508	
	6	6st Mapped Object	Uint 32	Ro	0x21100608	
	7	7st Mapped Object	Uint 32	Ro	0x21100708	
	8	8st Mapped Object	Uint 32	Ro	0x21100808	

Manufacturer Specific Profile Objects (0x2110 Angle Values):

Index	Sub Index	Name	Type	Access	Default value	Comments
2110h	0	Number of entries	Uint 8	Ro	8	View 7.PDO Sensor data
	1	Angle 1 byte MSB	Uint 8	Ro	-	
	2	Angle 1 byte LSB	Uint 8	Ro	-	
	3	Angle 2 byte MSB	Uint 8	Ro	-	
	4	Angle 2 byte LSB	Uint 8	Ro	-	
	5	Reserved	Uint 8	Ro	0xFF	
	6	Reserved	Uint 8	Ro	0xFF	
	7	Error	Uint 8	Ro	-	
	8	CRC	Uint 8	Ro	-	

9. Examples:

How to change the PDO rate (time interval) from 100ms to 20ms:

Write (in the example the Node-ID = 0x05)

Arbitration Field		Data Field								
COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	
0x605	8	0x2B	0x00	0x18	0x05	0x14	0x00	0x00	0x00	

Answer successful storing:

Arbitration Field		Data Field								
COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	
0x585	8	0x60	0x00	0x18	0x00	0x00	0x00	0x00	0x00	

Save in memory:

Arbitration Field		Data Field								
COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	
0x605	8	0x23	0x10	0x10	0x00	0x73	0x61	0x76	0x65	

Answer successful storing:

Arbitration Field		Data Field								
COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	
0x585	8	0x60	0x10	0x10	0x00	0x00	0x00	0x00	0x00	

How to activate an automatic NMT Start after power ON:

Send NMT start (in the example the Node-ID = 0x05):

Arbitration Field		Data Field							
COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x000	2	0x01	0x05	These bytes are not sent					

Save in memory:

Arbitration Field		Data Field							
COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x605	8	0x23	0x10	0x10	0x00	0x73	0x61	0x76	0x65

Answer successful storing:

Arbitration Field		Data Field							
COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x585	8	0x60	0x10	0x10	0x00	0x00	0x00	0x00	0x00